ATTACHMENT 5
SEPTA STANDARDS
Structural Design Criteria and Guidelines

By Southeastern Pennsylvania Transportation Authority

Structural Engineering
Structural Design Criteria and Guidelines
August 2006

To: Distribution

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Purpose
This document provides general structural design guidance and criteria for buildings, bridges, and miscellaneous structures. The design requirements provided herein, or cited by reference, are based on national building codes and industry standards. Requirements unique to SEPTA facilities are indicated. Supplemental information to help engineers interpret and apply code provisions, and meet serviceability and strength performance objectives is also included in this document. The intent of this document is to provide general guidelines and minimum requirements to design organizations performing work for SEPTA.

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Structural Engineering
Structural Design Criteria and Guidelines

Revision 0 – Initial Issue
August 2006

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SIGNATURES ARE ON FILE

SEPTA – Structural Design Criteria and Guidelines
Approvals
### Structural Engineering
### Structural Design Criteria and Guidelines

#### Revision Record

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CHAPTER 1
INTRODUCTION

1. SCOPE

1.1. This document provides general structural design guidance along with SEPTA mandated requirements for buildings, building systems, bridges, and miscellaneous structures. The design recommendations and requirements provided herein, or cited by reference, are based on national building codes and industry standards. Requirements unique to SEPTA facilities are indicated. Supplemental information to help engineers interpret and apply code provisions, and meet serviceability and strength performance objectives is also included in this document.

1.2. The intent of this document is to provide general guidelines and minimum requirements to design organizations performing structural engineering work for SEPTA. This document does not represent all legal or contractual requirements, which are or may be associated with design, engineering, construction, and/or related activities.

1.3. The Engineer of Record and Designer shall evaluate this document for appropriateness against specific project application, current policy, latest codes, and requirements, and shall allow for reasonable amount of flexibility in its application.

1.4. Patented and proprietary systems are not generally included in this criteria but may be appropriate for a specific project. It is not the intent of this criteria to exclude such systems from consideration or use unless expressly noted.

1.5. This document applies to all SEPTA owned or operated facilities. This is a living document and will be periodically reviewed, updated, and made available to all users. SEPTA reserves the right to make unilateral changes to this document at any time, at its sole discretion.

1.6. This document uses US Customary (English) units. If a project requires SI or metric units, the Designer shall make all necessary conversions.

2. BACKGROUND

SEPTA owns and uses its facilities and right-of-way for the primary purpose of operating a mass transit and railroad system. Therefore all work shall be designed and performed in a manner such that transit and railroad operations and facilities are not interfered with, interrupted, or endangered. In addition, any facilities that are a result of the proposed work shall be located to minimize encumbrance to the
right-of-way so that SEPTA will have unrestricted use of its property and/or Right of Way for current and future operations.

The Designer of the project shall be ultimately responsible for assuring that its agents, consultants, contractors, and sub-contractors fully comply with the requirements contained herein.

3. ALTERNATIVE AND SPECIAL DESIGNS.

Deviation from these criteria and guidelines, where a valid need exists or an alternative solution is more desirable, may be accepted subject to approval of SEPTA's Chief Engineer - EM&C or designee.

4. DEFINITIONS

ADA – Americans with Disabilities Act


AISI – The American Iron and Steel Institute

AREMA - The American Railway Engineering Association.

ASCE – American Society of Civil Engineers

ASCE/SEI 7 - American Society of Civil Engineers’ publication “Minimum Design Loads for Buildings and Other Structures”

AWS - The American Welding Society

COMBINATION OF LOAD EFFECTS - The effect on the structure and its components due to gravity loads, wind loads, and seismic forces combined in accordance with the applicable codes.

CORPORATION - Any firm duly incorporated under laws of a state government.

DESIGN LOADS - Dead load (D), earthquake loads (E), loads due to fluids (F), flood loads (Fa), loads due to soil and water in soil (H), live loads (L), roof live load (Lr), and rain load (R), snow loads (S), self-restraining loads (T), and wind loads (W). Earthquake (seismic), snow, and wind loads are also based on the requirements of ASCE/SEI 7, except as indicated in the International Building Code (IBC).
DESIGNER - The individual, partnership, firm, corporation or any combination thereof, or joint venture, contracting with SEPTA for the design and engineering of a Project.

ENGINEER, ENGINEER OF RECORD, STRUCTURAL ENGINEER OF RECORD (SER) – The individual(s) with has responsibility for the structural integrity and completeness of the structural systems and components. This individual shall be a Registered Professional Engineer (PE) in the state where the project is located.

GOVERNMENT - Federal, State, Town, City, County and other forms of government.


INDIVIDUAL - Any party not defined by "Owner, Utility, Government or Corporation".

LIGHT RAIL – SEPTA’s Suburban Transit Division (STD) Media/Sharon Hill trolley lines (Routes 101 and 102) and the Norristown High Speed Line (NHSL or Route 100).

PennDOT – Commonwealth of Pennsylvania Department of Transportation

RAILROAD – SEPTA’s Regional Railroad (Commuter) system (RRD) including all non-operating railroad branches that may or may not be currently used for freight operations.

RAIL TRANSIT – All of SEPTA’s transit lines that operate on rails including subway and elevated lines, trolley lines, light rail, and commuter rail systems.

SEPTA - Southeastern Pennsylvania Transportation Authority

SEPTA ENGINEERING - SEPTA’s EM&C Division, Bridges & Buildings Department Engineering Staff

SEPTA PROPERTY - All rights of way and property owned and/or controlled by the SEPTA.

SPECIAL INSPECTIONS – Inspection required by the IBC or other applicable codes or regulations of the material, installation, fabrication, erection, or placement of components and connections requiring special expertise to ensure compliance with approved construction documents and referenced standards.

STRUCTURAL DESIGN – The selection of appropriate materials, systems, and details for the structure and performing calculations of stress and strain in each component caused by the prescribed loading.
STRUCTURAL ENGINEER – A professional engineer (PE) who is competent, due to specialized education, expertise, or experience, to engage in the practice of structural engineering.

STRUCTURAL ENGINEERING – The application of mathematics, material science, and the physical principles of statics and dynamics, to the design, analysis, construction, and rehabilitation bridges, buildings, towers, and other structures, and parts there of, to make them safe and serviceable while enduring the effects of various loads.

UTILITY - Public or private entities with electric power, telephone (including fiber optics), telegraph, cable television, water, gas, oil, petroleum products, steam, chemicals, sewage, drainage, irrigation and similar lines which may or may not be regulated by the Pennsylvania Public Utilities Commission (PUC).

5. GENERAL REQUIREMENTS

5.1. All projects shall be designed in such a manner as to safeguard the operations, facilities, right-of-way, and property of SEPTA. All work adjacent to, over, or under SEPTA's tracks, facilities, right-of-way, and property shall be governed by SEPTA's standards and by such other requirements as specified by SEPTA so as to insure the safe operation of SEPTA’s transit system and facilities, prevent delay to trains, trolleys, and buses, and insure the safety of all concerned.

5.2. All work shall be planned, designed, and conducted so that there will be no interference with or damage to SEPTA operations, including rail transit and bus operations, tracks and rails, power, signal, telephone and telegraphic services, or damage to the property of SEPTA, or to poles, wires, and other facilities of tenants on SEPTA’s right-of-way or property.

5.3. All work shall be designed to account for SEPTA's operational and maintenance needs. Items such as snow removal, snow plowing, use of de-icing chemicals, use of cleaning agents, ability to clean and maintain surfaces, and passenger protection must all be considered in the design of a project.

6. DOCUMENTATION OF STRUCTURAL ENGINEERING AND DESIGN

6.1. The design of all structures shall be documented to provide a permanent reference for future use. This reference may be used to answer questions during construction, safety inspections, maintenance, and when major rehabilitation or reconstruction is necessary. Documentation of the design should include:

- design computations,
- specific references to specifications and codes,
- assumptions,
- specific design criteria and design loads,
• hydraulic and hydrology reports,
• foundation reports,
• quantity calculations,
• materials properties,
• computer printouts, if the design was prepared on the computer (include both input and output, the name and version of the software),
• design checklist,
• As-built modifications, and
• any design exceptions.

6.2. Load Factor Design, Allowable Stress Design, and Load Resistance Factor Design (LRFD) are generally acceptable design methods. The designer shall coordinate the specific design methodology with SEPTA’s structural engineering prior to commencing with preliminary design calculations and layout.

6.3. All structural designs shall be signed and sealed by a Professional Engineer registered in the Commonwealth of Pennsylvania. All revisions shall be reviewed, and signed and sealed by a Professional Engineer registered in the Commonwealth of Pennsylvania.

6.4. The structural design shall follow the codes, manuals, and/or specifications specified as modified here-in as appropriate.

6.5. Calculations

6.5.1. The engineer of record must prepare structural calculations to support all structural designs including field and fabrication modifications. The structural calculations shall be prepared legibly and presentably.

6.5.2. Design calculations shall be complete with a cover sheet, index, list of assumptions, governing codes and regulations, specifications used, design loads and load combinations, and design criteria used. All pages shall be numbered and initialed by both the originator and the checker. The calculations shall include fully identified, dimensioned, and annotated diagram(s) of each member or structure.

6.5.3. When computer calculations are included, provide a synopsis of the computer program(s) including: documentation or certification(s) of the program, required input, method of solution, output generated, extent of previous usage, and the name of the author of the program(s). A hard copy of input and output of any computer analyses should be included and so should a description of the software used.

6.5.4. In general, structural calculations and supporting documentation should include, but not necessarily be limited to:

6.5.4.1. Design criteria, covering:

6.5.4.2. Description of location for structural elements;
• Discussion and description of the design basis, including assumptions,
• Latest building codes with edition dates,
• Listing of all applicable live loads (They include, but are not limited to snow loads, seismic factors and wind-load criteria, and any special loads and provisions greater than building code requirements used,
• Structural material specifications for concrete, reinforcing steel, masonry, structural steel, wood and other materials used, including any existing structures or components incorporated into the design,
• Geotechnical report information and design criteria,
• Deflection limitations of structural elements and systems

6.5.4.3. Vertical load analysis and design of (including but not limited to): roof structures floor structures, frames or trusses, columns, walls and foundations. This includes existing structures and foundations being re-used or modified.;

6.5.4.4. Lateral-load analysis, including, but not limited to, design for seismic, wind and unbalanced-lateral earth forces;

6.5.4.5. Computer analyses and design input and output, and software identification, if applicable;

6.5.4.6. Special studies and analyses (dynamic, vibration, etc.), where used;

6.5.4.7. Independent check of the final structural design and documents to confirm the adequacy and appropriateness of the design (The independent check shall be performed by an engineer other than the original designer.);

6.5.4.8. The names of the structural design engineer(s) and design-check engineer;

6.5.4.9. Project name and date.

6.6. Structural Drawings

6.6.1. Drawings should indicate the project name and date.

6.6.2. Structural drawings should show the locations, sizes, reinforcing, and connections of the structural elements in sufficient scale and detail to enable the fabrication, installation and connection of the members in a reasonable sequence by a competent constructor familiar with the techniques of construction for the specified materials.

6.6.3. Framing plans for buildings may refer to architectural drawings for dimensions where appropriate and mutually agreed to by the structural engineer of record and the architect. Elevations, sections, and details should be of appropriate scale, number, and extent to portray the relationship of members to each other and their interconnection(s). Care should be taken to ascertain and determine that details noted "typical" are applicable to the condition being portrayed and that their location and extent are made explicit.

6.6.4. The drawings should define the complete extent and detail of the work. Requirements may vary depending on the complexity of the job and the
materials, and the drawings should include, but not necessarily be limited to, the following.

6.6.4.1. Structural notes should include:
- Design criteria indicating all superimposed vertical and horizontal loads used in the design including but not limited to live, normal and maximum Cooper E rating, highway vehicle inventory and operating load rating, snow, earthquake, wind, and dead loads (such as landscape, partition and equipment loads) not shown on the structural drawings;
- Requirements set forth in IBC;
- Reference to the geotechnical report on which the foundation design is based, or, in the absence of a geotechnical report, the assumed design criteria;
- Brief material specifications, including any fabrication criteria;
- Absolute or relative deflection and vibration criteria for structural members;
- Where forces are shown, they should be clearly identified as factored or unfactored.
- Building codes and edition dates;
- Pertinent design standards;
- Reference to drawings and specifications prepared by other participants of the design team;
- Reference to submittals and field-review requirements;
- Any other data that would be pertinent to future structural modifications, structural analysis, or evaluation.

6.6.4.2. Typical details

6.6.4.3. Foundation plans and schedules should include:
- General gridline dimensions and overall structure dimensions;
- Allowable soil-bearing capacity, pile capacities and lateral earth pressures for retaining structures if not otherwise specified;
- Sizes, locations, dimensions, orientation and details of all foundations;
- Estimated pile length(s) or source of this information;
- Location of known existing services and existing foundations that conflict with structural foundations, or the source where this information can be found should be referenced;
- PA One Call Information including Design Serial Number;
- If underpinning or temporary shoring is specified to be designed by others, there should be indication on the drawings of the areas designated to be shored or underpinned. If shoring or underpinning is designed by the structural engineer of record, there should be indication of all details and construction sequences.

6.6.4.4. Framing plans and details should include:
• General gridline dimensions and overall building dimensions;
• Sizes, locations, dimensions and details of all structural elements;
• Elevations, including slopes and depressions;
• Lateral-load-resisting system;
• Governing forces, moments, shears or torsion required for the preparation of shop and detail drawings;
• Reinforcing bar sizes and details with placing criteria;
• Locations and details of control, construction, contraction and expansion joints;
• Locations, sizes and reinforcing of significant openings;
• Provision for future extensions.

6.6.4.5. Schedules and details for columns, beams and walls should include:
• Element sizes;
• Anchorage to supporting elements;
• Elevation of bottom of columns;
• Reinforcing steel and splice details for concrete columns;
• Splice locations for structural steel columns;
• Structural details of masonry or reinforced concrete walls, including lintels, details and reinforcing of significant openings;
• Stiffeners, lateral bracing, and local reinforcements for steel members.

6.6.4.6. Connections: Where connections are specified to be designed by others, the drawings should indicate all required information and governing forces. In such cases, the fabrication drawings shall be either sealed by a Registered Professional Engineer or the Structural Engineer of Record (SER) shall certify that he/she have reviewed the connections and verified that the connections will support the design loads. Where connections are designed by the SER, they should show all dimensions and comprehensive connection details requiring no further engineering input. Under these circumstances, the SER retains responsibility for these connections. The SER shall consider the design of the connections when sizing the structural members, e.g. HSS truss joints, post-tensioned anchorages, etc.

6.6.4.7. General arrangement and details at intersections of different structural materials should be shown.

6.6.4.8. Sequence of construction should be included if this is critical to the functioning of the finished structure.

6.7. For existing structures, the current condition and remaining service life of the structure shall be determined and considered in all calculations, analysis, and design.
6.8. Drawings for structures along the ROW of railroad and light rail lines shall note the milepost location of the structure(s) and stationing where available.

6.9. All Drawings, Plans, and Calculations shall be stamped by a Professional Engineer registered in the State where the work is located.

6.10. Upon completion of the Project, an database inventory of all fatigue-sensitive details and fracture critical members shall be provided to SEPTA for incorporation into SEPTA's Structure Inspection Program. This inventory shall note compliance with the fabrication requirements of AASHTO or AREMA as applicable.

6.11. Upon completion of the Project, as-built plans off all permanent installations shall be provided to SEPTA in electronic format on CD ROM using either Adobe® Acrobat® or AutoCAD format. Drawings shall follow SEPTA's AutoCAD Standards.
CHAPTER 2
GENERAL REQUIREMENTS

1.0 SCOPE AND GENERAL REQUIREMENTS

1.1. This document establishes the minimum standards to be used in the design of SEPTA facilities. The criteria and guidelines presented herein were developed considering passenger comfort, safety, maintenance, service life, and accepted engineering practices used in currently operating mass transit and railroad systems.

1.2. The Engineer of Record is responsible for the suitability of the design, the selection of the proper materials, and for adequate details meeting SEPTA’s operational and maintenance requirements and for conformance with the Contract Documents.

1.3. All structures are to be designed to sustain, within the permitted stress allowances and load factors, all applicable design loads and forces, which are properly distributed. Standards (latest editions) to be used in the selection of design loads and method of distribution include the following:

1.3.1. The American Association of State Highway and Transportation Officials (AASHTO), Standard Specification for Highway Bridges (latest edition) and Specifications for the Design and Construction of Structural Supports for Highway Signs (latest edition). Elevated portions of the Market Frankford Subway Elevated (MFSE), motor vehicle bridges, and pedestrian bridges shall be designed per the applicable AASHTO standards as modified here-in.

1.3.2. The American Railway Engineering Association (AREMA), Manual for Railway Engineering (latest edition) for railroad and light rail bridges, catenary structures, and other railroad right-of-way (ROW) and rail transit structures.

1.3.3. The International Building Code (IBC), (latest edition).

1.3.4. The requirements of the Occupational Safety and Health Act (OSHA).

1.3.5. All non-transit structural steel structures shall be designed per AISC unless otherwise noted.

1.3.6. All non-transit concrete structures shall be designed per ACI 318 unless otherwise noted.

1.3.7. The governing code or specifications of the agency under whose jurisdiction the structure is located.

1.3.8. PennDOT Structures Design Manuals Publication #15 and specifications shall be followed as applicable.
1.3.9. Sound Barrier walls shall be designed per AASHTO Guide Specifications for Structural Design of Sound Barriers.

1.3.10. For the Broad Street Subway including the Ridge Avenue Spur (BSS or Orange Line), the Market Frankford Subway Elevated (MFSE or Blue Line), and the Subway-Surface Trolley Lines (Green Line), the provisions of the City of Philadelphia Transit Design Manual Part IV – STRUCTURES, shall be followed as modified by this document and current codes and regulations.

1.3.11. Refer to SEPTA’s “Structural Engineering Right-of-Way Design and Construction Standards” for additional requirements as applicable.

1.4. Some of SEPTA’s Regional Rail lines run on AMTRAK owned and operated tracks. At these locations, the Designer shall be familiar with and follow AMTRAK requirements and specifications as applicable.

1.5. The requirements of OSHA (29 CFR 1910 and 1926) shall be considered in all designs. For railroads, the Federal Railroad Administration (FRA) rules and regulations must also be followed.

2.0 STRENGTH AND SERVICEABILITY PERFORMANCE OBJECTIVES

2.1 General requirements with respect to strength and serviceability are indicated in the following paragraphs. Specific requirements on strength and serviceability with respect to the various types of structures, building systems, and construction materials are provided in the following chapters.

2.2 Strength: Bridges, buildings, and other structures, and all parts thereof, shall be designed to safely support the loads and load combinations indicated.

2.3 Serviceability: Structural systems and members thereof shall be designed to have adequate stiffness to limit deflections, lateral drift, vibration, or any other deformations that adversely affect the intended use and performance of the structure. Designs must also consider deformation loads such as temperature, differential settlement, creep, and shrinkage. Measures necessary to keep structures free from deformation load cracking and deterioration, such as crack control joints, shall be considered an essential part of the building design. In addition buildings and structures when necessary, shall be capable of withstanding severe environmental effects without incurring damage or deterioration that would reduce the structure’s service life.

2.4 Deflection and Drift Limits: Deflections of structural members shall not be greater than allowed by the applicable material standard (AREMA, AASHTO, ACI, AISC, IBC, etc.). Deflection limits are needed to restrict damage to ceilings, partitions, and other fragile nonstructural elements, maintain alignment of cables and wires in the case of catenary support structures, or prevent infringement of clearance.
envelopes. Therefore, the deflection over span length (l) shall not exceed that permitted by the governing codes. In certain cases, drift limits lower than those specified will be required to restrict damage to partitions, stair and shaft enclosures, glass, and other fragile nonstructural elements.

2.5 Creep and Shrinkage: Concrete and masonry structures should be investigated for stresses and deformations induced by creep and shrinkage.

2.6 Vulnerability to accidents, vandalism, or sabotage is a concern for all infrastructure facilities.

   2.6.1 This should be addressed in part by designing redundancy into the structures where feasible.
   2.6.2 The application of anti-graffiti coatings in addition to any corrosion protection coating system is generally required in graffiti prone areas.
   2.6.3 The layout of facilities shall minimize blind corners, hiding spots, areas where vandals, vagrants, and/or others can reside. Layout of public facilities should open and visible or have other crime deterrent characteristics.
   2.6.4 Vandal resistant hardware should be used for non-structural applications in public areas.

3.0 LOAD PATH CONTINUITY AND INTEGRITY

3.1 Designers must understand how the structures will respond to vertical and lateral loads. Follow all loads through the structure to assure all the structural elements and connections along the load path have sufficient strength and stiffness to maintain structural integrity. Direct and continuous load paths from the roof to foundation must be provided. Configuration, continuous and redundant load paths, connection detailing, system ductility, quality of materials, and construction are important to the structure’s performance.

3.2 Modifications to existing structures shall follow the load path through the new and existing construction. All existing structures and structural components shall be checked and verified that there is sufficient strength and capacity for all new or re-used loading conditions.

3.3 Consistent with ASCE/SEI 7, “Minimum Design Loads for Buildings and Other Structures”, and SEPTA serviceability needs, buildings and other structures shall be designed to sustain local damage under extreme loading conditions with the structural system as a whole remaining stable. This objective can be achieved by an arrangement of structural elements which assures loads can be transferred from any locally damaged region to adjacent regions capable of resisting those loads. This can be accomplished by providing sufficient continuity, redundancy, and energy dissipating capability (ductility).
4.0 SERVICE LIFE

4.1 A quality design shall be provided with a long service life based upon minimal maintenance.

4.2 The minimum design service life of various structures and facilities is defined as follows:

   4.2.1 Railroad and Roadway Bridges: Main load carrying members of the superstructure and substructure shall be designed and constructed for an expected functional life of 100 years.
   4.2.2 Stations: designed and constructed for an expected functional life of 50 years or more.
   4.2.3 Shops and Yards: designed and for an expected functional life of 50 years.
   4.2.4 Substations And Other Critical Structures: designed and constructed for an expected functional life of 75 years.
   4.2.5 Sign supports, high mast lighting supports (50 feet or greater), cantilever and monotube structures, communication towers, and similar structures: designed and for an expected functional life of 50 years.
   4.2.6 Catenary support, signal support structures, and transmission line structures: designed and for an expected functional life of 75 years.
   4.2.7 Storm Drainage Facilities: designed and constructed for an expected functional life of 50 years.
   4.2.8 Rigid (concrete) pavements: Designed for a service life of 30 years.
   4.2.9 Long-term repairs: Design for a service life of 20 years or more.
   4.2.10 Reconstruction, and major structural renovations: designed and for an expected functional life of 50 years including all existing components and structures.
   4.2.11 Other Permanent Construction: Permanent construction shall be designed and constructed to serve a life expectancy of 25 years or more.
   4.2.12 All permanent construction shall be energy efficient, and shall include finishes, materials, and systems selected for low maintenance and low life cycle costs.
   4.2.13 Limited life structures. Limited life structures include both semi-permanent and temporary construction as defined below.

   4.2.13.1 Semi-permanent construction shall be designed and constructed to serve a life expectancy of more than 5 years but less than 25-years (generally a 15-year service life), shall be energy efficient, and shall include finishes, materials, and systems selected for a moderate degree of maintenance using the life-cycle approach.
   4.2.13.2 Temporary construction shall be designed and constructed to serve life expectancy of 5 years or less, shall use low cost...
construction, and systems selected with maintenance factors being a secondary consideration.

4.2.14 Temporary sheeting, shoring, and falsework supporting structures (not formwork) shall be designed for a minimum of 3 years design life. Temporary sheeting, shoring, and falsework that will be in use for 5 years or more shall be designed as a permanent structure.

5.0 STABILITY

5.1 The foundation must be capable of safely transferring all vertical and horizontal forces, due to specified design load combinations, to the supporting soil or rock. The mechanism used for the transmission of horizontal forces may be friction between the bottom of the footing and ground, friction between the floor slab and ground, and/or lateral resistance of soil against vertical surfaces of grade beams, basement walls, footings, piles, or pile caps. Net upward forces on footings and piles, which must be resisted to prevent overturning and/or flotation, shall be considered in the foundation design. Dead load should include the benefits of weight of the overlying fill in resisting sliding, overturning, and flotation.

5.2 Structures shall be designed to resist overturning effects caused by seismic and wind forces as well as other structure specific loads.

5.3 For load combinations other than earthquake when load combinations applicable to allowable stress design (ASCE/SEI 7, paragraph 2.4.1) are used for the foundation design, the structures shall have a minimum safety factor of 1.5 against sliding, and flotation and 2.0 (1.5 on rock) against overturning. For additional information, refer to Chapter 5 – Foundations and Chapter 15 – Earth Retaining Structures.

5.4 Unless noted otherwise, stability relates to sliding, overturning, buoyancy, and other sources of gross displacement and not to stability as related to buckling. Except for foundation elements, a structure or any of its elements shall be designed to provide a minimum safety factor of 2.0 against failure by sliding, overturning, or uplift. This required degree of stability shall be provided solely by the dead load plus any permanent anchorage.

6.0. CLEARANCES

6.1. Railroad, Rail Transit, and other Right-of-way:

6.1.1 All designs shall provide adequate and appropriate clearance for the passage of rail transit and railroad vehicles throughout the mainline trackage, switches and special trackwork, stations, storage yards and operations facilities. Clearances must be rigorously monitored during
both the design and construction phases. Design criteria for clearances are complex and are based on numerous assumptions and interfaces.

6.1.2 Existing clearances shall not be reduced.
6.1.3 Minimum design clearances are provided in Attachment 1.
6.1.4 Drawings for bridges, stations, and other ROW structures must clearly show all clearances.

6.2. Public Facilities:

6.2.1 Facilities shall be laid out to be user friendly and follow industry best practices.
6.2.2 Clearances associated with compliance with ADA design requirements shall be followed. These clearances are generally noted on architectural drawings.

7 DESIGN DETAILS

7.1 Proper drainage shall be provided including but not limited to the following conditions or locations:

7.1.1 All structural and walking surfaces exposed to weather or water shall be sloped to drain. Attention to and compliance with ADA requirements is required.
7.1.2 Intersecting surfaces forming valleys or pockets that may retain water shall be arranged to provide drainage.
7.1.3 Structural steel and wood members shall be designed so they will not retain moisture or, when in pairs or multiples, so water or moisture will not be held between members.
7.1.4 Structural items like expansion plates, rocker joints, and surfaces intended to permit movement shall be designed so they are protected against direct contact with water or condensation and shall be detailed to readily drain.
7.1.5 Surfaces and members shall be designed so water will drain from points where steel contacts or enters into masonry or concrete.
7.1.6 Surfaces shall be designed so water will drain away from structures including all entrances to buildings.
7.1.7 Design and layout of facilities shall account for snow removal.
7.1.8 Structural drawings must be coordinated with other disciplines. Drain lines and roof scuppers shall not be located over or adjacent to main structural members, critical equipment, or electrical panels.

7.2 All structures and in particular bridges, must be inspected periodically to ensure the integrity of the structure and its components. Septa's structural inspectors must be able to visually check all components of each structure at arm's length. Designs shall address a means of access to facilitate these inspections.
7.2.1 Designs should include a means of access to facilitate these inspections. Design bridges so they can be inspected easily. Make openings and accesses wide enough and place them logistically so inspectors can get into them. Generally, not less than 18 inches shall be provided between main load bearing members.

7.2.2 Joints shall be designed such that they can be easily accessed for maintenance and inspection.

7.2.3 List critical inspection items, such as fracture critical members on the plans. A database inventory of all fatigue-sensitive details and fracture critical members shall be provided to SEPTA for incorporation into SEPTA’s Structure Inspection Program and to advise structural inspectors.

7.2.4 Ensure that bridge components are accessible for inspection.

7.2.5 Provide access to the interiors of box girders for structural inspections. Painting the interior of box girders white or other light color makes inspection easier.

7.2.6 Bridge structures, towers, and similar structures shall be designed to include and/or accommodate fall protection devices.

7.3 The structure configuration and layout must meet project objectives. Items such as platform canopy framing shall have a height and extend so that they provide adequate protection from rain and snow.

7.4 The structural engineer shall be cognizant of the design and common industry installation methods of the other disciplines on a project and their affect on the structural elements, serviceability, and service life.

8 RAIL TRANSIT COLLISION WITH STRUCTURES

8.1 Unless otherwise protected by an embankment or barrier, bridge abutments and piers located within a distance of 25'-0" to the centerline of a rail transit track, shall be protected by a reinforced concrete crash wall designed per the requirements of AREMA.

8.2 Unless otherwise protected by an embankment or barrier, structures and buildings critical to septa operations or life safety related and located within a distance of 25'-0" to the centerline of a rail transit track shall be protected by a crash wall. The provisions of this section need not be considered for structures if they are protected by:

- An embankment
- A structurally independent, crashworthy ground mounted 6'-0" high barrier or wall, located within 10 feet from the component being protected,
• A 3'-6" high barrier located at more than 10 feet from the component being protected.

8.3 Where the rail transit vehicles are restrained with guardrails or direct fixation containment walls, any adjacent structures need not be designed for the collision force.
CHAPTER 3
DESIGN LOADS

1. INTRODUCTION

1.1. This Chapter provides minimum design loads noting SEPTA specific requirements. It is not intended to be all encompassing. Loadings not covered by this document shall be obtained from available technical literature, manufacturer's brochures, or shall be carefully formulated. In case of any conflict between this criteria, specified codes and standards, and available data, the most stringent data or practice shall be used.

1.2. All structures should be designed to sustain, within the permitted stress allowances and load factors, all applicable design loads and forces which are properly distributed. Standards to be used in the selection of design loads and method of distribution include the following:

1.2.1. The design standards in this document.
1.2.2. Commonwealth of Pennsylvania (PennDOT), Bridge Design Manual,
1.2.4. The American Railway Engineering Association (AREMA), Manual for Railway Engineering for railroad and light rail bridges and all other structures subjected to rail transit live loads.
1.2.5. The International Building Code (latest edition).
1.2.6. American Society of Civil Engineers (ASCE) ASCE/SEI 7, Minimum Design Loads for Buildings and Other Structures.
1.2.7. The City of Philadelphia Transit Design Manual Part IV – STRUCTURES for the Broad Street Subway including the Ridge Avenue Spur (BSS or Orange Line), the Market Frankford Subway Elevated (MFSE or Blue Line), and the Subway-Surface Trolley Lines (Green Line).
1.2.8. The governing code or specifications of the agency under whose jurisdiction the structure is to be constructed and maintained.

1.3. Attention shall be given to wind, seismic, dynamic, and fatigue loads particularly on cable or hanger rod supported structures, other similar force-oscillating structures, and cantilever and pole type structures.

1.4. Unless otherwise specifically addressed, classification of buildings and other structures for flood, snow, wind, seismic, and other loads shall be for Occupancy
Category II. Electrical substation structures, communication towers, emergency facilities, command centers, and other similar facilities shall be Category IV. Unmanned storage structures for non operational critical components and equipment can be considered Occupancy Category I.

2. DEAD LOAD

2.1. Dead load consists of the vertical earth loads and the weight of the complete structure, including permanent building partitions, fixed service equipment, the roadways, sidewalks, railings, car tracks, ballast, and utilities. In addition, the dead load for bridge structures should also include an anticipated future wearing surface in addition to any surface or deck seal placed on the structure initially or additional depth of ballast for rail transit structures.

2.2. The dead weight of fixed equipment shall be obtained from published sources, vendors, or SEPTA. In the absence of such information, the weight shall be conservatively determined.

2.3. The unit weight of materials used in computing the dead load are listed in AASHTO - Section 2, AREMA - Chapters 8 and 15, and ASCE/SEI 7.

2.4. For earth covers less than the width of structures, the vertical earth load is computed ordinarily as the weight of earth directly above the structure with the minimum unit weight of earth taken as 120 pcf (shallow earth cover). For greater earth cover, the structure is designed as a subsurface structure. For calculating pullout or uplift restraint, use a maximum unit weight of 110 pcf for earth unless site specific data is available from a geotechnical investigation.

2.5. For ballasted structures, design for an additional 65 psf dead load as an allowance for future increase in ballast depth.

2.6. Assumed weights or dead loads shall be indicated on the design documents.

3. LIVE LOAD

3.1. The live loads used in the design of buildings and other structures shall be the maximum loads expected by the intended use or occupancy but shall in no case be less than the minimum uniformly distributed or concentrated loads specified herein, in ASCE/SEI 7 - Minimum Design Loads for Buildings and Other Structures, and any other applicable standard or code.

3.2. For bridges and vehicle loads, see Section 8 in this chapter.
3.3. Parking Garage structures shall follow the recommendations set forth in PCI’s “Parking Structures: Recommended Practice for Design and Construction”.

3.4. General

3.4.1. Storage areas, mechanical and electrical rooms: 150 psf uniform and 300 lbs concentrated
3.4.2. Air Conditioning Equipment: 200 psf
3.4.3. Roof Live Load: 30 psf uniform
3.4.4. Ceiling and Roof Loads: Many buildings are subject to unanticipated additional ceiling-roof equipment loads. Give consideration to providing for a future 10-20 psf additional structural loading.
3.4.5. Partition Weights: Consider an allowance for the weights of partitions, where partitions are likely to be rearranged, added, or relocated:
   - For partition weights of 150 plf or less, an equivalent uniform dead load of 20 psf should be applied.
   - For partition weights above 150 plf, consider actual linear loads.
   - Partitions that are likely to be rearranged or relocated can be calculated as live loads for load factor design.
   - Lateral Loads on Partitions: Consider a minimum live load of 5 psf applied laterally for design of interior walls, permanent partitions, and temporary partitions that exceed 6 feet in height, except where earthquake or other lateral loads are greater.

3.5. Stations

3.5.1. Platforms
   - High Level: 150 psf uniform and 300 lbs concentrated
   - Low Level where vehicle access is not possible: 150 psf uniform and 300 lbs concentrated
   - Low Level and at grade: 250 psf uniform and 8,000 lbs concentrated
3.5.2. Stairs and ramps: 150 psf uniform and 300 lbs concentrated
3.5.3. At grade plazas and sidewalks: 250 psf uniform and 8,000 lbs concentrated
3.5.4. Railings
   - High Level - CTD: 150 plf horizontal, 100 plf vertical
   - High Level - STD and RRD 100 plf applied in any direction at any location;
   - Low Level, stairs, ramps: 50 plf and concentrated load of 300 lbs
   - Loads shall be applied in any direction at any location.

3.6. Design shall consider loads due to piping, cable and conduit, and other loads in addition to roof and live loads.

3.7. In the absence of firm information on concentrated loads to be carried by roof trusses, trusses for shops, repair facilities, equipment buildings, and similar use
buildings shall be designed to carry the equivalent of a concentrated load of 3 kips applied at center span.

3.8. Floors shall be designed for truck and/or forklift loads where they may be used. For hand trucks, use 15% for impact. For motor driven trucks, use 25% impact.

3.9. Walls and columns adjacent to driving surfaces and not otherwise protected, shall be designed for vehicle impact up to a height of 3'-0" above finished floor (AFF).

3.10. **Live-Load Reduction:** Columns supporting a building roof level shall not be subjected to live-load reduction. For new construction, the designer may apply the International Building Code for live-load reduction, or the current model building code for the area, whichever contains the more stringent requirements. For the structural design evaluation of sound existing buildings for renovation and re-use, the designer may use the allowable live-load reduction allowed by the building code of the year during which the building was originally constructed, unless engineering judgment views the live-load reductions as being too liberal.

4. **WIND LOADS**

4.1. Determination of wind loads on structures other than railroad catenary structures shall be in accordance with *ASCE/SEI 7, Minimum Design Loads for Buildings and Other Structures*, Chapter 6.0. Based upon Figures 6-1 and 6-1c, the basic wind speed (3 second gust) for SEPTA’s operating territory is 90 mph except as noted below:

   - R3 West Trenton Line Neshaminy Falls to Langhorne 91 mph
   - R3 West Trenton Line Langhorne to West Trenton 92 mph
   - R7 Trenton Wissinoming to Torresdale 91 mph
   - R7 Trenton Torresdale to Eddington 92 mph
   - R7 Trenton Eddington to Croydon 93 mph
   - R7 Trenton Croydon to Levittown 94 mph
   - R7 Trenton Levittown to Trenton 95 mph

4.2. Exposure Category B shall be used except for high and exposed areas where Category C may be required. Importance Category II shall be used in most cases except where a higher category is required for structures such as for electrical substations structures, communication towers, emergency facilities, and other facilities listed in Table 1-1 of ASCE/SEI 7.

4.3. **Wind speed conversion:** When referenced documents are based on fastest mile wind speeds, the three-second gust wind velocities noted in ASCE/SEI 7 and IBC shall be converted to fastest mile wind velocities using Table 3-1.
4.4. The maximum net inward and outward loads used in the design shall be indicated on the drawings. The engineer is responsible for calculating the wind loads based on the applicable criteria and project specific requirements. However, in calculating component and cladding loading, the smallest acceptable internal pressure coefficient shall be as defined in ASCE/SEI 7.

<table>
<thead>
<tr>
<th>TABLE 3-1</th>
<th>EQUIVALENT BASIC WIND SPEEDS</th>
</tr>
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<tbody>
<tr>
<td>3 second</td>
<td>85  90  95  100  105  110  120  125  140  145  150</td>
</tr>
<tr>
<td>gust</td>
<td></td>
</tr>
<tr>
<td>Fastest</td>
<td>70  75  80  85  90  100  105  110  120  125  130</td>
</tr>
<tr>
<td>mile</td>
<td></td>
</tr>
</tbody>
</table>

4.5. Wind Loads on Building Additions: Consider building additions to be designed as parts of a totally new building without regard to shielding from the original building and without regard to lesser wind resistance for which the original building may have been designed. The original portion of the building may require strengthening due to an increase in the wind loads.

4.6. New antenna towers and antenna supporting structures shall be designed for fastest mile wind speed of 80 mph. Analysis of existing structures designed and installed prior to 2005, shall be based fastest mile wind speed of not less than 75 mph. Refer to Chapter 17 for additional information and requirements.

4.7. Railroad catenary structures shall be designed for wind loads per AREMA, Manual for Railway Engineering, Chapter 33 Section 4.2. Wind Speeds shall be as follows:

4.7.1. Operating Wind Speed: 60 mph This value should be used to compute catenary support and wire deflections for the interface with the vehicle/pantograph system.
4.7.2. Design Wind Speed: 80 mph This value is used to determine the strength requirements of the catenary structural support system without ice loading.
4.7.3. Wind Speed with Icing: 40 mph

5. RAIN, SNOW, AND ICE LOADS

5.1. Determination of snow loads on structures shall be in accordance with ASCE/SEI 7, Minimum Design Loads for Buildings and Other Structures, Chapter 7.0 and the International Building Code. The effects of sliding and drifting snow shall be incorporated in the design.
5.2. The Ground Snow Load $p_g$ for SEPTA’s operating territory is noted in Table 3-2.

5.3. Ice loads shall be considered in the design of antennae structures, transmission line structures, catenary structures, and similar structures and where required by codes or standards.

5.3.1. The density of ice shall be considered to be 56 pcf (minimum).
5.3.2. For ice and wind load combinations, use the following:
   5.3.2.1. ½ inch radial ice load and basic wind speed of 90 mph
   5.3.2.2. 1 inch radial ice load and basic wind speed of 50 mph
   5.3.2.3. For railroad catenary structures, Refer to AREMA Chapter 33 and Chapter 14 of this document.

5.4. Rain on snow loads shall be considered for flat roofs per ASCE/SEI 7.

5.5. Rain and ponding loads on roofs shall be determined and applied in accordance with ASCE/SEI 7.

5.6. When the design roof snow or snow plus rain-on-snow loading is less than 30 pounds per square foot, a roof live loading for construction and maintenance of 30 pounds per square foot shall be used for design of the structure. The minimum roof live load of 30 psf is used in lieu of and not in addition to the snow or rain plus snow loading.

<table>
<thead>
<tr>
<th>TABLE 3-2</th>
<th>GROUND SNOW LOAD $p_g$ FOR SEPTA’S OPERATING TERRITORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>County</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>Bucks</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>Chester</td>
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<td>Pennsylvania</td>
<td>Philadelphia</td>
</tr>
<tr>
<td>New Jersey</td>
<td>All</td>
</tr>
<tr>
<td>Delaware</td>
<td>All</td>
</tr>
</tbody>
</table>

6. SEISMIC

6.1. The seismic analysis and design procedures to be used in the design of buildings and other structures and their components shall be as prescribed in this section.

6.2. The structure shall include complete lateral and vertical force-resisting systems capable of providing adequate strength, stiffness, and energy dissipation capacity to withstand the design ground motions within the prescribed limits of deformation.
and strength demand. The design ground motions shall be assumed to occur along any direction of the structure. Individual members shall be provided with adequate strength to resist the shears, axial forces, and moments. Connections shall develop the strength of the connected members or the forces calculated. The deformation of the structure shall not exceed the prescribed limits.

6.3. A continuous uninterrupted load path, or paths, with adequate strength and stiffness shall be provided to transfer all forces from the point of application to the final point of resistance. The foundation shall be designed to accommodate the forces developed or the movements imparted to the structure by the design ground motions. In the determination of the foundation design criteria, special recognition shall be given to the dynamic nature of the forces, the expected ground motions, and the design basis for strength and energy dissipation capacity of the structure.

6.4. Applicable Codes, Standards, and References

6.4.1. Railroad and light rail bridges shall be designed per AREMA.

6.4.2. Highway and roadway bridges and rail transit elevated (not railroad or light rail) and associated structures shall be designed per AASHTO.

6.4.3. Buildings and other structures shall, as a minimum, be designed in accordance with the applicable provisions of the IBC and ASCE/SEI 7 as supplemented by FEMA 368 “NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures”. Where the FEMA recommended criteria are different from those of the IBC, it is intended that the FEMA recommendations take precedence.

6.4.4. The AISC Seismic Provisions provide design requirements for steel moment-frame structures. FEMA addresses the AISC Seismic Provisions by reference as the design provisions for seismic-force-resisting systems of structural steel. The International Building Code is based generally on the FEMA provisions, and incorporates design requirements for steel structures primarily based on the AISC Provisions.

6.4.5. FEMA 350, “Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings” focuses on design and construction standards for new steel structures. The recommendations address the type of steel used, the way that columns and beams are connected, the way the steel is fabricated, the type of welding that is performed and techniques that are used to assure that the work is performed properly. Based on FEMA recommendations, these guidelines should be followed as appropriate when developing new structures for SEPTA facilities. When the revised AISC seismic manual and prequalified connections standards (based upon
the 2002 AISC Seismic provisions) are released, these provisions may be utilized in lieu of FEMA 350.

6.4.6. For projects rehabilitating existing buildings and facilities, follow SEI/ASCE 31, “Seismic Evaluation of Existing Buildings”. Existing Critical and Essential Facilities (Importance or Occupancy Category III or IV) should be evaluated using the procedures in SEI/ASCE 31 for the Immediate Occupancy Performance Level. Other existing buildings and facilities should be evaluated using the procedures in SEI/ASCE 31 for the Life Safety Performance Level.

6.5. Use Table 5.2.2 from FEMA 368 for design coefficients and factors for basic seismic force resisting systems. For the spectral response coefficients, the zip code for the project location along with the USGS Zip Code earthquake ground motion hazard look-up page (which can be found on the internet world wide web address http://earthquake.usgs.gov/hazmaps/) can be used.

6.6. The minimum requirements for structures within the City of Philadelphia are as follows:

- The short period spectral response acceleration (SS) shall be 0.32 (32%g) and the 1-second spectral response acceleration (S1) shall be 0.082 (8.2%g).
- The site coefficient (Fa) for Site Class D shall have a value of 1.54.
- The determination of Seismic Design Category for Site Class D shall be based on SDS = 0.327 and SD1 = 0.131.

7. HYDRAULIC DESIGN CRITERIA

7.1. Stormwater design flows shall be determined using methods specified by the technical criteria of the jurisdictional agency and the requirements of SEPTA’s Civil and Track Engineering group.

7.2. A complete hydrology study should be performed when additional drainage is added to the SEPTA’s right of way, or a drainage structure is being added, removed, or its size changed. The hydrology study must include, but not limited to:

- Top of rail elevation.
- The 50-year and 100-year water surface elevations for both the existing and proposed conditions.
- Flow rates for both events.
- Location map of drainage area including railroad mileposts and engineering stations.
7.3. Preliminary and final drawings must note the hydraulic and hydrologic design data for 50-year and 100-year frequencies including drainage area, design discharge, design water surface elevation, and energy line elevation.

7.4. Bridge and culvert replacement projects should not increase water surface elevations for the 100-year flood event and there should be no significant reduction in existing waterway openings.

7.5. Bridge and culvert maintenance or replacement projects over waterways of the Commonwealth of Pennsylvania shall be designed and constructed in accordance with the criteria of PA DEP that includes:

7.5.1. The structure shall pass flood flows without loss of stability.
7.5.2. The structure may not create or constitute a hazard to life or property, or both.
7.5.3. The structure may not materially alter the natural regimen of the stream.
7.5.4. The structure may not increase velocity or direct flow in a manner which results in accelerated erosion of stream beds and banks.
7.5.5. Where required by the PA DEP, bridges and culverts with paved bottoms shall provide for fish passage by constructing a low flow channel.

7.6. Unless otherwise specified, the following criteria shall be used to determine the minimum adequacy of the sizing of existing bridge and culvert structures:

7.6.1. The 50-year flood elevation should not come into contact with the crown of the culvert or the low chord of the bridge, whichever is applicable.
7.6.2. The 100-year flood elevation should not exceed the track subgrade elevation at the structure.
7.6.3. SEPTA’s criteria along with the local jurisdiction’s and the State’s criteria shall be evaluated, and the more restrictive shall be utilized.
7.6.4. If the existing structure opening satisfies the foregoing criteria, a smaller section which satisfies the criteria set forth above may be recommended.

7.7. Multi-culvert groups and multiple span bridges which may tend to collect debris, contribute to the formation of ice jams, and cause excessive increases in head losses shall be avoided to the maximum extent practicable. Spans of less than 15 feet shall be by single-opening structure, except where conditions make it impractical to design the crossing with a single span.

7.8. Bridge Piers and Abutments
7.8.1. Bridge piers shall be kept to a minimum in number and cross-sectional area and shall be designed to offer the least obstruction to the passage of water and ice, consistent with safety and current engineering practice.

7.8.2. Bridge piers in channels subject to unstable or super critical flow shall require special investigation and shall be so designed as to minimize backwater and avoid standing waves downstream of the pier.

7.8.3. Bridge abutments shall be aligned with the flow of the stream for the design flood. The PADEP may require the construction of wing walls on either side of the bridge to assist in directing flood flows.

7.8.4. The pier width used for the hydraulic design of the open channel shall account for debris.

7.9. Culverts.

7.9.1. Culverts shall be aligned with the stream flow.
7.9.2. Culverts shall be of sufficient width to minimize narrowing of the stream channel.
7.9.3. The ends of culverts shall be protected by wing walls, or with other structures sufficient to assist in directing flood flows to and through the culvert opening.
7.9.4. The bottom of culverts for steams shall be depressed to accommodate fish passage.

8. BRIDGES AND BRIDGE LIKE STRUCTURES

8.1. Live load consists of the applied moving load of vehicles, cars, trains, pedestrians, etc.

8.2. Highway Live Load: The highway live loading and its application on the roadway of bridges or incidental structures is specified by PennDOT and AASHTO. The AASHTO HS25 and HS20-44 loadings are the minimum loading for SEPTA roadways and highway structures. Highway structures carrying tracks for trolley or light rail vehicles must account for the current revenue vehicles plus a 10% increase allowance for future vehicles not yet in service (or possibly even in design). The design shall also incorporate all maintenance and work vehicles including any temporary support and shoring for in service structures.

8.3. Railroad Transit Live Load: Railroad live loads should be Cooper E-loading as recommended in the AREMA Manual, Chapters 8 and 15. All SEPTA Regional Rail structures shall be designed for a Cooper E80 normal loading. Light Rail structures shall be designed for a Cooper E65 normal loading. The BSS and MFSE system shall account for current revenue vehicles plus a 10% increase allowance for future vehicles not yet in service (or possibly even in design). The design of structures for the BSS and MFSE system shall also incorporate all...
maintenance and work vehicles including any temporary support and shoring for in service structures.

8.3.1. Many of SEPTA's rail lines are also open for or available for use for freight operations. Whether or not there are current freight operations on the line, designs shall account for these loads.

8.3.2. While current SEPTA timetables may have speed restrictions for segments of a line or for bridges, these restrictions should not be used as the basis for design and analysis.

8.4. Bridge designs must allow for movements due to temperature. Both steel and concrete structures expand and contract because of temperature changes, but the rate of change for massive concrete members or structures is slower than for steel. Use a temperature range of -10°F and 110°F for steel bridges, and 0°F and 100°F for concrete bridges.

8.5. Miscellaneous Loads: The following are design loads to be used for frequently encountered miscellaneous structures or their elements. These minimum loadings should be increased if higher loads are anticipated.

8.5.1. The design live loads for sidewalks, curbs, and railing (traffic and pedestrian) are specified in AASHTO. The design uniform continuous live loading to be applied to the top railing is 50 plf. In addition, all balusters, pickets, intermediate rails and other railing elements should be designed to resist that uniform load or a 200 pounds concentrated load applied at any location. These loadings are not cumulative. Member deflections should be limited to 0.5% of the span.

8.5.2. Railroad Bridge walkways shall be designed per AREMA but for not less than 85 psf.

8.5.3. Provide for utility loads, signs, and other miscellaneous attachments to bridges.

8.5.4. Bridges over SEPTA tracks shall be provided with a protective barrier.

8.6. Pedestrian Bridges: The design live loading for pedestrian bridges is as specified in AASHTO Guide Specifications for Design of Pedestrian Bridges except that the bridge should be designed using one of the following live loads, whichever produces higher stress in the members:

8.6.1. A minimum live load of 85 psf shall be used except where designated as a means of egress in which case the live load shall not be less than 100 psf.

8.6.2. A light sidewalk sweeper or bobcat loader (snow removal) where access to the bridge is available. Design for the actual weight of the sweeper or bobcat if available, but not less than a total weight of 4,000 pounds (H5) distributed as four concentrated wheel loads.
8.6.3. Ramps where required, shall be designed to accommodate people who are disabled. Grades shall be no steeper than 1:12 (1:13 recommended) with level landings spaced at not more than 30 ft. in compliance with ADA requirements.

8.6.4. Vertical and horizontal clearances over roadways should be greater than for highway bridges in recognition of the probability of severe damage from vehicle impact. The recommended minimum vertical clearance over highway, driveway, roadway traffic, or public right-of-way is 17'-6" but shall not be less than 15'-0". The minimum vertical clearance over railroads is 24'-6" in electrified territory and 23'-0" in non-electrified and 3rd rail territory.

8.6.5. Chain-link enclosure should be considered to discourage foreign objects being dropped onto the highway or railroad. Enclosures should have rounded tops for aesthetics except that if any part is horizontally curved, the enclosure can be flat-topped to avoid severe construction difficulties. Solid side panels (protective barrier) shall be provided where directly over rail tracks.

8.6.6. For flexible structures, dynamic response and side sway due to loading and likely to cause pedestrian discomfort shall be considered.

8.6.7. Decks should not be constructed to a level gradeline. A minimum grade of 1 percent is recommended as a straight grade or ending tangent to a vertical curve. Calculated sag should be compensated by extra vertical curve or slope.

8.6.8. The use of pre-engineered/pre-fabricated pedestrian steel truss bridges is acceptable. The minimum thickness of metal shall be 1/4 inch.

9. THERMAL

9.1. Provisions shall be made for movements and stresses resulting from temperature variations. For exterior applications, the temperature range shall be between -10°F and 110°F for steel structures and 0°F and 100°F for concrete structures. For interior members in conditioned spaces and not in contact with earth, a normal temperature of 68°F with a variance of ±20°F can be assumed. Temperature gradients across the thickness of interior walls and members can normally be neglected. The temperature at the time of construction or installation must be taken into account.

9.2. Provisions shall be made for forces due to temperature from continuous welded rail (CWR) through direct fixation fasteners. The rail shall be assumed to be installed at a mean temperature of 60°F with a temperature range of -10°F to 130°F. Additionally, the design shall consider the effects of thermal loads of installed guard angles.
10. FLOOD

10.1. Local flooding may add load to subaqueous structures and structures located in a flood plain. Design of these structures shall make allowance for this loading as required by the particular type of structure and the conditions affecting each location. Flood levels for design shall be based upon a 100-year storm event.

11. HYDROSTATIC AND BOUYANCY

11.1. The effects of hydrostatic pressure and buoyancy shall be considered whenever the presence of ground water is indicated. The possibility of future major changes in groundwater elevations shall be considered. During construction and backfilling operations, the elevation of groundwater shall be observed and controlled so that the calculated total weight of the structure and backfill shall always exceed the calculated uplift due to buoyancy by 10%. The design shall take into account the effects of hydrostatic pressures pertaining to construction sequence.

12. CONSTRUCTION LOADS

12.1. Structures should be checked for loads sustained during construction. Allowable stresses for temporary construction loads may be increased as permitted by codes. Refer to SEI/ASCE 37, Design Loads on Structures During Construction, for the minimum design load requirements during construction for buildings and other structures as well as for partially completed structures and temporary structures used during construction. For shoring and falsework, see Chapter 13.

12.2. Steel column base plates and anchor rods shall be designed for a 300 lb load located 18" off the face of the column at the top of the column, acting in any direction.

13. HORIZONTAL EARTH PRESSURES

13.1. Structures which retain earth shall be designed for side pressures due to earth abutting against the structures and load surcharges resting on the abutting earth. Allowances shall be made for both dry and submerged earth pressures and for hydrostatic pressure. Consideration shall be given to multi-layer effects where substantial differences in soil properties occur over the depth of underground structures. The effects of construction procedures on the development of lateral pressures shall be considered.

13.2. Live and dead loads from adjacent structures shall be considered in computing horizontal pressures.
13.3. The rock pressures to be used in design shall be established by the engineer in consultation with the geotechnical engineer.

13.4. Refer to Chapter 5 – Foundations (Section 3) and Chapter 15 – Earth Retaining Structures for additional information.

14. CRANE AND HOIST LOADS

14.1. The design of supports for electrically driven permanently installed cranes and hoists shall use the impact percentages, horizontal force percentages, and fatigue requirements in the Manual of Steel Construction (AISC publication, current edition).

14.2. Vertical deflection of crane runway girders shall be limited as set forth in Crane Manufacturer’s Association of America (CMAA) 70 and 74. Horizontal deflection shall be checked to assure compatibility with clearance between flanges of double-flanged wheels and bearing area of single-flanged wheels.

14.3. Crane Runways and Supports.

14.3.1. Stops and Bumpers. Stops refer to rigid assemblies installed at the ends of crane runways to prevent traveling cranes from running beyond the ends of the runway. Bumpers refer to those devices (usually fitted onto the crane) which are resilient or other energy absorbing construction designed to limit the deceleration force resulting from the crane’s hitting the runway stops. Stops engaging the thread of the wheel shall not be less than the radius of the wheel. Stops engaging other parts of the crane are recommended. Requirements for the design of crane stops are controlled largely by the design of the crane bumpers.

14.3.2. Crane bumpers be designed in accordance with requirements of the Occupational Safety and Health Act (OSHA 49CFR1910.179).

14.3.3. Bumpers shall be capable of stopping the crane (not including lifted load) at an average deceleration of no more than 3 feet per second per second with the crane traveling at 20 percent of rated speed.
14.3.4. Bumpers shall, at a minimum, have sufficient energy absorbing capacity to stop the crane when its traveling at 40 percent of rated speed. The forces to be resisted by the stops shall either be indicated by the crane manufacturer or determined as set forth in Whiting Corporation Overhead Crane Handbook.

14.4. For electrically driven cranes, a design check shall be made assuming the live loading on the crane is 2.75 times the rated loading. For this loading case, the allowable material may be 90% of the yield stresses. In lieu of this design check, an electric limit switch may be used.

14.5. Crane, monorail, and other hoist support structures shall be designed for 1.5 times the rated loading to account for load testing of the crane/hoist.

15. BOX CULVERT DESIGN RECOMMENDATIONS

15.1. AREMA contains the required design method for culverts under railroads. Live load is applied to the culvert regardless of depth of fill. The minimum slab and wall thickness is 10 inches with 2 inches of cover over the reinforcement. Four percent minimum longitudinal reinforcement is required. Refer to Section 8 – Bridges, in this Chapter for live loads.

15.2. PennDOT box culvert standard detail sheets can be used where not subjected to rail transit live load applications and can significantly reduce the need for special designs for culverts and end treatments where applicable. However, if a special design is warranted, some minimum design parameters are as follows:

15.2.1. Vertical earth pressure 120 pcf
15.2.2. Lateral earth pressure 40 pcf
15.2.3. Live load is a 16 kip wheel with impact per AASHTO as applicable.
15.2.4. Distribution of a wheel is a square of 1.7 x fill depth for fills greater than 2 ft.
15.2.5. For fill heights less than 2 ft., load is considered a point load. Distribution and design per AASHTO slab design requirements.
15.2.6. Two feet of surcharge and full lateral pressure used for corner moments.
15.2.7. Half lateral pressure used for positive moments.
15.2.8. Spans loaded according to influence lines for moments.
15.2.9. Slab thickness based on allowable shear.

16. ROADWAY LOADING

16.1. Roadway live loads on pavements and underground structures other than box culverts, which are addressed above, shall be based on a minimum of HS20-44
and HS25 loadings per AASHTO Specifications and PennDOT requirements. Superimposed wheel loads from this loading shall be distributed in accordance with AASHTO to a maximum depth of four feet. At depths between 4 and 8 feet, a graduated live load of 440 psf to 300 psf shall be used. Below 8 feet, a uniform live load of 300 psf shall be used. The depth used in the live load calculations shall be measured to the top of the underground structure’s roof slab.

16.2. All manhole covers, catch basin openings, utility vault access doors, vent grating, emergency exit hatches, and other castings located in sidewalks, parking lots, roadways, or otherwise subjected to possible vehicle loading shall be rated for highway use (HS20-44/HS25) loading.

16.3. All underground structures having less than 8 feet of cover shall be designed for two conditions. The more severe of these two conditions shall govern.

16.3.1. The actual depth of cover plus superimposed HS20-44 wheel load distributed in accordance with AASHTO and PennDOT.
16.3.2. An assumed future cover of 8 feet plus a uniform live load of 300 psf.

17. ELECTRICAL AND COMMUNICATION SYSTEM STRUCTURES

17.1. Electrical and communication system structures not addressed by AREMA, shall be designed in accordance with industry standards. In all cases, the Institute of Electrical and Electronics Engineers (IEEE) and National Electric Safety Code (NESC) shall be considered as establishing minimum requirements for design of structures associated with electric power systems.

17.2. Transmission towers and poles: Design methods and stresses shall be as appropriate for the power transmission towers and pole structures and shall be designed in accordance with the following:

- ASCE 10 - Design of Latticed Steel Transmission Structures
- ASCE Manual 72 - Design of Steel Transmission Pole Structures,
- NESC - National Electric Safety Code

17.3. Substation structures and equipment: Substation, switching station, and similar structures for supporting electrical equipment shall be constructed, where possible, of manufacturer’s standard unit components. All structures, however, must be strong enough to resist the climatic and design load requirements for the site and in accordance with AREMA and/or paragraph 17.2 above as applicable.

17.4. Steel Antenna Towers and Antenna Supporting Structures: The design, fabrication and erection of structural steel antenna support towers and structures
shall be per the requirements of ANSI/TIA/EIA –222-F-1996 (or latest). Refer to Chapter 17 for additional requirements.

17.5. Railroad and light rail catenary support structures shall be designed per Chapter 14.

17.6. Structures shall be designed to accommodate grounding per NESC, local utility standards, and SEPTA standard practices.

18. MECHANICAL SYSTEM STRUCTURES AND SUPPORTS

18.1. Design of support features for mechanical systems such as heating, plumbing, fire protection, ventilating, and air-conditioning (HVAC) systems (including items such as foundations, support frames, braces, and other items) shall be in accordance with current practice, sound engineering principles, and manufacturer’s recommendations as appropriate.

18.2. The requirements set forth in SEPTA’s mechanical and plumbing design criteria and guideline documents shall be addressed.

18.3. The Engineer shall address the anchorage of mechanical and electrical equipment and devices to structures with particular attention to wind and seismic loads and the affect on the structure of the attachment method.

18.4. **Equipment Support Resonance**: Equipment supports are designed to avoid resonance resulting from the harmony between the natural frequency of the structure and the operating frequency of reciprocating or rotating equipment supported on the structure. Resonance effects may be minimized by designing equipment isolation supports to reduce the dynamic transmission of the applied load to as low a level as can be economically achieved.

18.5. **Hanging Loads**: Loads exceeding 50 lbs shall not be suspended from metal decking. All ductwork, piping, and so on should be suspended directly from the structural steel framing, supplementary steel members, or reinforced concrete deck. Loads suspended from steel joists shall be suspended from the top chords unless structural analysis is furnished that allows otherwise.

18.5.1. For new concrete construction, cast-in inserts should be considered for hanging items in mechanical rooms, attaching overhead lights and equipment, or hanging any heavy loads.

18.5.2. For existing construction, expansion anchors shall not be used to carry significant load in tension, except with written approval of a Registered Professional Engineer for the specific use requested and the anchors conform to the design requirements of ACI318 Appendix D. Install
18.6. Equipment supports and enclosures:

18.6.1. Static: Design of supports and enclosures for static equipment shall consider the maximum weight and eccentricity of the equipment as well as the required clearance for access to and maintenance of the equipment. Lateral supports and bracing shall be provided as necessary to maintain the stability of the equipment under lateral loading, particularly seismic.

18.6.2. Rotating or vibrating: Design of supports and enclosures for vibrating or rotating machinery shall consider the need for isolation pads, isolation joints, and damping devices either alone or in combination. Care shall be taken to assure that the natural frequency of supports is sufficiently offset from the operating frequency of the equipment so that there is no danger of objectionable deformation or damage.

18.6.3. Forces due to starting or operating torque shall be considered where applicable.

18.6.4. Provide concrete housekeeping pads under floor mounted equipment.

18.6.5. For foundations, see Chapter 5, Section 9 for additional requirements.

18.7. Pipe supports

18.7.1. Pipe supports shall be designed to resist the various forces to which the piping system will be subjected.

18.7.2. As a minimum, all pipe supports shall be designed to carry the weight of the piping system plus water to account for hydrostatic testing. Other forces including those due to wind, snow, seismic activity, thermal expansion and contraction, thrust, impact, etc., shall be considered as appropriate for the details of the system and materials being used.

18.7.3. For systems conveying materials at temperatures other than ambient, consideration shall be given to the effect of thermal expansion and contraction on the support system.

18.7.4. Where possible, the flexibility of the support structure should be considered to avoid the need for slide bearings or similar construction. In any case, appropriate allowance shall be made for movement and restraint to conform with the assumptions made in the pipe system flexibility analysis. Particular attention shall be given to assure that sufficient lateral support is provided for seismic activity.

18.7.5. Hangers located off center of beams shall be avoided. If this cannot be avoided, then the beams shall be designed for torsion.
19. LOAD COMBINATIONS

19.1. Except as otherwise required by the applicable design codes as cited in Paragraph 1.2 of this Chapter and elsewhere in this document, combinations of loads for buildings and miscellaneous structures shall be per the provisions of the IBC and ASCE/SEI 7. AREMA and AASHTO shall govern as applicable.

19.2. Structures are proportioned for the following loads and forces when they exist:

19.2.1. Dead Load of structure including superimposed loadings.
19.2.2. Live Load including applicable overloads.
19.2.3. Impact or dynamic effect of the live load.
19.2.4. Snow Loads
19.2.5. Wind Loads
19.2.6. Seismic forces
19.2.7. Earth pressures
19.2.8. Thermal forces
19.2.9. Other forces including longitudinal forces, centrifugal forces, buoyancy, shrinkage stresses, ice, rib shortening, rail loads, erection stresses, water pressure, construction loads, etc.

19.3. Both wind and seismic loading for components and cladding must be investigated to determine controlling forces regardless of controlling loads on the main force resisting system.

19.4. If wind loading on the main lateral force resisting system and/or the components and cladding members are greater than seismic loadings and thus are the controlling forces that are used for structural design, the structural seismic detailing requirements noted elsewhere should also be used.

19.5. The one-third (1/3) increase in allowable stress for load combinations that include wind are not permitted unless otherwise noted.
CHAPTER 4
BASIC STRUCTURAL SYSTEMS FOR BUILDINGS

1. SELECTION OF STRUCTURAL SYSTEM.

The goals in the selection of a load resisting system are simplicity in the structural framing layout and symmetry in the structural system reaction to design loadings. The selections must consider the need for economy, function, maintenance, and reliability. Structural systems selected must have deformation characteristics that are compatible with the architectural and other nonstructural building elements and features. Regular structure configuration, continuous and redundant load paths, and system ductility are attributes encouraged.

2. COMMONLY USED STRUCTURAL SYSTEMS (Adapted from FEMA).

The following is a list of building systems commonly found in existing building construction. These systems are provided for informational purposes with the understanding that not all the systems listed in this paragraph are recommended for use in new building construction.

2.1. Building Type 1 - Wood, Light Frame. The essential structural character of this type is repetitive framing by wood joists on wood or metal studs. Loads are light and spans are small. Some of these buildings are engineered: however, most are not, but are constructed in accordance with the International Building Code prescriptive requirements. Shear walls are exterior walls sheathed with plank siding, stucco, plywood, gypsum board, particleboard, or fiberboard. Interior partitions are typically sheathed with gypsum board. This type of construction has limited use for permanent construction of SEPTA facilities, and is generally only for selected small railroad station buildings.

2.2. Building Type 2 - Wood, Commercial and Industrial. Commercial and industrial wood buildings with few, if any, interior walls. The essential structural character is framing by beams on columns. The beams may be glulam beams, steel beams, or trusses. Lateral forces are resisted by wood, or metal diaphragms, and exterior walls sheathed with plywood, or particle board. The walls may have rod or metal strap bracing. Large openings often require post-and-beam framing. Lateral force resistance on walls with large openings can be achieved with steel frames or diagonal bracing. This type of construction is not recommended for SEPTA facilities.
2.3. Building Type 3 - Steel Moment Frame. These buildings have frames of steel columns and beams. The beam-column connections are usually fully developed as a moment connection to resist lateral forces. Lateral loads are transferred by diaphragms to the moment resisting frames. The diaphragms can be steel decking, reinforced concrete, or a composite of steel decking with a concrete topping slab. The frames develop their stiffness by full or partial moment connections. The frames can be located almost anywhere in the building. Usually the columns have their strong directions orientated so that some columns act primarily in one orthogonal direction while others act in the other orthogonal direction, and the frames consist of lines of strong columns and their intervening beams. Steel moment frame buildings are typically more flexible than shear wall buildings, and their design is often controlled by drift limitations.

2.4. Building Type 4 - Steel Braced Frame. Steel braced frame buildings are similar in construction to steel moment frame buildings except lateral resistance is provided by bracing rather than beam to column moment connections.

2.5. Building Type 5 - Steel Light Frame. Steel light frame buildings are typically pre-engineered and prefabricated with rigid frames in the transverse orthogonal direction. The roofs and walls usually consist of lightweight metal panels. The frames are often designed for maximum efficiency, often with tapered beam and column sections built up of light plates. The frames are built in segments and assembled in the field with bolted joints. Lateral loads in the transverse direction are resisted by the rigid frames with loads distributed to them by the roof and wall panels. Lateral loads in the longitudinal direction are resisted by steel strap or rod bracing, or by shear panels located in the roof and walls. Refer to Chapter 10 for additional information.

2.6. Building Type 6 - Steel Frame with Concrete Shear Walls. These buildings are of typical steel frame construction with lateral loads resisted by cast-in-place reinforced concrete shear walls. The steel frame is designed for vertical loads only. The shear walls may also serve as bearing walls carrying vertical loads that would otherwise be carried by steel columns. The steel frames may provide a secondary lateral force resisting system if the steel columns and beams are rigidly connected as in Building Type 3. This combined system is termed a "dual" system in which the steel moment frames are designed to work together with the concrete shear walls with load sharing dependent on the stiffness of the two systems. In this case, the walls would be evaluated as concrete shear walls, and the frames would be evaluated as steel moment frames.

2.7. Building Type 7 - Steel Frame with Infill Shear Walls. In this older type of construction, some of which still remains, solidly infilled masonry panels act as a diagonal strut between moment frames. This type of construction is not recommended, because if the infill walls do not fully engage the frame members (i.e., lie in the same plane), diagonal compression strut action will not develop.
2.8. Building Type 8 - Concrete Moment Frame. These buildings are similar to steel moment frame buildings except the frames are of reinforced concrete construction. In high seismic areas the concrete frames have large quantities of longitudinal and transverse reinforcing steel, with closely spaced transverse steel (spiral reinforcement and stirrups) required to confine the concrete and produce a ductile response to earthquake ground motion.

2.9. Building Type 9 - Concrete Shear Walls. The vertical components of the lateral-force resisting system in these buildings are concrete shear walls that are usually bearing walls. Buildings in which the shear wall area is relatively large with respect to the floor area, there often is no need to provide boundary elements to handle the large compressive strains that can occur in the wall extremities. Buildings with limited shear wall area will require shear wall boundary elements in accordance with ACI 318.

2.10. Building Type 10 - Concrete Frame with Infill Shear Walls. These buildings are similar to Type 7 buildings except that the frame is of reinforced concrete.

2.11. Building Type 11 - Precast/Tilt-Up Concrete Walls with Lightweight Flexible Diaphragm. These buildings often have a metal deck or wood roof diaphragms that distributes lateral forces to precast concrete shear walls. The connections between the diaphragms and walls and between precast concrete wall elements are extremely important. Tilt-up buildings often are more than one story.

2.12. Building Type 12 - Precast Concrete Frames with Concrete Shear Walls. These buildings typically have floor and roof diaphragms composed of precast concrete elements with or without cast-in-place concrete topping slabs. In high seismic regions, cast-in-place concrete topping slabs are generally used unless diaphragm spans are very small. Precast concrete girders and columns support the diaphragms. The girders often bear on column corbels. Closure strips between precast floor elements and beam column joints usually are cast-in-place concrete. Welded steel inserts often are used to interconnect precast elements. The capacity of these type buildings to resist lateral loads is dependent on connection strength and ductility. Buildings with precast frames and concrete shear walls should perform as intended during major earthquakes if the connections have sufficient strength and displacement capacity.

2.13. Building Type 13 - Reinforced Masonry Bearing Walls with Metal Deck Roof Diaphragms. These buildings have perimeter bearing walls of reinforced concrete masonry units (CMU) or reinforced brick construction. The bearing walls are also the vertical elements of the lateral force resisting system. The roof diaphragm is of metal deck construction with or without a cast-in-place topping. Floor diaphragms are generally a reinforced concrete slab or precast concrete slab supported by steel beams or CMU walls. The roof and floor diaphragms should have sufficient
strength and stiffness to transfer lateral loads to the transverse shear walls without imposing excessive out-of-plane displacements on the longitudinal walls.

2.14. Building Type 14 - Reinforced Masonry Walls with Precast Concrete Roof Diaphragm. These buildings are similar to Type 13 buildings except the roof diaphragm is composed of interconnected precast concrete elements such as planks, or tee beams with or without a cast-in-place topping. The roof diaphragm is stiffer than the metal deck diaphragm of the Type 13 building and therefore roof diaphragm deflections will generally not impose excessive displacements on the longitudinal walls. Because of efflorescence problems, double wythe construction with grout fill between wythes is not recommended for SEPTA buildings.

2.15. Building Type 15 - Unreinforced Masonry Bearing Wall Building. These buildings are similar in construction to Type 13 and Type 14 buildings except the masonry is unreinforced or has the minimum reinforcement required by code. The performance of unreinforced masonry buildings when subjected to earthquake ground motions has often been unsatisfactory. These building also do not perform where subjected to vehicle impacts. For these reasons, Type 15 building construction is not permitted by SEPTA without the express prior approval of the Chief Engineer - EM&C.

2.16. Other Systems - Because of fire protection concerns, systems of wood construction (Type 1 and Type 2 buildings) are generally limited. Steel light frame (Type 5) buildings are often used for industrial type buildings. Infill systems (Type 7, and 8 buildings) although commonly used in older construction, are not recommended for new SEPTA buildings because of undesirable interaction that occurs between the infill walls and the frames when the building is subjected to lateral loads.

3. CHARACTERISTICS IMPORTANT TO BUILDING PERFORMANCE

3.1. Proper design and detailing of structural systems and their connections is critical. Structural engineers should work closely with the building architect in the early phases of building design to assure characteristics important to building performance such as structural system configuration, load path continuity, redundancy, ductility, and the quality of materials and construction, become an integral part of the concept design.

3.2. The configuration of the structural system is important. Irregularly configured structures under extreme loading conditions, especially earthquake loadings, experience greater damage than regularly configured systems. Irregular structures are structures having one or more plan irregularities or one or more vertical irregularities.
Plan irregularities, such as large reentrant corners or differences in stiffness between portions of diaphragms, produce stress concentrations and high localized forces. Other plan irregularities can cause an undesirable torsional response to lateral loads. Buildings that are T, L, U-shaped, or cruciform configurations are examples of irregular plans. Often seismic joints, which separate the various wings of buildings, are provided to allow each wing to perform as an individual structure. This is often more practical than using a rigorous three-dimensional analysis to determine how the wings of the building will interact if connected together.

Vertical irregularities, such as an abrupt change in stiffness from one story to the next, or offsets in the lateral force resisting systems from one story to the next, can also produce stress concentrations and high-localized forces. Regular structural system configuration should be encouraged for new designs. It is realized however that a regular configuration is not always possible. In such cases the designer must recognize the effect each particular irregularity will have on structural response and make a conscious effort to ensure his design will meet all strength and serviceability requirements.

3.3. Load Path Continuity: Direct and continuous load paths should be provided to assure that all loads to which the structure is subjected can be delivered from the load point of application to the foundation. All elements and connections along the load path must have sufficient strength, stiffness, and deformation capability to deliver the loads to the foundation without impairing the buildings ability to perform as a unit. When connection is required to develop the strength of the connected members (such as in the design of earthquake-resistant systems), the effect member over-strength will have on system performance must be considered. Different parts of the building should be adequately interconnected to resist extreme loads, to prevent progressive type failures, and resist foundation settlement. Beams and girders should be adequately tied to columns, and columns should be adequately tied to footings. Concrete and masonry walls should be adequately anchored to floors and roofs for lateral support. Diaphragms that distribute lateral loads to vertical resisting elements must be adequately tied to those elements. Collector or drag struts should be provided to collect shear forces and deliver them to shear-resisting elements, such as shear walls or other bracing elements, that may be spaced at various intervals around the diaphragm. Shear walls must be adequately tied to floor and roof slabs and to footings. Non-structural elements such as exterior cladding and interior stairs should be isolated from structural load paths to assure loads are delivered as intended from the point of application to the foundation. Rigid nonstructural features if not properly isolated can attract loads that will most likely damage nonstructural elements and in the process create unintended load paths that can damage structural elements.

3.4. Redundancy: Redundancy of load paths is a desirable structural system characteristic. Redundancy means that when one structural element or system fails a new load path develops allowing the loads once carried by the failed
structural element or system to be safely transferred to another primary or secondary system thereby preventing progressive collapse of the structure. Redundant systems if properly designed will also prevent the formation of unwanted load paths. For instance if two or more bays of lateral bracing are provided on each side of a building the failure of one bay of bracing will not cause a serious torsional response which could jeopardize the bracing on the other sides of the building. A single row of bracing could be considered to have redundant characteristics if each bracing element is designed to carry both tension and compressive loads. This is not, however, as reliable as a system containing two or more braced bays. The practice of limiting the bracing on a side of a building to a single bay should be avoided if possible. A single braced bay consisting of tension-only bracing is unacceptable. In a building without redundant components, every component must function as intended to preserve the overall structural integrity of the building.

3.5. Ductility: It is desirable, and required by code, that structures be ductile to avoid brittle failure mechanisms which could lead to an unexpected failure. Ductility is imperative for the design of earthquake resistant structures.

3.5.1. Structural steel is an inherently ductile material. The ductility of steel structures is achieved by designing connections to avoid tearing or fracture and by ensuring an adequate path for loads to travel across the connection. Detailing for adequate stiffness and restraint of compressive braces, outstanding legs of members, compression flanges, etc. must be provided to avoid local and global instability by buckling of relatively slender steel members acting in compression. Deflections must be limited to prevent overall frame instability. Steel bracing systems must be configured such that bracing forces can not distort columns in a manner that would amplify the effects.

3.5.2. Less ductile materials, such as concrete and unit-masonry, require steel reinforcement to provide ductility. Concrete structures should be designed to prevent brittle failure mechanisms such as compressive failure, shear failure, anchorage failure, and bond failures from occurring. Compressive failures in flexural members can be controlled by limiting the amount of tensile reinforcement or by providing compressive reinforcement and confining the reinforcement with closely spaced transverse reinforcement such as spirals, or stirrup ties. Confinement increases the strain capacity and the compressive, shear and bond strengths of concrete and masonry. Shear failures in concrete and masonry can be prevented through the use of adequate shear reinforcing. Anchorage and splice failures can be controlled by providing adequate splice development length, or by providing suitable mechanical or welded connections. Masonry walls must be adequately reinforced and anchored to floors and roofs.

3.5.3. Quality of Materials and Construction. It has been observed that the quality of materials used in construction and the quality of construction are
important factors, which can determine whether or not a building will survive extreme loadings due to earthquakes or wind. Testing and inspection programs are necessary to ensure the finished structure meets code requirements. It is the designer's responsibility to assure all testing and special inspections required by code are part of the contact documents.
1. GENERAL

1.1 This chapter prescribes criteria for the design of foundations including spread footings, pile supported foundations, pier supported foundations, and machinery foundations.

1.2 A foundation is the interfacing element between the superstructure and the underlying soil or rock. The loads transmitted from the superstructure to the underlying soil must not cause soil shear failure or damaging settlement. It is essential to systematically consider various foundation types and to select the optimum alternative based on the superstructure, the subsurface conditions, proximity to existing structures and facilities, and cost.

1.3 This section does not preclude the use of other foundation systems where the alternate is more desirable based upon site and project conditions and an engineering justification is provided.

1.4 The design shall take into consideration the requirements for shoring during construction.

1.5 In many instances either a shallow or pile foundation alternative is technically feasible. Under such circumstances, a reasonably detailed shallow foundation analysis including (1) dimensions and depth of shallow footings based on allowable bearing capacity, and (2) the magnitude and time-rate of settlement under anticipated loads, should be performed. A comparative analysis of the pile foundation alternatives should also be made. An approximate cost analysis of both alternatives should be performed and may include such factors as construction time and uncertainties. The emphasis in the selection of foundation type must be placed on the cost analysis of feasible alternatives and impact on SEPTA operations.

1.6 It is recommended that the following approach be used to determine the optimum foundation alternative.

1.6.1 Select or assume structure or bridge characteristics, pier type, superstructure and substructure types, span lengths, etc.

1.6.2 Determine the foundation loads to be supported and special requirements of the foundation. Special requirements may include limits on total and
differential settlements, negative skin friction, lateral loads, scour, and time constraints on construction.

1.6.3 Evaluate the subsurface investigation and the laboratory testing data.
1.6.4 Evaluate the proximity to tracks and/or other foundations and associated restrictions, construction methods, shoring requirements, and track outage availability.
1.6.5 Prepare a final soil profile and critical cross sections - on major projects.
1.6.6 Determine soil layers suitable or unsuitable for spread footings or pile foundations.
1.6.7 Consider alternative designs, if feasible.
   - Shallow Foundations - spread footings
   - Deep Foundations - drilled shafts, pile foundations, or caissons

1.7 Excavations for foundations near or adjacent to existing structures shall be carefully reviewed with shoring requirements considered. Deep foundations including augered piles and caissons must be protected from water and runoff entering the excavation. SEPTA has had problems in the past with settlement of existing structures where caissons were left open for an extended period and not protected from water and runoff.

2. BASIS FOR DESIGN

2.1. Allowable bearing pressures and allowable stresses where required in the design of pile and pier foundations shall be used with the allowable stress design load combinations of ASCE/SEI 7. Where foundations are designed for seismic overturning using the strength design load combinations of ASCE/SEI 7, the seismic overturning moment need not exceed 75% of the value determined by either the equivalent lateral force method, or the modal analysis method.

2.2. Foundations for railroad and light rail bridges and right-of-way structures shall be designed per AREMA. Foundations for rail transit structures located with-in 15 feet of the centerline of the nearest tracks shall exclude the top 1'-0" in determining embedment depth.

2.3. Foundations for highway and roadway bridges and rail transit elevated (not railroad or light rail) structures, and associated right of way structures shall be designed per AASHTO.

2.4. Foundations shall be designed so that the allowable bearing capacity of the soil is not exceeded and that differential settlement is minimized. The minimum width of footings shall be 12 inches. Footing design shall meet the requirements of ACI 318, except as noted above. Loads and load combinations for buildings and other structures shall be per the requirements of IBC and ASCE/SEI 7 as applicable.
2.5. For slabs on grade, see Chapter 7. For retaining walls see Chapter 15.

3. FOUNDATION AND SOILS INVESTIGATIONS

3.1 A proper design of a structure foundation requires thorough knowledge of the subsurface conditions at the structure site. The investigation should consist of subsurface investigation (borings, in situ testing, and sampling); laboratory testing; geotechnical analysis of all data; and design recommendations.

3.2 The Engineer shall be responsible for obtaining all soils information from a geotechnical investigation (soils boring) program. For minor structures, the presumptive values set forth in the IBC may be used with prior SEPTA engineering approval. In the event of changes in the design or construction concepts, between the preliminary and final design phases, the engineer shall keep the geotechnical engineer informed and his/her recommendations obtained.

3.3 Foundation and soils investigations when required shall be in accordance standard industry practice. For rail transit applications, the requirements of AREMA shall also be followed. Pile and pier foundations shall be designed and installed on the basis of a foundations investigation and pile load test when required.

3.4 Geotechnical Reports

3.4.1 Geotechnical reports are required for most structures, all major structures, and/or where foundation problems are anticipated. The reports shall include the following information:
- a summary of the findings,
- a plan view of the structure showing the location of the borings,
- the boring logs,
- an evaluation of the borings, and
- a foundation type recommendation.

3.4.2 The site investigation shall include:
- soil parameters, including depth, thickness and variability of soil strata, identification and classification of soils, shear strength, compressibility, stiffness, permeability, frost susceptibility, and expansion potential;
- rock parameters, including depth to rock, identification and classification of rock, rock quality (i.e., soundness, hardness, jointing, resistance to weathering, and solutioning), compressive strength, and expansion potential;
- presence of boulders, if encountered
- water table elevation; and
- settlement considerations including required waiting period.
3.5 Foundation Reports

3.5.1 Foundation reports are required for all structures and shall include:
- the soil bearing capacity,
- the type of foundation,
- bottom footing elevation,
- settlement considerations including required waiting period,
- shoring or cofferdam requirements, if needed,
- any construction instrumentation and monitoring requirements,
- the anticipated scour depth, and
- slope stability.

3.5.2 If piles are recommended, the recommendations should also include:
- the type or types of piles,
- size of pile,
- the design bearing capacity of the piles,
- proposed pile lengths,
- the minimum pile tip elevation (even if it is higher than the final tip elevation), and
- the ultimate design pile capacity for drivability through the estimated scour layer

4. STRUCTURAL DEFORMATIONS AND SETTLEMENTS

All structural deformations, including foundation settlement, shall be considered, not only for their effect on structural behavior, but also for their effects on track work and ADA requirements. The control of deformations through proper structural design is of paramount importance in obtaining acceptable ride quality and for the safety of transit trains and passengers.

5. ALLOWABLE LOAD BEARING VALUES AND LATERAL SLIDING RESISTANCE OF SOILS.

5.1. Allowable Bearing Pressures. Maximum allowable bearing pressures shall be determined for soil foundations and for rock foundations in accordance with an approved geotechnical investigation and a registered professional geotechnical engineer. The presumptive allowable bearing pressures for spread footing as provided in IBC can be used with caution for spread footings supporting small or temporary structures.

5.2. Lateral Sliding Resistance. The resistance of footings to lateral sliding shall be calculated. The lateral soil resistance shall not exceed one-half the computed passive resistance.
5.3. Increases in Allowable Bearing Values. Allowable bearing pressures may be increased by 1/3 for load combinations involving wind or earthquake where permitted by code. This increase is not permitted for structures such as catenary and backguy foundations where limiting movement is critical.

6. FOOTINGS AND FOUNDATIONS

6.1. Footings and foundations shall be built on undisturbed soil or compacted fill material.

6.2. Frost Protection. The minimum design depth of foundations to protect against frost penetration shall be 36 inches.

6.3. Foundations 36" in thickness or greater shall have vertical reinforcement to prevent cracking.

6.4. Where the depth from the bottom of the footing to rock is minimal, the designer has four options for determining the optimum foundation alternatives. Because short piles are generally undesirable, the designer should specify excavation to rock rather than placing short driven piles. Options to preclude the use of short piles include:

   6.4.1. Specifying subfoundation backfill from the rock surface to the bottom of the footing.
   6.4.2. Using subfoundation concrete instead of backfill where the depth to bedrock is shallow. Dimensions of the subfoundation concrete should be shown in the drawings.
   6.4.3. Lowering the bottom of the footing (creating a thicker footing).
   6.4.4. Constructing a taller pier or abutment.

6.5. Where required, the designer must specify excavation into the rock to key the foundation into the rock and to establish a suitable level bearing surface. The excavation in the rock can be full width of the footing or be benched.

6.6. Seismic Footing Ties. Where a building is assigned to Seismic Design Category D, E, or F, as defined in FEMA 368, "NEHRP Recommended Provisions for the Seismic Design of New Buildings and Other Structures", individual spread footings founded on soil should be interconnected by ties in accordance with the provisions of FEMA.

6.7. Gable Bent Footing Ties. The gable bent type of moment frame requires a horizontal reaction force at the foundation to resist horizontal spreading. Because
often it is unreliable to count on the soil surrounding the footings to provide this reaction, (i.e., excavation next to the building may reduce lateral bearing resistance), footing ties are advisable. These ties, may consist of reinforced concrete tension tie beams that are located below the slab-on-grade, or for short span frames may be reinforcing steel which anchors the gable bent footing directly to the slab-on-grade. When gable bent frames are anchored to the slab-on-grade it is imperative that the location of the ties be coordinated with the slab-on-grade jointing to assure tie capacity is not reduced or impaired by the joints. Reinforced concrete tension tie beams are required for gable bent frames with spans of 50 feet or more.

6.8. Footings on Expansive Soils. Expansive soils change volume from changes in water content leading to total and differential foundation movements. Seasonal wetting and drying cycles have caused soil movements that lead to long-term deterioration of structures. Soils can have large strengths and bearing capacity when relatively dry. Expansive soils consist of plastic clays and clay shales that often contain colloidal clay materials. They include marls, clayey siltstone, sandstone, and saprolites. Some of these soils, especially dry residual clayey soil, may heave under low applied pressure but collapse under higher pressure. In certain cases, clay soils may not exhibit swelling characteristics if undisturbed. This same soil, when dried by manipulation and re-compacted at less than the initial moisture content, may exhibit some swell. Other soils may collapse initially but heave later on. Estimates of the potential heave of these soils are necessary for consideration of the foundation design.

7. SHALLOW AND SPREAD FOOTING FOUNDATIONS

7.1. It is necessary to consider the feasibility of spread footings in any foundation selection process. Spread footings are generally more economical than deep foundations (piles and caissons).

7.2. The term "bearing capacity" denotes a loading intensity which the bearing materials can sustain without such deformation as would result in settlement damaging to the structure. The designer must be aware of the possibility of settlement of the earth below footings. Check the soils report for types of soil that are prone to settle.

7.3. Spread footing foundations may be used for bridges only with the prior approval of the Chief Engineer or his/her designee

7.4. The minimum required safety factors for design of spread footings are:

- against sliding = 1.5
- against overturning = 2.0 (1.5 in rock)
- against bearing capacity failure = 3.0
8. DEEP FOUNDATIONS

8.1. Deep foundations such as piles or pier foundations are needed to transmit the load of a structure through a material of poor bearing capacity, or to eliminate differential settlements.

8.2. Pile foundations should not be used indiscriminately for all subsurface conditions or for all structures. There are subsurface conditions where pile foundations are difficult to install and others where they may not be necessary.

8.3. The choice of pile or pier type for a given foundation should be made on the basis of a comparative study of cost, permanency, stability under vertical and horizontal loading, and the required method of installation.

8.3.1 Piles are frequently needed because of the relative inability of shallow footings to resist inclined, horizontal or uplift forces and overturning moments.

8.3.2 Pile foundations are often required where scour around footings could cause loss of bearing capacity at shallow depths or where future excavation is anticipated. In either case the piles must be extended to develop the necessary capacity below the level of expected scour or excavation. This will prevent costly damage and eliminate the need for future underpinning.

8.3.3 Pile foundations may be needed in some areas to prevent undesirable seasonal movements of the foundations. Piles under such conditions are designed to transfer foundation loads, including uplift or downdrag, to a level unaffected by seasonal moisture movements.

8.1 Driven piles should not be used where the depth to bedrock is less than 10 feet. In these cases, it is difficult to develop adequate lateral stability. Driven piles should also not be used where the associated vibrations may cause damage to adjacent structures or property.

8.1 Pile Foundations. Pile foundations can consist of concrete or steel elements either driven or drilled into the ground. Piles are relatively slender in comparison to their length. Piles derive their load carrying capacity through skin friction, end bearing, or a combination of both.

8.5.1 Load-bearing piles of various materials and design characteristics are commonly used. The types of load-bearing piles used for SEPTA projects are:

- Precast, Prestressed Concrete Piles,
- Precast-Prestressed Concrete Cylinder Piles,
- Cast-in-Place Concrete Piles,
• Steel H-Piles
• Micro Piles

8.5.2 Typical minimum safety factors to be used in designing pile foundations are:
• piles with a load test = 2.0
• piles without a load test, but with pile driving analyzer (PDA) = 2.25
• piles without a load test and without PDA = 2.5

These safety factors are based on the use of a wave equation in determining bearing capacity in all cases.

8.5.3 In addition to axial loads, piles are expected to transmit lateral loads into the soil. This causes both shearing forces and bending moments in the pile. The designer must evaluate pile capacity considering the axial load, the lateral loads and the combination of these loads. Lateral deflections and displacement of the pile axis must be evaluated simultaneously. These lateral loads must be resisted by the stiffness of the pile or pile group through mobilization of resistance in the surrounding soil as the pile deflects. Battered piles should be evaluated for resistance of lateral loads.

8.5.4 Two of the pile types common to building construction, along with their advantages and disadvantages, are described below.

8.5.5 Steel H-Piles. Steel H-piles are rolled steel sections with wide flanges so the depth of the section and widths of the flanges are about equal dimension. The cross-sectional area and volume of the H-pile are relatively small; consequently, they can be driven through compacted granular materials and into soft rock. Steel H-piles because of their small volume displacement have little or no effect in causing ground swelling or rising of adjacent piles. Steel piles protruding above the ground lines are subject to corrosion at or somewhat below the ground line and must be addressed in the design.

8.5.5.1 Steel piles are ductile and therefore are suitable for use in high seismic areas.
8.5.5.2 The use of driving shoes is recommended.

8.5.6 Prestressed Concrete Piles. Prestressed concrete piles are used and have replaced for the most part the reinforced concrete precast pile. Some of its advantages are prestressing eliminates open cracks in a concrete pile, permits ease in handling, and reduces the tendency to spall during driving. The compression induced in the pile permits piles to
sustain considerable bending stresses. However when used in high seismic areas, prestressed concrete piles must contain large quantities of confinement steel in the form of spiral reinforcement to resist the curvature demands place on the pile by differential subsurface ground distortions.

8.5.7 Load testing is the most accurate method of verifying pile capacity. The designer must specify the type of load test to be used. Conventional load test types are included in ASTM D 1143. This test method defines procedures for testing vertical or battered piles individually or in groups to determine the response of the pile or group to an axially applied static compressive load.

8.5.7.1 Additional methods for testing vertical or battered piles either individually or in groups include:

- The modified ASTM load test, which follows ASTM D 1143 methods but may include modifications that must be approved by the Engineer of Record and SEPTA Engineering;
- The ASTM D 3966 test method, which covers procedures to determine the load-deflection relationships when the pile or pile group is subjected to lateral loads; and
- The ASTM D 3689 test method, which covers procedures to determine the response of the pile or pile group to an axially applied static tensile load.

8.5.7.2 Before a pile load test is conducted, an economic comparison between the cost of the additional length of pile and the cost of the load test should be made. Generally, one pile load test will be conducted for each 100 piles required on a structure. Under unique circumstances, more tests may be specified. Refer to the FHWA Manual on Design and Construction of Driven Pile Foundations for additional information.

8.5.7.3 Load tests that are witnessed (preferred) by and/or approved by a Registered Professional Engineer are generally required by SEPTA

8.1 Pier Foundations. A pier foundation is a drilled shaft that is formed by boring an open cylindrical hole into the soil and subsequently filling the hole with concrete. Excavation is accomplished usually by a mobile drilling rig equipped with a large helical auger or a cylindrical drilling bucket. Once in place, a drilled shaft acts essentially like a driven pile, except that its behavior under load may differ because of the dissimilar geometries and installation techniques.
8.6.1 The following special features distinguish drilled shafts from other types of foundations:

- Unlike a displacement pile, the drilled shaft is installed in a drilled hole.
- Wet concrete is cast and cures directly against the soil forming the walls of the bore hole. Temporary casing may be necessary for stabilization of the open hole and may or may not be extracted.
- The installation method for drilled shafts is adapted to suit the subsurface conditions.

8.6.2 Other terminology commonly used to describe a drilled shaft includes: drilled pier, drilled caisson, and bored pile.

8.6.3 The drilled shaft is usually employed as a deep foundation to support heavy loads or to minimize settlement. Because of the methods of construction, it is readily applied to soil that is above the water table, or soil that is nearly impermeable, and to profiles where rock or hard soil is overlaid by a weak stratum.

8.6.4 Steel casings may or may not be used to facilitate pier construction. Two pier foundation types common to building construction, along with their advantages and disadvantages, are described below. The design of pier foundations shall follow the recommendations contained in ACI and FHWA-IF-99-025, “Drilled Shafts: Construction Procedures and Design Methods”.

8.6.5 Augured Uncased Piers. Augured uncased pier foundations are constructed by depositing concrete into an uncased augured hole. In advancing through granular materials, drilling mud is often required to keep the hole open. The drilled shaft is filled with concrete in the dry, or by means of a tremie pipe through the drilling mud. When the concrete is to be reinforced, care and planning is required to assure the reinforcement can be placed in the desired location and to the depth required. For drilled piers installed with a hollow stem auger, where longitudinal steel reinforcement is placed without lateral ties, the reinforcement shall be placed through ducts in the auger prior to the placement of concrete. When transverse reinforcement is required, the reinforcement shall be fabricated in cages which are securely tied so they will not rack or otherwise distort when handled and placed in the augured hole. Transverse confinement reinforcing similar to that indicated for prestressed piling is required for uncased concrete piers constructed in high seismic areas.
8.6.6 Drilled Shaft Piers. Drilled shaft piers can be generalized as large diameter cast-in-place concrete filled pipes. The casing may, or may not remain part of the load-carrying element. Casings where used are usually thick-walled. Drilled shaft piers can be designed to carry extremely heavy loads to extreme depths. Once installed to the desired depth, the pipe is cleaned, reinforcement placed, and filled with concrete if dry, or filled by the tremie method if water is present. The pipe can then either be pulled for reuse, or left in place to increase load carrying capacity. Transverse confinement reinforcing similar to that indicated for prestressed piling is required for caisson piers constructed in high seismic areas in those cases where the pipe is to be pulled. When the pipe is left in place, the pipe can be used to provide the necessary concrete confinement. Where limiting lateral movement is critical such as catenary support structures and back guy anchors, the space outside any casing that remains shall be pressure grouted.

8.6.7 For drilled shafts in soil or socketed in rock, a minimum design factor of safety of 2.5 should be used against bearing capacity failure. A factor of safety of 2.5 should be used when designing for conditions which produce uplift.

9 FOUNDATIONS FOR MACHINERY

9.1 Commonly used machines such as pumps, fans, centrifuges, blowers, generator engines, and compressors have vibrational characteristics that can be damaging to foundations. The design of foundations supporting these types of equipment requires special consideration to assure the equipment and foundations supporting the equipment are not damaged due to resonant vibration.

9.2 Minimum Requirements for Spread Footings Supporting Machinery. Machinery foundations shall be reinforced as required by design loads but in no case with less than 0.15 percent reinforcing each way distributed at top and bottom. Minimum bar size shall be No. 4, and maximum spacing of bars shall be 12 inches. These foundations shall be completely isolated from floor slab on grade with isolation joints. The allowable bearing pressure shall be one-half that assumed for static load conditions. When the depth of foundation (D) is 36 inches or more and its length-to-width (L/W) ratio is 3 or more, the following reinforcing steel requirements shall be met.

9.2.1 Longitudinal reinforcing shall be distributed at top, bottom, and faces of foundation within 6 inches of the surface.

9.2.2 Horizontal bars, bent and lapped to be continuous with sidewall, top and bottom bars shall be provided on end and sidewall faces.
10 WATER AND DAMP PROOFING

10.1 Waterproofing methods must comply with the highest of current industry standards. The designer is expected to make certain that the prevention of moisture from entering into interior spaces and/or from entering into various building systems is a top priority. Building designs (shapes, materials, details, etc.) that do not lend themselves to straightforward, direct, and secure waterproofing methods are discouraged and, if used, must be carefully and thoughtfully detailed.

10.2 Grade/slope building sites to drain away from buildings.

10.3 Provide waterstops at all joints in all below grade concrete joints.

10.4 A subgrade perimeter (footing) drainage system is generally required. If the soil report indicates water above the lowest slab level, an underslab drainage system is required.

10.5 Slope the top of underground structures, top of tunnels, slabs under plazas, decks, and walkways, and any below-grade space ¼ inch per 1'-0" minimum towards drains or over the edge of foundation walls. The design of the structure shall enhance slope as building creep relaxes.

10.6 Conduit and piping shall not penetrate any horizontal waterproofing membrane. All pipe and conduit penetrations shall be waterproof using a link seal system or approved alternate. Pipe and conduit penetrations in all new construction shall have embedded galvanized steel pipe sleeves.

10.7 Provide membrane waterproofing systems on vertical and horizontal surfaces with occupied or service spaces on the other side and for all subway tunnels.

10.7.1 A protection system is required when the proposed system is vulnerable to damage from backfill, other related construction, and under roadways and sidewalks. Typically the waterproof membrane should be extended up walls and curbs a minimum of 1 foot, and a minimum of 4 inches above pavers, sidewalks or planting soils.

10.7.2 Sheet membrane waterproofing shall be a self-adhesive, cold-applied composite sheet consisting rubberized asphalt and cross-laminated, high density polyethylene film.

10.7.3 The rubberized asphalt membrane shall be covered with a release sheet that is removed during installation. No special adhesive or heat shall be required to form laps.
10.8 Vertical joints shall have continuous interior and exterior waterproof gaskets. At transitions (floors, roofs, etc.) install gaskets in a manner that will shed water. Sealant is not acceptable as the primary barrier.

10.9 Horizontal joints shall have a cover designed for the specific use and location, waterproof gaskets, and an interior gutter drain system. Vehicular traffic areas shall be fully supported and designed for not less than a H-20 load. The joint shall be at the high point or a curb at the adjacent building. The structure shall slope away from the joint.

10.10 The purpose of sealers is to protect the exterior masonry and concrete walls from water. Sealants shall not be used for the primary weather barrier. Research material compatibility with proposed sealant. Prime all joints. Provide for adhesion tests for all materials and sealants. Provide sand textured finish on all masonry sealant joints.

10.11 Waterproofing for railroad bridge decks shall conform to AREMA.

10.12 **Damp-proofing:** For damp-proofing of below grade walls enclosing unoccupied spaces and of concrete and concrete masonry walls behind face brick in cavity wall construction, a bituminous damp-proofing system is often acceptable. This system shall be a cold applied, semi-mastic asphalt and solvent compound containing non-asbestos inorganic fibrous reinforcement.

10.13 Warrant by waterproofing material system manufacturer, installer and general Contractor, entire waterproofing system against defects in materials and workmanship for a period of 5 years from date of substantial completion. The warranty shall warrant against failure of the waterproofing membrane to remain waterproof, including abnormal deterioration of materials. Warranty shall include all components of the waterproofing system specified. Warranty shall also include the responsibility for removal and replacement of all work concealing the waterproof system. Upon completion, work which was removed and replaced must be approved by SEPTA Bridges & Buildings Department.

10.13.1 Sealer: Provide manufacturer’s standard warranty.

10.14 The existing waterproofing system on all subway tunnels shall be maintained and replaced in kind when disturbed.

11. **SPECIAL INSPECTIONS**

11.1 Pile and Pier Foundations. Inspectors familiar with pile and pier construction shall be present when pile or pier foundations are being installed, and during load testing. Records shall be kept for each pile or pier installed, including the results of all load tests, and the final tip elevation.
11.2 Contractors and/or inspectors shall be required to provide detailed written records of drilled shaft and/or caisson foundations noting the actual type and depths of each earth layer and rock, depth of rock sockets, water table elevation, actual diameter, and other pertinent data.

11.3 Inspections required by building officials and IBC shall be addressed in the project documents and/or procedures.
CHAPTER 6
CONCRETE

1. INTRODUCTION

1.1. This chapter prescribes criteria for the design of structures using cast-in-place or precast construction for plain, reinforced, or prestressed concrete.

2. BASIS FOR DESIGN

2.1. The basis for design for buildings and building components constructed of reinforced concrete, prestressed concrete, or plain concrete shall be ACI 318, "Building Code Requirements for Structural Concrete and Commentary". In executing designs in accordance with ACI 318, cognizance shall be given to ACI 318 commentary; Portland Cement Association (PCA) Notes on ACI 318 Building Code Requirements for Reinforced Concrete with Design Applications, and to ACI standards and committee reports referenced in this document.

2.2. The basis of design for structures subjected to railroad and light rail transit structures shall be AREMA Manual of Railway Engineering, Chapter 8.

2.3. The basis of design for roadway and highway type structures, rigid pavements, and rail transit structures not addressed in Paragraph 2.2 above, shall be per AASHTO.

2.4. Precast Concrete and Prestressed Concrete design shall follow the Prestressed Concrete Institute (PCI), Manuals and ACI requirements.

2.5. For slabs on grade and rigid pavements, see Chapter 7 for additional requirements.

2.6. For additional requirements related to foundations, see Chapter 5.

2.7. Concrete repairs shall follow the recommendations of the International Concrete Repair Institute (ICRI) and ACI. PennDOT standard repair details and materials are normally acceptable.

3. PROHIBITED TYPES OF CONSTRUCTION

3.1. The use of hollowcore precast concrete planks or slabs are prohibited except for roofs where the planks will be covered with roofing materials for the life of the structure.
3.2. The use of shotcrete (gunite) for structural applications on SEPTA projects is limited and must be reviewed and approved by SEPTA Engineering on a case by case basis where justified by project specific restrictions or needs.

3.3. The use of lightweight concrete is not allowed for use in structural members.

4. DESIGN STRENGTHS

4.1. The minimum concrete design strengths ($f'_{c}$) for various applications and various exposures are listed in Table 6-1.

<table>
<thead>
<tr>
<th>Usage</th>
<th>Minimum Strength at 28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete fills</td>
<td>1,000 psi</td>
</tr>
<tr>
<td>Encasements for utility lines and ducts</td>
<td>2,500 psi</td>
</tr>
<tr>
<td>Foundation walls, footings and cast-in-place concrete piles</td>
<td>3,500 psi</td>
</tr>
<tr>
<td>Drilled shaft piers (caissons)</td>
<td>4,000 psi</td>
</tr>
<tr>
<td>Slabs on grade.</td>
<td>4,000 psi</td>
</tr>
<tr>
<td>Reinforced concrete buildings</td>
<td>4,000 psi</td>
</tr>
<tr>
<td>Precast members (including architectural and structural members and piles).</td>
<td>5,000 psi</td>
</tr>
<tr>
<td>Walls, floors, walkways, stairs, bridge decks, parking garages, and other structures subjected to severe exposure (Severe exposure includes extreme heat or cold and/or exposure to deicing or other aggressive chemicals.)</td>
<td>4,500 psi</td>
</tr>
<tr>
<td>Concrete deposited under water (tremie concrete)</td>
<td>4,000 psi</td>
</tr>
<tr>
<td>Columns in multistory buildings carrying heavy loads and bridge piers.</td>
<td>4,000 psi</td>
</tr>
<tr>
<td>Reinforced concrete in contact with seawater, alkaline soils or waters, or other destructive agents.</td>
<td>4,500 psi</td>
</tr>
<tr>
<td>Prestressed concrete construction.</td>
<td>5,000 psi</td>
</tr>
<tr>
<td>Concrete Pavements</td>
<td>4,000 psi</td>
</tr>
</tbody>
</table>
5. DESIGN CHOICES

5.1. The selection of the structural concrete framing system, strength of concrete and reinforcement, conventional versus lightweight concrete, conventional versus prestressed design, and cast-in-place versus precast construction shall be based on economic and functional considerations, SEPTA operational needs and restrictions, outage availability, and long term maintenance needs.

5.2. Designers should take into account the specific type and size of structure, architectural features or special performance requirements, seismic exposure, construction cost factors for the building site, and the availability of materials and labor. The use of precast concrete is encouraged to the greatest extent possible.

6. CONCRETE PAVEMENTS

6.1. The design of concrete pavements is addressed in Chapter 7.

6.2. Exterior concrete pavements and interior concrete pavements subjected to vehicle loads such as bus garages shall be designed to be resistant to surface scaling due to freezing and thawing and the use of common deicing chemicals. Proper
attention shall be given to design and construction that will ensure scale-resistant concrete pavements. The following practices are required for all areas where pavements are subjected to freezing and thawing and the application of deicing materials:

- Strict adherence to the fundamentals of quality concrete
- Adequate curing
- A period of air drying

7. FUNDAMENTALS OF QUALITY CONCRETE

7.1. The resistance of concrete to scaling and the effects of de-icing chemicals shall be considered in all designs. The following fundamentals should be followed:

- Minimum cement content—564 lb per cubic yard
- Maximum water-cementitious material ratio—0.45
- Low slump—not more than 4 in (unless a water-reducer or plastisizer is used)
- Sound, clean, durable, well-graded aggregates
- Adequate air void system (air entrainment)
- Proper proportioning, mixing, placing, and finishing

7.2. The use of entrained air in a concrete mixture is required in most if not all cases but must be closely monitored. An insufficient amount of entrained air will not properly protect the concrete from damage caused by freeze-thaw effects. In addition, if too much air is used, the strengths of the concrete will be lessened to an unacceptable level. Recommended air contents of concrete per ACI 318 and PCA publication *Design and Control of Concrete Mixtures* shall be followed based upon severe exposure.

8. CURING

8.1. Proper curing procedures and durations must be strictly adhered to in order to ensure adequate strength and durable concrete. Curing procedures shall be clearly specified and shall begin as soon as possible after the finishing operations are complete and as soon as marring of the pavement surface will not occur.

8.2. Concrete pavements and slabs have a high ratio of exposed surface area to volume of concrete with curing a critical issue. The proper curing of all concrete pavements including sidewalks and curbs shall be addressed.

8.3. Curing methods and duration (along with the design) shall account for vibrations and loads from existing and adjacent in service structures or operations.
8.4. Cold weather and hot weather concrete placement and curing requirements must be specified and strictly followed in accordance with ACI and other applicable standards.

8.5. The specified curing methods must be matched with the type of placement and the concrete design mix used.

9. SERVICEABILITY

9.1. Structures must remain serviceable throughout their service life. Concrete buildings and concrete structural elements must be durable, free from objectionable cracking, and have adequate protection of the reinforcing steel to prevent corrosion. In addition, structural deflections that can damage interior partition walls, ceilings and various architectural features must be kept within acceptable limits.

9.2. Durability of portland cement concrete is defined as its ability to resist weathering action, chemical attack, abrasion, or any other process of deterioration. Durable concrete will retain its original form, quality, and serviceability when exposed to its environment. The most significant causes of concrete deterioration are freezing and thawing, and corrosion of reinforcing steel. The design shall include measures that insure that durability problems do not occur.

9.2.1. Freeze-thaw Protection. All exterior concrete and concrete used in tunnels, bridges, or similar applications shall be designed for freeze thaw protection. Concrete shall be made with good aggregates, low water-cement ratio, and air entrainment shall have good resistance to cyclic freezing. The recommended air contents to prevent freeze-thaw damage per ACI 318 and IBC shall be followed. SEVERE EXPOSURE requirements shall be used for all pavements, platforms, bridge decks, sidewalks, parking garages, and surfaces immediately adjacent to these structures. MODERATE EXPOSURE may be used for interior concrete not exposed to de-icing chemicals or other harsh chemicals or conditions.

9.2.2. Corrosion protection is accomplished primarily by providing a sufficient thickness of concrete cover over reinforcing steel and other embedded items. For normal exposure conditions, or those conditions where the concrete is not exposed to chlorides, the minimum concrete cover protection specified in ACI 318 shall be provided. Concrete reinforcement shall be hot dip galvanized (preferred) or epoxy coated.

9.2.3. For severe conditions and parking garages, the use of corrosion inhibiting admixtures in addition to coated reinforcement is recommended.

9.3. The Designer shall be aware of the possibility of stray current induced corrosion to reinforcing steel that is often associated with electrified rail transit systems,
electrical substations, and similar type construction. Steps to prevent or reduce this corrosion shall be taken. The structural engineer shall work closely with electrical engineer in selection of materials and grounding of all steel.

9.4. Crack Control. Cracking in concrete occurs mainly when volume changes due to drying shrinkage and temperature effects are restrained. Cracking can also occur due to externally applied loads. Cracks indicate a major structural problem, or a serviceability problem. Reinforcing steel exposed to moisture and air can corrode. The corroded steel has a volume several times that of the parent material. Cracking and spalling occurs due to the expansion of the steel as it corrodes. Cracking can be controlled by providing adequate temperature and shrinkage reinforcement, by reducing steel stresses at service load conditions, and by reducing restraint through the use of joints. Tolerable crack widths for reinforced concrete under various exposure conditions are provided in Table 6-2.

9.4.1. Shrinkage and Temperature Reinforcement: To keep cracks widths within acceptable limits for structures under normal exposure conditions the minimum shrinkage and temperature reinforcement as required by ACI 318 shall be provided.

9.4.2. Reducing Steel Stresses under Service Load Conditions: Cracking due to service loads can be controlled by limiting the maximum stress in the reinforcing steel, and by providing small diameter bars at close spacing, rather than large size bars at wide spacing. Rules for distributing flexural reinforcement in beams and slabs to control flexural cracking are provided in ACI 318. Suitable distribution of flexural reinforcement in beams and slabs for normal interior and exterior exposure conditions shall comply with ACI 318 requirements.

<table>
<thead>
<tr>
<th>Exposure Condition</th>
<th>Tolerable Crack Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry air or protective membrane</td>
<td>0.40 mm (0.016 inch)</td>
</tr>
<tr>
<td>Humidity, moist air, soil</td>
<td>0.30 mm (0.012 inch)</td>
</tr>
<tr>
<td>Deicing chemicals</td>
<td>0.20 mm (0.007 inch)</td>
</tr>
<tr>
<td>Sea water and saltwater spray</td>
<td>0.15 mm (0.006 inch)</td>
</tr>
<tr>
<td>Water retaining structures</td>
<td>0.10 mm (0.004 inch)</td>
</tr>
</tbody>
</table>

(From ACI Committee 224 Report)

9.5. Concrete slabs and decks adjacent to rail transit tracks shall have a high damping capacity to counteract (absorb) vibrations. Provide slab thicknesses and reinforcement sufficient to minimize vibration levels that are likely to cause
discomfort to patrons. Account for these vibrations during the placement and curing.

9.6. Exterior high level platforms for railroad and light rail stations shall have a minimum slab thickness of 6 inches with the recommended thickness of 8 inches.

10 JOINTS AND JOINT SEALANTS

10.1. The effects of deflection, creep, shrinkage, temperature contraction and expansion, and the need for vibration isolation must be addressed when determining the location of expansion and contraction joints in concrete buildings. Appropriate allowances for the aforementioned effects shall be included in the design; location, details or provisions for required contraction joints, control (weakened-plane) joints, expansions joints, isolation joints, and seismic joints.

10.2. The location of expansion, contraction, and seismic joints shall be shown on the drawings since joints are critical with respect to other design considerations, e.g., configuration of the structural concrete, effects of joints on structural strength and shrinkage cracking, and the appearance of joint lines on exposed concrete surfaces.

10.3. Where reinforced concrete foundation walls support masonry, crack control measures shall be designed to be compatible with crack control measures in the masonry. All crack control joints in the foundation wall shall be carried upward into masonry crack control joints.

10.4. Expansion and Isolation Joints: In general, expansion joints should be provided in accordance with the following rules:

- Expansion joints should be spaced so straight lengths of building measure no more than 200 feet between joints.
- An expansion (or seismic) joint is usually required between adjoining building areas which are different in shape, or between areas where different rates of building settlement are anticipated.
- Joints for structural or seismic reasons are often located at junctions in L-, T-, or U shaped buildings.

10.4.1. Expansion joints should extend entirely through the building, completely separating it into independent units. Column footings located at expansion joints need not be cut through unless differential settlements or other foundation movements are anticipated.

10.4.2. Expansion joints should be carried down through foundation walls: otherwise the restraining influence of the wall below grade, without a joint, may cause the wall above to crack in spite of it's joint.
10.4.3. Reinforcement must never pass through an expansion joint.

10.4.4. The design and installation of other structural, architectural, mechanical, and electrical components and structures shall allow for and account for expansion joint movement.

10.4.5. An empirical approach for determining the need for expansion joints is provided in the PCA Report, "Building Movements and Joints".

10.5. Control Joints: Control joints are needed to eliminate unsightly cracks in exposed building walls by controlling the location in which cracking due to volume change effects takes place.

10.5.1. As a general rule:
   - In walls with openings, space control joints at 20-foot intervals
   - In walls with infrequent openings, space at 25-foot intervals
   - Provide a control joint within 10 or 15 feet of a corner
   - Where steel columns are embedded in the walls, provide joints in the plane of the columns.
   - If the columns are more than 25 feet apart, provide intermediate joints.

10.5.2. Numerous ways have been developed for forming control joints in walls. Whatever method is used, the thickness of the wall section at the joint should be reduced at least 20% by the depth of the joint; and the sum of the depths of the inside and outside grooves should not be less than 2 inches.

10.6. Construction Joints: Construction joints are used to allow concrete placement of separate construction elements at different times, e.g., between columns and beams, footings and pedestals, etc. Construction joints shall be made with tie bars, dowels, or keys to provide shear transfer. The location and details of critical construction joints shall be shown on the drawings and, to the extent practicable, shall coincide with the location of expansion or control joints. The location of other construction joints need not be shown. Cautionary and advisory notes regarding acceptable joint locations shall be included on the drawings.

10.7. Seismic Joints: Buildings that are irregular in plan such as T, L, U, or cruciform shaped buildings can generate high torsional or twisting effects when subjected to earthquake ground motions. These structures would require a three-dimensional analysis for a rigorous determination of stress distribution. Since such analyses are generally not practical, seismic joints are provided to separate various blocks of the structure into regular shaped units that will not exhibit a torsional response. The joints should be of sufficient width to prevent hammering on adjacent blocks during earthquakes, and should be adequately sealed to protect the structure from the environment.
10.8. **Sealing joints:** All exterior expansion, control, and construction joints in structures and pavements shall be sealed against moisture penetration using methods such as waterstops or sealants as appropriate for the prevailing conditions. Refer to Chapter 5 Section 10 and Section 17 in this Chapter for water and damp proofing requirements.

11. **LOAD PATH INTEGRITY**

11.1. Loads must be transferred from their point of application to the foundation. All structural elements and connections along the load path must have sufficient strength, and in the case of seismic resistant structures, sufficient ductility to transfer the loads in a manner that will not impair structural performance. Most load path deficiencies are a result of inadequate connections between precast elements, or between cast-in-place concrete elements and precast elements.

11.2. The analysis of shear transfer shall be in accordance with the provisions of ACI 318. Special attention shall be given to transfer of shear at locations such as shear heads, bases of walls, brackets, and corbels.

11.3. The combined action of flexible and rigid shear connectors shall not be considered as providing simultaneous shear transfer. Rigid shear connectors include roughened surfaces and structural shapes. Flexible connectors include bolts, stirrups, dowel bars, and ties.

11.4. Modified, renovated, and/or rehabilitated structures and elements must be checked to verify sufficient strength to account for the changes.

12. **DETAILING REQUIREMENTS**

12.1. Concrete reinforcement shall conform to ASTM A615 Grade 60 and shall be either epoxy coated or galvanized. For exterior cast in place concrete, hot dip galvanizing is the preferred coating system for rebar. Reinforcement for underground concrete (foundations) and interior concrete not exposed to de-icing chemicals, cleaning agents or other harsh environmental exposures may be uncoated.

12.2. Details and detailing of concrete reinforcement shall conform to ACI 315, "Details and Detailing of Concrete Reinforcement". Engineering and placing drawings for reinforced concrete structures shall conform to ACI’s "Manual of Engineering and Placing Drawings for Reinforced Structures".

12.3. The welding of reinforcing steels is covered by AWS D 1.4, "Structural Welding Code - Reinforcing Steel." Most new reinforcing steel bars can be welded.
However, the preheat and other quality control measures that are required for bars with high carbon equivalents are extremely difficult to achieve. It is recommended that carbon equivalents be limited to 0.45 percent for No. 7 bars (No. 23 bars) and higher, and to 0.55 percent for smaller bars. ASTM A615, Grade 60 reinforcing steel will most likely not meet the aforementioned carbon equivalent requirements. However, reinforcing bars meeting ASTM Specification A706 have a low carbon equivalent, are easy to weld, and should be considered when welding is required.

12.3.1. Welding to existing rebar is generally not recommended and is prohibited without prior chemical and physical property tests having been performed to verify weldability.

12.4. Mechanical connectors are another way of connecting reinforcing bars and should be considered in lieu of welding where ever possible. Mechanical connections are permitted for reinforcing steel in accordance with the provisions of ACI 318. There are many applications that make the use of mechanical connections feasible or more practical.

12.5. The engineer shall carefully review the details in lap splice zones (including all shop drawings) to insure that adequate space is provided to permit concrete to flow between and around the reinforcing. Particular attention shall be given to coarse aggregate size and slump.

12.6. Anchorage zone concrete reinforcing should be given careful attention. Supporting members must be able to resist the forces delivered by the anchor rods. Vertical reinforcing must have sufficient development length to resist stresses delivered by the anchorage plate. Confinement reinforcing is beneficial, and transverse reinforcing can improve the shear strength of the anchorage.

12.7. Prestressing Steel: The maximum diameter for prestressing strands shall be 0.6 inches for a 2 inch minimum spacing and 0.5 inches for a 1-3/4 inch minimum spacing.

12.8. Post-Tensioning Steel Systems: Provide corrosion protection for the strands consisting of grout filled galvanized or nonmetallic ducts. Grout shall meet the requirements of PennDOT Standard Specifications. Prestressing systems shall from PTI Certified plants.

13. CONCRETE STRUCTURES PROTECTING THE ENVIRONMENT

13.1. Concrete building features that must be designed to protect the environment from chemical spills, or to protect water supplies from contamination, shall be designed in accordance with the provisions of the ACI Committee 350 Report,
"Environmental Engineering Concrete Structures". These features include tanks, reservoirs, sewers, wet wells, pump stations, and other similar structures and appurtenances. The main purpose is to minimize cracking to avoid leakage of chemicals and wastewater.

13.2. In accordance with the ACI Committee 350 Report the design strength required by the ACI 318 load factor equations shall be multiplied by a durability coefficient equal to 1.3 to obtain the required design strength for environmentally engineered concrete structures. The purpose of the durability coefficient is to reduce reinforcing steel stresses (and cracking potential) at service load conditions.

13.3. Small diameter bars at close spacing are encouraged in order to limit crack widths.

13.4. Cover requirements greater than those of ACI 318 are required to provide increased protection against reinforcing steel corrosion.

14. **STAY-IN-PLACE FORMS**

14.1. For exterior applications, metal decking where used, shall be used only as stay-in-place (SIP) forms and shall not be used in the design as contributing to the strength and capacity of the permanent structure.

14.2. Welding of forms or form supports to structural components is not permitted in tension zones for bridges.

14.3. It is preferred that the spacing of reinforcement match the spacing of the corrugations but it is not a requirement.

14.4. SIP forms must be designed for a dead load that includes the form, reinforcement and plastic concrete plus 50 psf for construction loads. Designs should also incorporate an allowance for the weight of additional concrete (15psf). In no case shall this load be less than 120 psf.

14.5. Deflection under the weight of the forms, plastic concrete, and reinforcement cannot exceed the form span divided by 180, or ½ inch, whichever is less.

15. **ELEVATED DECKS**

15.1. The design of bridge decks and other elevated concrete decks should be evaluated to determine the need for a pouring sequence. The designer should consider the effect of the plastic concrete on the girders and beams in evaluating the need for a pouring sequence. The designer must consider beam or girder deflection in developing the pouring sequence.
15.2. Deck pouring sequences must be shown on the plans, as appropriate.

16. CONCRETE REPAIRS

16.1 To achieve durable repairs it is necessary to consider the factors affecting the design and selection of repair systems as parts of a composite system. Selection of a repair material is one of the many interrelated steps; equally important are surface preparation, the method of application, construction practices, and inspection. The critical factors that largely govern the durability of concrete repairs in practice must be considered in the design process so that a repair material compatible with the existing concrete substrate can be selected.

16.2 Compatibility is defined as the balance of physical, chemical, and electrochemical properties and dimensions between the repair material and the concrete substrate. This balance is necessary if the repair system is to withstand all anticipated stresses induced by volume changes and chemical and electrochemical effects without distress or deterioration in a specified environment over a designated period of time. For detailed discussions of compatibility issues and the need for a rational approach to durable concrete repairs.

16.3 Dimensional compatibility is one of the most critical components of concrete repair. Restrained contraction of repair materials, the restraint being provided through bond to the existing concrete substrate, significantly increases the complexity of repair projects as compared to new construction. Cracking and debonding of the repair material are often the result of restrained contractions caused by volume changes. Therefore, the specified repair material must be dimensionally compatible with the existing concrete substrate to minimize the potential for failure. Those material properties that influence dimensional compatibility include drying shrinkage, thermal expansion, modulus of elasticity, and creep.

16.4 Entrapped moisture can cause failure at the bond line or critically saturate the substrate and, in the case of non air-entrained concrete, can cause the substrate to fail if it is subjected to repeated cycles of freezing and thawing. Entrapped moisture can be a particularly troublesome problem with structures that are subject to freezing and thawing. Materials with low water absorption and high water vapor transmission characteristics are desirable for most repairs.

16.5 The conditions under which the repair material will be placed and the anticipated service or exposure conditions can have a major impact on design of a repair and selection of the repair material. The following factors should be considered in planning a repair strategy.

16.5.1 Application conditions.
16.5.1.1 Geometry. The depth and orientation of a repair section can influence selection of the repair material. In thick sections, heat generated during curing of some repair materials can result in unacceptable thermal stresses. Also, some materials shrink excessively when placed in thick layers. Some materials, particularly cementitious materials, will spall if placed in very thin layers. In contrast, some polymer-based materials can be placed in very thin sections. The maximum size of aggregate that can be used will be dictated by the minimum thickness of the repair. The repair material must be capable of adhering to the substrate without sagging when placed on vertical or overhead surfaces without forming.

16.5.1.2 Temperature. Portland-cement hydration ceases at or near freezing temperatures, and latex emulsions will not coalesce to form films at temperature below about 45 °F (7°C). Other materials may be used at temperatures well below freezing, although setting times may be increased. High temperatures will make many repair materials set faster, decrease their working life, or preclude their use entirely.

16.5.1.3 Moisture. A condition peculiar to hydraulic structures is the presence of moisture or flowing water in the repair area. Generally, flowing water must be stopped by grouting, external waterproofing techniques, or drainage systems prior to repair. Some epoxy and polymer materials will not cure properly in the presence of moisture while others are moisture insensitive.

16.5.1.4 Location. Limited access to the repair site may restrict the type of equipment, and thus the type of material that can be used for repair. Also, components of some repair materials are odorous, toxic, or combustible. Obviously, such materials should not be used in poorly ventilated areas or in areas where flammable materials aren’t permitted.

16.5.2 Service conditions.

16.5.2.1 Downtime. Materials with rapid strength gain characteristics that can be easily placed with minimal waste should be used when the repaired structure must be returned to service in a short period of time.

16.5.2.2 Traffic. If the repair will be subject to heavy vehicular traffic, a high-strength material with good abrasion and skid resistance is necessary. Repairs on exterior platforms must also be able to adequately perform where subjected to snow removal by snow plows and steel snow shovels.
16.5.2.3 Temperature. A material with a coefficient of thermal expansion similar to that of the concrete substrate should be used for repairs subject to wide fluctuations in temperature. High-service temperatures may adversely affect the performance of some polymer materials. Resistance to cycles of freezing and thawing will be very important in many applications.

16.5.2.4 Chemical attack. Acids and sulfates will cause deterioration in cement-based materials while polymers are resistant to such chemical attack. However, strong solvents may attack some polymers. Soft water is corrosive to portland-cement materials. Repair materials must also be resistant to the effects of de-icing chemicals and cleaning agents.

16.5.2.5 Appearance. If it is necessary to match the color and texture of the original concrete, many, if not most, of the available repair materials will be unsuitable. Portland cement mixtures with materials and proportions similar to those used in the original construction are necessary where appearance is a major consideration.

16.5.2.6 Service life. The function and remaining service life of the structure requiring repair should be considered in selection of a repair material. An extended service life requirement may dictate the choice of repair material regardless of cost. On the other hand, perhaps a lower cost, less durable, or more easily applied material can be used if the repair is only temporary.

16.6 Considerations in selecting materials and methods. Selection of a method for repairing spalling or disintegration involves answering the following questions:

- What is the nature of the damage?
- What was the cause of the damage?
- Is the cause of the damage likely to remain active?

If the answer to this question is yes, procedures for eliminating the factors contributing to the cause of damage should be considered. For example, if poor design details have contributed to freezing and thawing damage by allowing water to pond on a structure, drainage may be improved as part of the repair. Similarly, if attack by acid water has caused disintegration of a concrete surface, elimination of the source of the acid may eliminate acid attack as a cause of future problems.

16.7 Knowledge of the future activity of a causative factor is essential in the selection of a repair method. In the example just cited, elimination of the source of acidity might make possible a satisfactory repair with Portland Cement based material rather than a more expensive coating.
16.7.1 What is the extent of the damage? Is the damage limited to isolated areas or is there major spalling or disintegration? The answer to these questions will assist in the selection of a repair material or method that is economical and appropriate for the problem at hand.

16.8 **General repair approach:** A general repair approach shall be selected which presents a comparison of the possible causes of spalling and disintegration symptoms with a repair method that may be appropriate for each case. As is true for repairing cracks, there will usually be several possible methods. The final selection must take into account the general considerations discussed above with other pertinent project-specific considerations.

16.9 For FRP structural repairs and strengthening, see Chapter 12 Section 5.

17. **DAMP AND WATER PROOFING**

17.1. Size and detail reinforcement to limit crack widths.

17.2. Provide waterstops in all underground joints and joints exposed to hydrostatic forces.

17.3. Refer to Chapter 5, Section 10 for water proofing and damp proofing requirements.

18. **SPECIAL INSPECTIONS.**

18.1. Special inspections as required by the provisions of IBC shall be performed.

18.2. Periodic special inspection during and upon completion of the placement of reinforcing steel in intermediate moment frames, in special moment frames, and in shear walls is required.

18.3. Continuous special inspection during the welding of reinforcing steel for structural members is required. All welding shall be in accordance with AWS D1.4. The welding of rebar shall be avoided wherever possible.

18.4. Periodic special inspection during and upon completion of the placement concrete in intermediate moment frames, in special moment frames, and in shear walls is required.

18.5. Periodic special inspection is required during the placement and after completion of placement of prestressing steel, and continuous special inspection is required during all stressing and grouting operations and during the placement of concrete.
18.6. Periodic special inspection is required during the placement of anchor rods, expansion anchors, and chemically grouted anchors to verify the anchor system is in conformance with approved plans and specifications.

18.7. QA/QC controls shall be in place to verify the accurate placement of all reinforcement steel, anchors, and embedments. All verification inspections shall be documented in writing, signed and dated by the inspector.

18.8. All structural concrete placed for SEPTA projects shall be inspected and tested to verify conformance with design and specification requirements to include but not be limited to: approved design mix used, slump, air entrainment, unit weight, and design strength.
CHAPTER 7
SLABS-ON-GRADE & RIGID PAVEMENTS

1. INTRODUCTION

1.1. This chapter provides design and construction requirements for industrial type (non-residential) lightly loaded slabs on grade. This Chapter also addresses to a lesser degree, rigid concrete pavements. Industrial type slabs refer to those slabs that are reinforced to minimize the number of crack control joints (maximize joint spacing). Unreinforced residential type concrete slabs, which utilize crack control joints spaced at frequent intervals to minimize cracking, are not to be used for permanent SEPTA structures.

1.2. Lightly loaded slabs on grade are those supporting stationary live loads of not more than 250 pounds per square foot, stationary concentrated line (wall) loads of not more than 300 pounds per foot, or vehicle axle loads of not more than 5000 pounds. The guidance in Section 2 and Table 7-1 in this Chapter is applicable to usual exposure conditions meaning locations other than pavements, bus garages and repair facilitates, and other areas with heavy axle or equipment loadings, where slabs are not subject to extreme climatic changes, and to typical subgrade conditions characterized by sufficient under drainage to prevent frost penetration, the absence of a wet environment, i.e., volume change due to change in moisture content is limited, and the absence of expansive soils. In addition, typical subgrade conditions are deemed to include only soils classified according to ASTM D 2487, "Classification of Soils for Engineering Purposes," as either Class ML, any of the S or G groups, or Class CH, CM, or CL having a modulus of subgrade reaction (k) of 100 pounds per cubic inch or greater. Slabs on grade may be designed to perform satisfactorily on subgrades of lower strength, but should be avoided.

1.3. Sidewalk pavement is normally governed by SEPTA’s Civil Engineering standards and local municipality requirements. Generally, sidewalks other than at driveways, ramps, or subjected to normal vehicular traffic shall be a minimum of a 4 inches thick slab. Sidewalks normally do not require steel reinforcement if synthetic fiber reinforced concrete is utilized along with adequately spaced joints. A properly prepared aggregate base shall be provided for all sidewalks.

1.4. Structural slabs shall be designed to handle all loading that may be potentially placed upon them. For slabs in areas handling pedestrian loading and snow loads, design shall include HS15 truck loading at a minimum. Reinforcing in areas exposed to weather and de-icing chemicals shall have galvanized or epoxy coated reinforcement. For slabs subjected to heavier loads, design shall include HS20 loading at a minimum.
1.5. Refer to Chapter 6 for concrete requirements.

2. BASIS FOR DESIGN – SLABS-ON-GRADE

2.1. Slabs-on-grade shall be designed for bending stresses due to uniform loads and concentrated loads and for in-plane stresses due to drying shrinkage and subgrade drag resistance. When appropriate for the type facility being designed, slabs shall be designed for the effects of warehouse loadings involving aisles, posts and racks, etc. In such instances, particular attention shall be given to the design for negative moment in aisles and fork lift wheel loads.

2.2. Proper construction methods, workmanship, and concrete mix proportioning shall follow the guidelines of ACI Committee 302 Report, "Guide to Concrete Floor and Slab Construction".

2.3. Slabs are required to have a minimum thickness of 4 inches. Station platform slabs shall have a minimum thickness of 6 inches. Table 7-1 provides the minimum thickness of slabs on grade for given maximum uniform design live loads based upon the modulus of subgrade reaction (k) being at least 100 pounds per cubic inch.

<table>
<thead>
<tr>
<th>Thickness of Slab</th>
<th>Maximum Uniform Design Live Load</th>
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<tbody>
<tr>
<td>5&quot;</td>
<td>150 psf</td>
</tr>
<tr>
<td>6&quot;</td>
<td>250 psf</td>
</tr>
<tr>
<td>8&quot;</td>
<td>400 psf</td>
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2.4. Slab thickness shall be determined in accordance with the Portland Cement Association (PCA) Publication entitled, "Slab Thickness Design for Industrial Concrete Floors on Grade" or other industry recognized method. In the PCA design process, compressive strength is converted to modulus of rupture, which is then reduced by a factor of safety to obtain the maximum allowable flexural tensile stress. The maximum allowable flexural tensile stress is then used to find the required slab thickness.

2.5. The use of proper subgrade materials and with adequate compaction is needed to ensure the serviceability of the slab.

3. BASIS FOR DESIGN – RIGID PAVEMENTS
3.1. Pavement slabs shall be designed per AASHTO and/or PennDOT standards and recommendations. Unless otherwise noted, the minimum design loads shall be AASHTO HS20-44/HS25 highway wheel loadings and shall include anticipated number of load repetitions.

3.2. The various types of rigid pavements are as noted below.

- **Jointed Plain Concrete Pavement (JPCP)** Pavement containing enough joints to control all natural cracks expected in the concrete; steel tie bars are generally used at longitudinal joints to prevent joint opening, and dowel bars may be used to enhance load transfer at transverse contraction joints depending upon the expected traffic and loading.

- **Jointed Reinforced Concrete Pavement (JRCP)** Pavement containing some joints and embedded steel mesh reinforcement (sometimes called distributed steel) to control expected cracks; steel mesh is discontinued at transverse joint locations.

- **Continuously Reinforced Concrete Pavement (CRCP).** CRCP contains both longitudinal and transverse steel. CRCP does not contain transverse joints except at construction joints. The function of the longitudinal steel is not to strengthen the concrete slab, but to control concrete volume changes due to temperature and moisture variations and to keep transverse cracks tightly closed. The function of the transverse steel is to keep longitudinal joints and cracks closed. If the steel serves its proper function and keeps cracks from widening, aggregate interlock is preserved and concrete stresses in the concrete slab due to traffic loading are reduce.

3.3. Rigid pavements for roads, streets, and open storage areas, and aprons may be either plain (non-reinforced) or reinforced concrete. AASHTO and PennDOT design procedures shall be used in determining pavement thickness. Generally, rigid pavements for SEPTA facilities should follow PennDOT standards which are Jointed Plain Concrete Pavement (JPCP). Sidewalks are normally Jointed Reinforced Concrete Pavement (JRCP).

3.4. In otherwise plain concrete pavements, steel reinforcement should be used for the following conditions:

3.4.1. **Odd-shaped slabs.** Odd-shaped slabs should be reinforced in two directions normal to each other using a minimum of 0.05 percent of steel in both directions. The entire area of the slab should be reinforced. An odd-shaped slab is considered to be one in which the longer dimension exceeds the shorter dimension by more than 25 percent or a slab which essentially is neither square nor rectangular.
3.4.2. **Mismatched joints.** A partial traffic reinforcement or slab is required where the joint patterns of abutting pavements or adjacent paving lanes do not match, unless the pavements are positively separated by an expansion joint or slip type joint having not less than ¼-inch bond-breaking medium. The pavement slab directly opposite the mismatched joint should be reinforced percentage with a minimum of 0.05 percent of steel in directions normal to each other for a distance of 3 feet.

3.4.3. **Poor sub-grade conditions.**

3.5. The design criteria for reinforced concrete pavement are subject to the following limitations.

3.5.1. No reduction in the required thickness of plain concrete pavement should be allowed for percentages of longitudinal steel less than 0.05 percent.

3.5.2. The maximum length L of reinforced concrete pavement slabs should not exceed 75 feet regardless of the percentage of longitudinal steel, yield strength of the steel, or thickness of the pavement.

3.5.3. When long slabs are used, special consideration must be given to joint design and sealant requirements.

3.5.4. The minimum thickness of concrete pavements is 6 inches.

3.5.5. The minimum thickness of sidewalks is 4 inches.

3.5.6. The minimum thickness for reinforced overlays over rigid pavements is 4 inches.

4. **SERVICEABILITY**

4.1. General: Cracking, warping, and curling can impair slab-on-grade serviceability. These problems are directly attributable to drying shrinkage. Cracking can be controlled by minimizing drying shrinkage, by providing adequate crack control and isolation joints, and through the use of reinforcing steel. Water penetrating the slab is a common serviceability problem that can be cured by proper drainage and by the use of vapor barriers.

4.2. Minimizing Drying Shrinkage: Cracking in slabs generally results from drying shrinkage and restraint caused by friction between the slab and subgrade. Curling and warping occur due to differential shrinkage when the top of the slab dries to lower moisture content than the bottom of the slab.

4.2.1. Drying shrinkage, curling, and warping can be reduced by using less water in the concrete.

4.2.2. Ways to reduce water content include using the largest maximum sized aggregate (MSA), using an MSA equal to 1/3 the slab thickness, and by using coarse sand.
4.2.3. Water content can also be reduced by using coarser ground cement and cement with a low C3A content.
4.2.4. On large and critical slab-on-grade projects, the designer should request by specification that shrinkage tests be made of several concrete mixes to obtain a mix with the lowest drying shrinkage potential.

4.3. Controlling Cracking through Control and Isolation Joints: Control and isolation joints can be used to minimize cracking and to force cracking to occur at joint locations. Designers should attempt to minimize the number of joints occurring in the slab. However, in most instances, the maximum slab area bound by crack control joints should not exceed 625 square feet, and distance between crack control joints should not exceed 25 feet.

4.3.1. The length/width ratio of panels bounded by joints should be as near 1.0 as possible and should not exceed 1.25.
4.3.2. Where extreme conditions of heat or dryness tend to produce excessive shrinkage, the maximum area and joint spacing may need to be decreased. Crack control joints may also be construction joints.
4.3.3. Joints in the vicinity of column pedestals shall be placed at column centerline, with diamond shaped or circular isolation joints provided at columns or square shape isolation joints provided at column pedestals.
4.3.4. When thickened slabs are used under column bases or partitions, joints should be offset from the thickened areas.
4.3.5. Corners of isolation joints shall meet at a common point with other joints so far as practicable.
4.3.6. Where discontinuous joints, (i.e., joints which are not continuous across their perpendicular joints), cannot be avoided, two No. 4 (#13) bars, 4 feet long, shall be placed parallel to the edge opposite the end of the discontinuous joint. Bars shall be at mid-depth and 4 inches apart starting 2 inches from edge of slab. Except for openings of less than 12 inches by 12 inches, corners of openings and reentrant corners in slabs shall be reinforced with two No. 4 (#13) bars, 4 feet long, placed diagonally to the corner.

4.4. Control Joints: Control joints form a weakened plane to direct cracking to preselected locations. Sawed control joints shall be cut to one-fourth depth of slab thickness. Control joints may be made in floors scheduled to receive a floor covering by inserting fiberboard strips in the unset concrete. Depth of fiberstrip should be one-fourth of the slab thickness.

4.4.1. Location and details of control joints shall be shown on drawings.
4.4.2. Concrete cover of 1-1/2 inches shall be provided over reinforcement.
4.4.3. One-half of the welded wire mesh reinforcement (alternate wires) shall be interrupted within 2 inches of each side of slab control joints.
4.5. Isolation Joints: Isolation joints form a separation of elements from the slab on grade and permit both horizontal and vertical relative movement. Isolation joints should be provided between the abutting faces of floor slab and fixed parts of the structure such as columns, walls, and machinery bases. At locations where slabs abut vertical surfaces, such as interior and exterior foundation walls and column pedestals, isolation joints often consist of 30-pound felt serving as a bond breaker. At exterior walls, perimeter insulation extended to the top of slab will serve the purpose. Where slabs will expand due to radiant heating systems, or extreme temperature changes, and where isolation from vibrations of machinery and equipment foundations is required, joint filler 3/8 inch or more thick shall be provided. Location and details of isolation joints shall be shown on drawings.

4.6. Construction joints: Construction joints are used to allow separate concrete placement. Construction joints should be kept to a minimum, and should generally be in conformity with a predetermined joint layout.

4.6.1. Construction joints shall have dowels, or keys to provide shear transfer. Dowel size and spacing should be in accordance with ACI Committee 302 Report, "Guide to Concrete Floor and Slab Construction."

4.6.2. Formed-keyed joints shall only be used in slabs having a thickness of 6 inches or more. In order to accommodate keyed joints in 4-inch thick slabs it is acceptable to taper the slab so the slab at joint locations is 6-inches thick. The taper should begin 3 feet each side of the joint. Preformed keys left in place may be used for 4 inch and thicker slabs. The key shall be centered on the depth of the slab with the base of the male portion about one-third the depth of the slab. Location and details of construction joints shall be shown on drawings.

4.6.3. Keyed joints or doweled joints should align with and function as a control joint or expansion joint.

4.6.4. For doweled joints lubricate one half the bar. Bar shall be hot dip galvanized or stainless steel when corrosion protection is required. The minimum dowel diameter, length, and spacing shall be per ACI 224.3R (Table 5.1 for building slabs and Table 6.1 for pavements).

4.6.5. Tied butt joints constructed with deformed rather than smooth bars shall be used when the construction joint is not at a planned control or expansion joint location. This type of joint restrains movement. As a minimum, use #4 (1/2" diameter) x 30 " long deformed tie bars spaced at 24" to 30" on centers.

4.6.6. Concrete cover of 1-1/2 inches shall be provided over reinforcement.

4.6.7. Welded wire reinforcement (sheets not rolls) shall be stopped 2 inches from each side of planned control or expansion joint locations. Welded wire reinforcement shall be continuous through tied butt joints.

5. SLAB-ON-GRADE REINFORCEMENT
5.1. Slab-on-grade shrinkage reinforcement should be located 1-1/2 inches clear from the top of the slab in order to restrain shrinkage and reduce curling.

5.2. Maximum spacing of reinforcing bars should not exceed three times the slab thickness.

5.3. The percentage of steel determined should not be less than 0.15 percent. Refer to Table 7-2 for the recommended minimum reinforcement requirements.

5.4. Deformed welded wire fabric in flat sheets, or deformed reinforcing bars shall be used.

5.5. The positioning of the steel in the slab is critical for proper crack control. Reinforcing steel shall be supported on chairs and every precaution taken to assure the reinforcing bars are positioned, as intended after construction is complete.

5.6. The engineer shall verify the availability of specified wire mesh reinforcement sizes. The use of the large bar sizes is desirable to prevent bending of the steel and provide adequate stiffness to keep the steel in the upper half of the slab during concrete placement. In those cases where the preferred wire mesh sizes listed in Table 7-2 are unavailable, wire mesh spacing with reduced bar diameters and closer spacing (alternate size) may be used provided minimum steel requirements are met. Alternately, deformed reinforcing bars may be used in lieu of WWF.

<table>
<thead>
<tr>
<th>Slab Thickness</th>
<th>Wire Mesh Reinforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preferred Size</td>
</tr>
<tr>
<td>4-inch</td>
<td>12 x 12 – D 7.5 x D 7.5</td>
</tr>
<tr>
<td>5-inch</td>
<td>12 x 12 – D 9 x D9</td>
</tr>
<tr>
<td>6-inch</td>
<td>12 x 12 – D11 x D11</td>
</tr>
</tbody>
</table>

6. VAPOR/MOISTURE BARRIERS

6.1. Concrete slab on grade construction beneath conditioned space or covered with a moisture sensitive floor covering system shall have an under slab moisture barrier.

6.2. High levels of moisture in the subgrade increase slab curling. If the subgrade can become moist because of ground water, an impermeable vapor barrier should be provided.
6.3. The minimum thickness of the vapor barrier shall be 15 mil and be covered with a 6 inches of crushed stone topped with a 1/2 inch thick layer of sand. The advantage of the 6-1/2 inch stone / sand cover over the vapor barrier is that the vapor barrier will not be punctured nor will the fill material be easily displaced as construction equipment is driven over the stone and sand cover.

6.4. Under slab vapor barriers shall have a perm rating at least equal to the applied floor covering system inclusive of its adhesive.

6.5. If the only purpose of the vapor barrier is to reduce friction between the slab and subgrade in order to reduce drag, then a polyethylene slip sheet can be placed directly under the slab provided holes are punched in the polyethylene to allow water to leave the bottom of the slab before final set occurs in the concrete.

7. **EXTERIOR SLABS ON GRADE**

7.1. Exterior slabs on grades supporting pads for equipment, sheds, or light buildings shall have thickened perimeter (integral perimeter turndown walls) extending to frost depth. Refer to figure 7-1.

7.2. The minimum width of the walls is 8 inches at the base. This is provided for frost protection and to prevent curling.

7.3. The bottom of the wall shall have a minimum of one #4 continuous bar.

7.4. The thickened slab shall also be provided where the slab will support masonry walls.
FIGURE 7-1
TYPICAL SECTION - EXTERIOR PAD
CHAPTER 8
MASONRY

1. INTRODUCTION.

This Chapter provides design guidance for reinforced masonry structures. Plain (unreinforced) masonry design and design using "empirical" methods are generally not permitted except for minor buildings that are normally not occupied.

2. BASIS FOR DESIGN.

2.1. All masonry design for SEPTA projects will be reinforced masonry.

2.2. Reinforced masonry shall be designed per ACI 530/ASCE 5, “Building Code requirements for Masonry Structures” and IBC. Special design and detailing requirements for masonry structures subjected to earthquake ground motions are provided in FEMA 368, "NEHRP Recommended Provisions for Seismic Regulations for New Buildings. Designers must be aware of, and should comply with all seismic design and detailing requirements.

2.3. For segmental retaining walls, see Chapter 15.

2.4. All CMU walls, whether interior or exterior, load bearing or non-load-bearing, shall be designed and constructed using load bearing concrete masonry units conforming to ASTM C90. The use of hollow and solid non-load-bearing units per ASTM C129, intended for use in interior bearing partitions, are not recommend in SEPTA projects.

3. SERVICEABILITY

3.1. Detail masonry structures to prevent efflorescence, and to prevent cracking due to shrinkage and temperature movements.

3.2. Large expanses of roof deck with supporting systems rigidly attached to masonry walls, pilasters, or columns can result in cracking due to thermal changes that take place during construction. Designers should therefore include provisions in the design to accommodate thermal movement both during and after construction.

3.3. Control joints and expansion joints shall be used to control cracking due to shrinkage and thermal movement. The joints should permit movement but have sufficient strength to resist required loads. Joints should be weather tight when located in exterior walls.
3.4. All embedded steel lintels and frames shall be hot dipped galvanized.

3.5. Adequate control joint spacing (not greater than 25 feet) and horizontal reinforcement shall be provided for above grade exposed walls. Either the empirical crack control criteria or the engineered crack control criteria may be used.

4. LOAD PATH INTEGRITY

4.1. Information on the design and detailing of connections between shear walls (vertical resisting elements) and floor and roof diaphragms (horizontal resisting elements) are provided in FEMA 368.

4.2. The design of headed anchor rods and bent-bar anchors embedded in masonry, and used to connect diaphragms and structural members to masonry, shall be in accordance with FEMA 368 Paragraph 11.3.12, "Headed and Bent-Bar Anchor Bolts" and the IBC.

5. DETAILING

5.1. Elevations of all masonry walls showing all openings, lintels, bond beams, horizontal and vertical reinforcement and control joints shall be shown on the drawings, including horizontal and vertical dimensions of wall panels, openings, etc. Elevations shall indicate all portions of the masonry wall that are piers or columns, and indicate the required details.

5.2. In structures with CMU structural and partition walls, all horizontal and vertical block layout dimensions shall be based on coursing using an 8 inch module when using imperial or English (IP) units for design (200mm module when using hard metric design). This includes all dimensions for openings as well as the total wall.

5.3. Walls adjacent to driving surfaces and not otherwise protected shall be fully grouted with vertical reinforcement. Provide a bond beam located between 36 inches and 48 inches above the finished floor or driving surface.

5.4. Single wythe CMU walls permanently exposed to weather shall be fully grouted.

5.5. The preferred method of construction of double wythe walls is that the wythes be brought up together. Often specifications prohibit the use of adjustable ties to prevent the construction of one wythe independent of the other, and to require that the wythes be brought up together. Because of efflorescence problems, double
wythe construction with grout fill between wythes is not recommended for SEPTA buildings.

5.6. In structural reinforced load bearing CMU walls, vertical reinforcing bars shall be hooked into the top horizontal bond beam at the roof level with a standard ACI 90 degree hook for resistance to roof uplift loads.

5.7. Structural CMU walls shall be placed in running bond pattern only. Stacked bond pattern for structural walls is not permitted.

5.8. All horizontal reinforcement in exterior walls shall be either galvanized or epoxy coated. For exterior walls, the reinforcement shall be hot dipped galvanized (recommended) or epoxy coated.

5.9. The use of thin brick veneer is not permitted.

6. SPECIAL INSPECTIONS

6.1. Inspections and special inspection as required by the provisions of IBC and ACI 530 shall be performed.

6.2. Provisions for periodic special inspections shall be addressed for the following:

- During the preparation of mortar, the laying of masonry units.
- Inspection of vertical, horizontal, and bond beam corner reinforcement.
- Continuous special inspection during the welding of reinforcement, grouting, consolidation, reconsolidation and placement of anchors (bent bar or anchor rods).
CHAPTER 9
STEEL STRUCTURE DESIGN
REQUIREMENTS

1. INTRODUCTION

This chapter prescribes criteria for the design of structural steel, open web joists, and cold-formed steel structural members.

2. GENERAL

2.1 Structural framing systems and elements of buildings and structures shall be designed in accordance with AISC, IBC, and accepted industry standards. The type of steel and unit dimension, (bay size, story, height, etc.), the system for structural framing, and the design method used shall be based on a comparative economic study and will be those that result in the least cost for the required structure.

2.2 The design and fabrication of structural steel for railroad and rail transit bridges shall be per the requirements of AREMA Manual of Railway Engineering, Chapter 15.

2.3 The design and fabrication of structural steel for other bridges shall be per the requirements of AASHTO and PennDOT.

3. BASIS FOR DESIGN

3.1. Structural Steel Construction: The design, fabrication and erection of structural steel for buildings and other structures shall be in accordance with per AISC using either Load and Resistance Factor Design (LRFD) or Allowable Stress Design (ASD) per AISC 2005 Manual of Steel Construction (or latest).

3.2. Structural Steel for Bridges: The design and fabrication of structural steel for railroad and light rail bridges shall be per the requirements of AREMA Manual of Railway Engineering, Chapter 15. The design and fabrication of structural steel for other bridges shall be per the requirements of AASHTO and PennDOT.

3.3. Welding shall conform to the requirements of the American Welding Society (AWS) as modified by AREMA and AASHTO for bridges.
3.4. Cold-Formed Steel and Light Gage Steel: The design of cold-formed carbon and low alloy steel structures shall be per ANSI Cold-Formed Steel Design Manual (SG03-2) including the "Specification for the Design of Cold-Formed Steel Structural Members" (SG02-1). The design of cold-formed stainless steel members shall be in accordance with ASCE 8, "Specifications for the Design of Cold-Formed Stainless Steel Structural members.

3.5. Metal deck: The design of metal decking shall follow the Steel Deck Institute (SDI), "Design Manual" and "Diaphragm Design Manual".

3.6. Composite slabs of concrete on steel deck shall be designed and constructed in accordance with ANSI/ASCE 9, "Standard for the Structural Design of Composite Slabs".

3.7. FEMA 350 – “Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings” focuses on design and construction standards for new steel structures. The recommendations address the type of steel used, the way that columns and beams are connected, the way the steel is fabricated, the type of welding that is performed and techniques that are used to assure that the work is performed properly. Based on FEMA recommendations, these guidelines should be followed as appropriate when developing new structures for SEPTA facilities.

3.8. Steel Joists: The design, manufacture, and use of open web steel joists and joist girders shall be in accordance with one of the following Steel Joist Institute (SJI) specifications: Standard Specifications for Open Web Steel Joists, K Series; Standard Specifications for Longspan Steel Joists, LH Series, and Deep Longspan Steel Joists, DLH Series; or Standard Specifications for Joist Girders.

3.9. Steel Cables Structures: The design, fabrication, and erection, including related connections, and protective coatings of steel cables for buildings shall be in accordance with ASCE 19, "Structural Applications of Steel Cables for Buildings” except as modified as follows for seismic design:

ASCE 19 shall be modified per the requirements of IBC Section 2207.2 – Seismic Requirements.

3.10. For railroad and light rail catenary structures, see Chapter 14 for additional requirements.

3.12. For communication and antennae support structures, see Chapter 17 for additional requirements.

3.13. Bolted connections shall be designed per RCSC “Specification for Structural Joints Using ASTM A325 or A490 Bolts” as modified by AREMA and or ASSHTO as applicable. Use ASTM A325 bolts wherever possible. The use of A490 bolts requires prior SEPTA Engineering approval. Any request to use A490 bolts shall include a thorough technical evaluation and justification. The use of ASTM A394 Steel Transmission Tower Bolts are acceptable as applicable for transmission tower type structures.

4. SERVICEABILITY

4.1. AISC Specification for Structural Steel Buildings provides design guidance with respect to the following serviceability related issues:
   - Camber
   - Expansion and contraction
   - Deflection, vibration and drift
   - Connection slip
   - Corrosion

4.2. Camber. Camber is important especially in bridges, catenary span beams, long girders and beams, and truss type structures. In general, however, the use of camber to offset dead load deflections in long span beams, girders, and joists has limited benefits with respect to building serviceability. Camber however can improve the appearance of structures where the support systems are exposed to view as well as in installation of the structure.

4.3. Expansion and Contraction. Expansion joints should be provided when necessary to minimize detrimental effects resulting from the lateral movement of long structures due to thermal expansion and contraction.

4.3.1. For non-rectangular steel-framed buildings, generally the maximum allowable building length without an expansion joint (or maximum length between expansion joints) is 300 feet for moderate climates (temperature change less than 30°F). This decreases to 200 feet for extreme climates (temperature change greater than 70°F). These distances may be increased for rectangular buildings, however, they should be decreased if the building is unheated, if the building is air conditioned, or if the building has fixed-base columns. A double column arrangement is the preferred method of establishing an expansion joint. Additional joints may be required at the junctures of T-, L-, U-shaped and other irregularly shaped
buildings, or when foundation conditions create a potential for differential settlement.

4.3.2. Expansion joints should extend entirely through the building, completely separating it into independent units.

4.3.3. Expansion joints should be carried down through the foundations.

4.3.4. The design and installation of other structural, architectural, mechanical, and electrical components and structures shall allow for and account for expansion joint movement.

4.4. Deflection, Vibration and Drift. Displacements of structural framing system under service load conditions must be controlled to prevent damage to various architectural features such as interior walls, partitions, ceilings, and exterior cladding.

4.4.1. Deflection limits, expressed as a function of span length, are provided in various codes (AISC, AISI, MBMA, etc.).

4.4.2. Deflection limits for catenary support structures shall be per AREMA. Refer to Chapter 14 for additional information.

4.4.3. Deflection limits for bridges shall be per AREMA or AASHTO as applicable.

4.4.4. Drift limits for earthquake loadings are provided in FEMA 368.

4.4.5. Designers should verify the deflection and drift limits imposed by code are suitable. Drift limits more stringent than those imposed by FEMA 368 may be warranted for those conditions where non-ductile cladding is used.

4.5. Connection Slip. When connection slip can cause a significant displacement increase in the framing system and thereby raise concerns about building serviceability, the use of slip critical connections should be considered. Other reasons for using slip-critical connections are provided in Section 6 of this chapter.

4.6. Steel Properties: Strength and ductility are properties important to building performance. Ductility is dependent on the yield strength and chemical composition of the steel. Designers must select steels that meet needed strength and ductility requirements. Designers specifying ASTM A36 steel must consider the impact a higher yield strength will have on the seismic design if substituted by the fabricator and make sure the substitution does not adversely impact seismic performance. Connections designed to develop the strength of the connected members may not perform as intended if the connected members were specified to be ASTM A36 steel and the contractor elected to substitute members of ASTM A572 Grade 50 or ASTM A992 steel.

4.7. For bridges and elevated structures, the design and detailing should minimize live load stresses in sections. Methods such as extending cover plates should be employed.
4.8. When appropriate, an increased thickness, i.e., corrosion or wear allowance, shall be used to attain the required service life. Refer to Sections 5 and 7 of this chapter for additional SEPTA specific requirements.

4.8.1. Exterior steel sections directly embedded in concrete shall be provided with 3/8" thick rust plates extending not less than 6" above and below the top of concrete.

4.8.2. The total thickness of design sections subject to wear should be increased beyond that required to meet stress requirements. The amount of such increase shall be based on the material involved, the frequency of use, and the designed service life. Estimates of the wear requirement shall be based on previous experience or accepted practice for the application. Use of replaceable wear plates should be considered where extremely severe conditions exist.

5. CORROSION PROTECTION

5.1. Corrosion protection is less of a problem in structures that have been designed to provide good drainage, designed to provide air circulation, and designed to provide access for maintenance. Paint systems and zinc coatings applied by the hot dip process or by spray on process are all good corrosion protection systems when metal surfaces are prepared properly and the coating systems are applied properly.

5.2. Corrosion can reduce structural capacity as well as cause serviceability problems. Painting of structural steel shall comply with the requirements contained in AISC, IBC, AASHTO, or AREMA as applicable. Except where fabricated of approved corrosion resistant steel or of steel having a corrosion resistant or other approved coating, individual structural members and assembled panels of cold-formed steel construction must be protected against corrosion with an approved coat of paint.

5.2.1. All steel embedded in concrete or masonry shall be hot dip galvanized for its entire length per ASTM A123 or A153 as applicable.

5.2.2. Exterior steel and steel exposed to corrosive environments or deicing chemicals shall be hot dip galvanized per ASTM A123 or A153 as applicable. A duplex coating system may be required where painting of the steel is required for aesthetic considerations or for additional protection. Refer to paragraph 5.4 for requirements.

5.2.3. Boldly exposed steel for bridges or catenary structures may be fabricated of approved corrosion resistant (weathering) steel where aesthetics is not an issue. It is recommended that the bearing area of bridges and the bottom 2 feet of catenary structures be painted for additional corrosion protection.
5.2.4. For weathering steel bolted connections, the faying surfaces shall have a one-coat paint system consisting of a high-quality air-drying rust-inhibitive shop-primer meeting AISC/RCSC slip resistance requirements. The primer shall be applied to a nominal dry film thickness of 1.5 to 2 mils. Additionally, limits on bolt spacing per AISC, AASHTO, and AREMA as applicable shall be followed. Plain or galvanized bolts should not be used in weathering steel connections.

5.2.5. Hollow steel members (HSS) and fabricated box sections should be sealed to prevent entry of moisture. If this is not possible, provisions must be made to insure adequate drainage and ventilation.

5.2.6. Where extremely corrosive conditions exist, consideration should be given to providing cathodic protection in addition to protective coatings.

5.2.7. Exterior railing, handrails, fences, guardrails, and associated anchor rods shall be galvanized or constructed of stainless steel. Interior railing, handrails, fences, guardrails, and associated anchor rods within 3 feet of a finished floor where subjected to water, deicing chemicals, or cleaning agents should also be galvanized or constructed of stainless steel.

5.3. Steel not galvanized or fabricated using weathering steel shall be provided with an appropriate paint system or metallizing following Society for Protective Coatings (SSPC) guidelines. Selection of the paint system shall take into consideration project specific requirements and the following:

- Corrosion Protection
- Abrasion Resistance
- Graffiti Resistance
- Appearance
- Gloss Retention
- VOC Content
- Slip Resistance
- Fire Resistance

5.4. Coatings shall be specified as a system including surface preparation. The selection of a coating system should follow the guidance in Chapter 1 of the SSPC Painting Manual

5.4.1. The coating system shall be selected based upon the anticipated exposure and the corresponding SSPC environmental zone. The minimum coating system for all steel including interior encased steel, shall be selected based upon a SSPC environmental zone of 1A or 1B.

5.4.2. The selection of the coating system must assume infrequent or minimal maintenance.

5.4.3. The faying surface of all exterior (exposed) bolted connections that are not hot dip galvanized shall be painted. All paint on faying surfaces shall
comply with the slip resistance classifications set forth in AISC and RCSC’s “Specification for Structural joints using ASTM A325 and A490 Bolts”.

5.4.4. For exposed steel in public spaces. A SSPC PS-17 (urethane) paint system is recommended.

5.4.5. For bridges and structural elements in a corrosive environment where not hot dip galvanized or weathering steel, a SSPC PS-12 (zinc-rich) with topcoat system is recommended. The bearing area of weathering steel bridges shall also receive this coating system for an area within the distance of not less than 1½ times the depth of the girder.

5.4.6. Where exterior steel is required to be painted, a duplex coating system of hot dip galvanizing and paint shall be used.

5.4.7. Where galvanized steel is to be painted, surfaces shall be properly prepared in accordance with AGA and the paint manufacturer's written recommendations. Apply wash primer, compatible with galvanizing and selected paint system, or brush-off blast the entire surface. Do not use steel shot for brush-off blast. Use a blast media with a low level of aggressiveness, such as crushed walnut shells, corn cobs or bi-carbonate of soda (for example but not inclusive), hydro sand blasting or similar method. Surface must be dry and free from dust, dirt, oil, grease or other contaminants. There shall be absolutely no "QUENCHING" of galvanized material that is to be painted.

5.4.7.1. The recommended paint system consists of the following:

- SSPC-SPI solvent clean galvaprep #5.
- Prime coat surface with 4-5 mils DFT of high build polyamide epoxy
- Intermediate and top coat shall be 2-3 mils DFT aliphatic polyurethane.
- Total milage of the coating should not be less than 8-11 mils dry film thickness.

5.4.8. For field applied coating systems, the season and ambient conditions, moisture content of the steel, and temperature of the steel must be taken into consideration when selecting and specifying surface prep and coating. The duration between coats shall also be considered in selecting the paint type and system.

5.4.9. For existing exterior steel structures and steel in a corrosive environment, the recommended system is a PennDOT approved self-curing, inorganic, zinc system consisting of a self-curing, inorganic zinc primer, an intermediate coat, and a finish coat. It is critical to obtain the proper surface prep. Where blast cleaning is not feasible, consideration must be given to using a “Noxyde” or similar rusty metal type primer. Optimal weather conditions are also critical in achieving a lasting and effective
coating. These conditions must be clearly addressed in the project specifications and strictly adhered to in the field.

5.5. The materials and methods of other trades and design disciplines need to be reviewed and verified that they do not adversely affect the corrosion protection and serviceability of structural elements. The use of screws and powder actuated fasteners into tube steel (HSS) have resulted in severe corrosion problems and the infiltration of moisture (water) into the interior of the sections. For these reasons, the use of screws and powder actuated fasteners into exterior (exposed) tube steel (HSS) is prohibited on all SEPTA projects.

5.6. The higher the strength of the steel, the more sensitive the material becomes to both stress corrosion and hydrogen stress cracking. A490 bolts are more susceptible to brittle fracture than A325 bolts. SEPTA recommends that A325 bolts be used wherever possible. The use of A490 bolts should be thoroughly evaluated prior to being included in a structure and justification for their use provided to SEPTA.

5.7. The designer shall be aware of the possibility of stray current induced corrosion of steel structures that is often associated with electrified rail transit systems. Steps shall be taken to eliminate or reduce this corrosion including grounding of all steel structures.

6. CONNECTIONS AND LOAD PATH INTEGRITY

6.1. Connections between framing elements are critical. They must perform at limit state and service load levels as intended to assure load path integrity is maintained during extreme loading events. Under service loading conditions, connection displacements and rotations should not lead to serviceability problems. Connections can be welded or bolted, although field welding of exterior connections should be minimized to the maximum extent possible.

6.2. Where connections are specified to be designed by others, the drawings shall indicate all required information and governing forces. Where connections are designed by the engineer of record, they drawings shall show all dimensions and comprehensive connection details requiring no further engineering input. Under these circumstances, the engineer retains full responsibility for these connections. The engineer shall consider the design of the connections when sizing the structural members (e.g. HSS truss joints, column size, post-tensioned anchorages, etc.).

6.3. Design of Connections for Wind and Seismic Loads: Connection design philosophy is different for earthquake than it is for wind. Connections used to resist wind load are designed to perform in the elastic range. Connections used to resist
earthquake loads, although designed in a fashion similar to that for wind load, are expected to experience forces greater than the code level design forces. This requires that earthquake resistant connections perform in a ductile manner. Under certain circumstances, such as moment frame connections, bearing connections may be desirable for wind load, but slip-critical connections may be recommended to resist earthquake loads.

6.3.1. There are significant differences between the strengths allowed for shear-bearing, and slip critical bolts. Therefore, the designer must check both wind and seismic loading conditions to make sure the connection satisfies both shear-bearing and slip-critical requirements.

6.4. Shear-bearing Type Connections: In a shear-bearing type connection, shear forces are transferred through the connection by bolts that act in shear. The connected material is in bearing adjacent to the bolts and must be evaluated for its load bearing capacity. Bolt shear strength is about 62 percent of the bolt-ultimate tensile strength. It should be recognized that all shear and moment connections at ultimate load conditions act in shear-bearing whether they are designed as shear-bearing connections or as slip-critical connections. The bolts in shear-bearing type connections are installed "snug tight" since shear strength in this type of connection is not related to the pretension load in the bolt.

6.5. Slip Critical Connections: Slip critical connections transfer shear load by shear-friction with the normal force provided by pretensioning the bolts. The shear strength at service load levels is dependent on the pretension load (normal force on joint) and the friction between joined materials.

6.5.1. Slip-critical connections are generally required when loads are repetitive and fatigue is a concern, where connection slip would effect structure performance, and where bolts and welds must act in unison to resist applied loads.

6.5.2. The use of slip-critical connections may add have a significant cost impact to a project. The need for slip-critical connections must be carefully evaluated.

6.5.3. Slip critical connections are recommended for earthquake resistant beam-column connections where web connections are bolted and flange connections are welded. Slippage of the bolts in these type connections can increase loads on the flange welds resulting in connection failure.

6.5.4. The engineer shall keeping mind that the ultimate load capacity of a slip-critical connection is the capacity of the bolts loaded in shear/bearing. If slip-critical bolts in the web connection of a moment resistant joint are too near the yielding flanges, the bolts may experience sufficient force to slip into a shear/bearing type of response, which may have a lower capacity than the slip-critical type of response.
6.6. **Bolts in Direct Tension:** When bolts act in tension to resist applied loads, the possibility of, and the effect of prying action on bolt tension must be considered.

6.7. For welded connections, see Section 8 of this Chapter.

6.8. Torsional loads shall be avoided where possible. If this cannot be avoided, then the beams shall be designed for torsion.

6.9. The use of powder actuated fasteners is not permitted with existing steel, hollow steel members, or locations exposed to weather or a corrosive environment. Other locations and uses require a case by case approval of the Chief Engineer or designee.

### 7. **STEEL DETAILING**

7.1. The detailing of structural steel framing, including connections, shall be complete. All weld types, weld sizes, bolting layouts, bolt sizes, connection plates and members sizes and locations and stiffener plates sizes and locations shall be shown. Elevations of steel frames used in the lateral load resisting system shall be shown on the drawings.

7.2. Field welding of connections should be minimized to the maximum extent possible.

7.3. For live load structures, high strength bolting is preferred over welding for all connections.

7.4. For bridges, enough vertical and horizontal space shall be provided between the superstructure and the substructure to accommodate the jacks required for bearing replacement. As a rule-of-thumb a minimum vertical clearance of 6 inches is suggested. For steel girders the web stiffeners of the end diaphragm must be located accordingly. Connections between bearings and shoe plates should be bolted and not welded.

7.5. **Minimum plate thickness and member thickness is 3/8 inch for bridges and exterior columns.** For prefabricated pedestrian truss bridges and other exposed steel, the minimum thickness shall be ¼ inch.

7.6. All bolted structural connections shall utilize ASTM A325 bolts. The use of A490 bolts is not recommended. The use of ASTM A394 Steel Transmission Tower Bolts is acceptable for transmission tower type structures.

7.7. Outstanding legs of angles shall face down.
7.8. The detailing of members and assemblies should avoid pockets, crevices, faying surfaces or locations that can collect and retain water, damp debris, or moisture or hinder the effectiveness of coating systems. Pockets or depressions in horizontal members should have drain holes to prevent water from ponding in low areas.

7.9. Box-shaped members should be designed so that all inside surfaces may be readily inspected, cleaned, and coated, or should be closed entirely to prevent exposure to moisture.

7.10. Hollow steel members should be hermetically sealed when possible to prevent entry of moisture. If this is not possible, provisions must be made to insure adequate drainage and ventilation. In the past, SEPTA has had problems caused by water being trapped inside of tubular, pipe, and HSS members leading to the member rusting from the inside and members splitting due to freezing.

7.11. Where the appearance of exposed tubular, pipe, and HSS members is a criteria, consideration shall be given to requiring seams and/or mill marks being located away from the prevalent field of view.

7.12. Bridge structures shall be designed to permit inspection and accommodate fall protection devices. The bottom flanges of parallel beams or girders shall have a clear width of not less than 18 inches to permit inspection.

7.13. The flanges of two (back to back) angle members, when not in contact, should have a minimum separation of \( \frac{3}{8} \) inch to permit air circulation.

7.14. Positive drainage should be provided away from exposed steel. Column bases should be terminated on concrete curbs or piers above grade, and tops of curbs or piers shall be pitched to drain. Detail exterior steel to eliminate geometries that serve as water or debris traps.

7.15. The detailing of weathering steel structures should be based upon the recommendations outlined in FHWA Technical Advisory T-5140.22, "Uncoated Weathering Steel in Structures".

7.16. The use of self tapping or self drilling screws and powder actuated fasteners on fatigue sensitive or fracture critical members is prohibited on all SEPTA projects.

7.17. In the past, SEPTA has had maintenance problems caused by galvanizing and detailing deficiencies. A number of tubular, pipe, and HSS members have rusted severely from the inside because of incomplete zinc coverage. The details provided insufficient openings to allow a free flow of zinc within the tubes, resulting in certain areas being coated with pickling acid rather than zinc. Additionally, details have permitted the ponding and trapping of water inside of tube structures. Detailing of tube structures shall address and prevent these problems.
7.18. Dissimilar metals, (e.g., aluminum and steel, stainless steel and carbon steel, zinc coated steel and uncoated steel) should be isolated by appropriate means to avoid the creation of galvanic cells which can occur when dissimilar metals come in contact. The affect of stainless steel fasteners on carbon steel structures which are often used to attach roofing decks and metal wall panels must also be evaluated.

7.19. The following measures should be considered to mitigate potential fatigue and fracture problems.

7.19.1. Provide ample fillets to avoid stress risers.
7.19.2. Use bolted joints whenever possible.
7.19.3. Where welded joints are used, take precautions to eliminate gas and impurities in welds. Proper weld design per AWS as well as preheating and post cooling are essential.

8. STRUCTURAL WELDING

8.1. A weldment may contain metals of different compositions, and the components of the framing system may be rolled shapes, pipes, tubes, or plates. In general, all metals are weldable, but some are much more difficult to weld than others. Certain types of reinforcing steels used in concrete and masonry construction can be very difficult to weld.

8.1.1. Various types of joints are used to connect framing components, including butt joints, corner joints, edge joints, lap joints, and T-joints. Various types of welds are used in joining steel components together, and several different welding processes can be used to make the weld.

8.1.2. Structural engineers involved in the design of weldments must be familiar not only with the various types of joints and types of welding procedures, but also with the effect welding position has on the selection of welding procedures, and with the effect factors such as base metal composition, electrode selection, preheat and interpass temperature, wire feed speed, travel speed, post weld treatment, ambient temperature, etc., have on weld performance.

8.1.3. Volume and shape change effects due to temperature gradients that occur during welding, joint restraint conditions, and weld toughness are factors which must be considered to assure weldments are free from cracks that could reduce joint capacity and ductility and well as maintaining shape and fabrication tolerances.

8.1.4. Corner joints and poor weld termination can cause stress concentrations that can also lead to weldment cracking.
8.2. Weldments shall comply with the American Welding Society (AWS) AWS D1.1 or AWS D1.5 as applicable.

8.2.1. Welding electrodes shall be specified as low hydrogen.
8.2.2. AWS contains many prequalified joint details that are known to produce quality weldments when fabricated in accordance with AWS Welding Procedure Specifications (WPS). These shall be used to the greatest extent possible.
8.2.3. WPS’s are required for all welding, including prequalified procedures.

8.3. Welding positions include the flat position, the horizontal position, the vertical position, and the overhead position. Certain welding processes have limitations on which welding positions can be used. The structural engineer designing the weldment must be familiar with these restrictions, and make sure the type of weldment specified can actually be applied as intended considering access conditions, weld position, and any environmental conditions that could adversely influence weldment fabrication.

8.4. Certain types of welds are not permitted to join members that may experience cyclic loadings due to earthquake ground motions, vibrations from trains, or due to vibratory motion caused by equipment.

8.4.1. Partial penetration butt joints in tension, intermittent groove welds, and intermittent fillet weld are examples.
8.4.2. Special Moment Resisting Frames (SMRF’s) and Ordinary Moment Resisting Frames (OMRF’s) used for earthquake resistance must be capable of performing in the nonlinear range (beyond yield) during major earthquakes. For SMRF’s this means the weldments designed for beam column joints must have greater strength than the connected members so that yielding occurs in the beam span away from the beam column joint.
8.4.3. Welded steel frame design for seismic resisting moment frame systems is covered by the American Institute of Steel Construction (AISC), Seismic Provisions for Structural Steel Buildings”.
8.4.4. Welding to the tension zones on main load carrying members on bridges, bridge like structures, and other elevated transit structures is prohibited.

8.5. The selection of weld type and details shall take into consideration the required coating system. Certain types of welds such as intermittent fillet welds are not recommended where the member will be hot dip galvanized.

8.6. Base metals selected for components of the structural framing system must possess certain strength and ductility characteristics. It is important that the electrodes for joint weldments, as well as welding procedures, be selected to produce a joint with strength and ductility properties equal to, or superior to, those of the base metal.
8.7. The use of intermittent fillet welds should be avoided in galvanized structures, weathering steel structures, and structures exposed to water or weather.

8.8. Field welding of galvanized steel and painted exterior steel structures should be avoided to the greatest extent possible.

8.9. Welding to existing steel (and iron) structures is generally not recommended and is prohibited without documentation of the steel material properties and/or prior chemical and physical property tests having been performed to verify weldability, compatibility, and any specific weld procedure requirements. The WPS’s for welding to existing steel shall address the existing steel properties. Refer to Section 11 in this Chapter for additional requirements.

8.10. The use of welded connections should be minimized for all live load structures.

8.11. Fatigue

8.11.1. Consideration shall be given to the effect of stress levels caused by the passage of vehicles over structures. Over the life of the structure, not less than 2 million cycles shall be used to determine the allowable range.

8.11.2. Details defined as Category D or E are not acceptable for new designs including repairs and rehabilitation projects.

8.11.3. Members and fasteners shall be detailed to reduce the effect of repeated variations or reversals of stress due to out-of-plane deformations or secondary forces.

8.11.4. Girder or floor beam flanges inserted through a slot cut in the web of an intersecting member and then welded to one or both sides of the web to provide continuity are not acceptable.

8.11.5. Consideration shall be given to the effect of cyclic movement in high mat lighting poles and similar structures due to wind and other loads.

8.12. Cracking can occur due to environmental factors such as the presence of moisture, and low ambient temperatures. Field welding should be avoided as much as possible. However, when field welding is required, especially under adverse environmental conditions, it is important that AWS welding specification procedures be followed to the letter. Preheating and inter-pass temperatures are critical if cracking is to be prevented. Preheating also helps to drive of excess surface moisture, and retards the cooling rate thereby minimizing temperature gradients. Controlling cool-down rates, especially during cold weather, is critical if cracking is to be eliminated. These shall be addressed in the Project documents.

8.13. Continuous special inspection is required for all structural welding, except periodic special inspection is permitted for single pass fillet or resistance welds and welds loaded to less than 50 percent of their design strength provided the qualifications of
the welder and the welding electrodes are inspected at the beginning of the work and all welds are inspected for compliance with the approved construction documents at the completion of welding and prior to painting or coating.

9. **STEEL JOISTS**

9.1. For steel joist design, use Standard Specification, Load Tables, and Weight Tables published by the Steel Joist Institute (SJI).

9.2. Open web and long span steel joists are designed as laterally supported simple beams under vertical uniform gravity loading. For any other condition, the joist manufacturer must be required to provide the certified design of the joist. The engineer shall provide the desired joist depth and spacing along with the required loading diagrams for both upward and downward loadings. The engineer shall require the manufacturer to select and certify the joist design for the loads specified on the drawings.

9.3. Open web steel joists used on sloping roofs or floors that exceed a slope of 1/2 inch vertical on 12 inches horizontal (1:24) shall be designed by the manufacturer for that slope. The design shall include the effects of axial loads that result from load components acting parallel to the slope.

9.4. The bottom chord of open web steel joists shall not be extended to supporting members except as specifically shown on manufacturer’s shop or erection drawings.

9.5. The bottom chord of open web steel joists shall not be used to support suspended loads.

9.6. Field welding to the bottom chord of open web steel joist is not permitted, except as expressly permitted in writing by the joist manufacturer.

10. **GROUNDING**

10.1. Provisions shall be made for the grounding of all steel structures associated with electrified rail transit facilities including but not limited to bridges, catenary structures, support steel, canopy framing, hand and guard rails. In addition to grounding for electrical and safety reasons, grounding may be required to reduce the affects of stray current corrosion.

10.2. For SEPTA facilities along AMTRAK territory, AMTRAK grounding requirements shall be followed.
10.3. Grounding shall conform to the requirements of the National Electric Safety Code (NESC), the National Electric Code (NEC), and SEPTA standards.

10.4. Provisions for either a standard NEMA 2 hole bolted ground wire connection or a Cadwelded connection shall be provided in the details. Bonding jumpers or straps shall be noted where appropriate. Tubular steel catenary and electrical transmission and substation structures shall be provided with a NEMA 2 hole bolted grounding lug.

11. MODIFICATIONS TO EXISTING STRUCTURES AND BRIDGES

11.1. General

11.1.1. The methods used to accomplish the repair, strengthening, or retrofitting of steel structures to correct damage or deficiency or other modifications may be different in terms of acceptable details, allowable stresses, and acceptable results depending on the type of structure and the type or intent of the repair. What may be acceptable for the emergency repair of accidental damage to a structure to restore traffic may not be acceptable for permanent repairs.

11.1.2. While this section primarily addresses bridge and bridge type structures, the intent of these requirements can and should be applied to other type structures as applicable.

11.1.3. The decision to repair, strengthen, retrofit, or to replace a structure should take into account the condition of the structure, the age of the structure, the material of which the various members are made, the fatigue effect of the live loads that have been operated over the structure, the comparative estimated costs, the added length of life to be obtained from the modified structure, and the possible future increase in the live loading.

11.1.4. An initial assessment of the bridge or structure shall be conducted to identify all damaged or deteriorated members and to determine if the extent of damage or deterioration warrants the implementation of load restrictions, speed restrictions, or other actions as may be appropriate.

11.1.5. The physical condition of the structure shall be determined by inspection.

11.1.6. The materials of which the members are made shall be determined together with their relevant properties. While this information may be determined by examining the drawings, specifications, or test records, in some situations it may be necessary to obtain test coupons from the structure or to employ appropriate field testing.

11.2. Design of Repairs

11.2.1. The permissible stresses in repaired, strengthened, or retrofitted members shall be in compliance with the design stresses specified in applicable...
codes and standards noted in Section 3 of this Chapter. In certain circumstances, rating stresses for bridges as specified in AREMA or AASHTO, or other stress levels, may be used as determined by the Engineer of Record and SEPTA Engineering.

11.2.2. The requirements and recommendations of AREMA for the repair, strengthening, or retrofitting of steel structures shall be followed for all railroad and rail transit structures.

11.2.3. In adding metal to stringers, floorbeams, or girders, or to members of trusses and viaducts, the new material shall be considered effective in carrying its proportion of live loads only, unless the dead load stress can be removed temporarily, or some other means is provided to introduce the proper dead load stress in the new metal when it is applied. Connections of adequate strength shall be provided for the added metal.

11.2.4. Where the added material carries its proportion of the live load only, the stresses in the remaining portion of the original members, which is carrying the total dead load as well as its portion of live load, shall be investigated for the live load for which the bridge is being repaired or strengthened. The added material may be considered fully effective in computing the radius of gyration for determination of allowable stress in axially loaded compression members.

11.2.5. Members to be repaired or strengthened shall be investigated for any decrease in strength or stability resulting from the temporary removal of rivets, bolts, lacing, batten plates, cover plates or other parts. In some cases, falsework or temporary members may be required. Refer to Chapter 13 for additional requirements.

11.2.6. Where compression members are being reinforced, lacing bars, batten plates or tie plates, if removed, shall be restored to an acceptable level before allowing traffic over the bridge.

11.2.7. The added material shall be applied so as to produce a balanced section, eliminating or minimizing the effect of eccentricity on the strengthened member. Where balanced section cannot be obtained economically, the eccentricity of the member shall be taken into account in determining the stresses.

11.3. Fasteners

11.3.1. Existing rivets that are removed to effect a repair or strengthening shall be replaced on a one for one basis with high strength bolts of equal or greater diameter.

11.3.2. Where the remaining safe fatigue life is a controlling limit state, existing rivet holes shall be reamed after removal of the rivets, and the replacement high strength bolt shall be one size larger in nominal diameter than the replaced rivet or if of the same diameter shall satisfy the requirements for an oversize hole unless the hole is examined and found to contain no significant flaws or stress raisers.
11.3.3. Where existing material is to be preserved for reuse, rivet shanks shall be removed by mechanical means only. Coring will be permitted to assist the mechanical removal provided that the coring process does not penetrate the surface of the rivet shank.

11.3.4. While the careful use of oxygen-fuel gas cutting and/or burning methods is an accepted industry practice to remove rivets (and sometimes bolts), it is not permitted on SEPTA projects. If a waiver is granted by SEPTA’s Chief Engineer – EM&C and the oxygen-fuel gas method is used, the use of a rivet cutting tip is mandatory.

11.3.5. Where existing material is to be discarded, rivets may be removed by any appropriate means acceptable to the Engineer.

11.3.6. If a rivet hole has been scored or otherwise damaged, the hole shall be reamed and the replacement high strength bolt shall be one size larger in nominal diameter than the replaced rivet, or if of the same diameter shall satisfy the requirements for an oversize hole.

11.3.7. Rivet and bolt removal and replacement sequence must be detailed. All work shall utilize procedures and methods that insure that tension is not induced on any rivets.

11.3.8. Existing high strength bolts removed to effect a repair or strengthening may not be reused. They shall be replaced with new high strength bolts of equivalent diameter.

11.3.9. The extent of contamination of the faying surfaces by damage, mill scale, rust, paint, grease, etc. shall be considered by the Engineer in assigning the allowable shear values for high strength bolts used in repair, strengthening or retrofitting applications.

11.3.10. Type 3 high strength bolts shall be used with weathering steel. Galvanized bolts shall not be used with uncoated steel.

11.3.11. The use of powder actuated fasteners is not permitted.

11.4. Welding

11.4.1. Electric arc welding may be employed subject to the approval of SEPTA Engineering.

11.4.2. In general, welds shall not be assumed to act together with rivets or bolts.

11.4.3. All field welding shall be witnessed and supervised by a qualified welding inspector.

11.4.4. Where welds are added to existing riveted or bolted connections, the welds shall be designed to transmit the entire force, except that in such members, where the existing material carries the entire dead load force, the welds shall be designed to carry the entire live load force in the member. Where some of the existing rivets in a member are loose or defective, they shall be replaced with high-strength bolts properly installed, and such bolts may be considered to carry the dead load stress of the replaced rivets provided they are installed prior to the welding. Loose rivet heads shall not be welded.
11.4.5. Welding shall be in accordance with AWS and the applicable sections of AREMA, ASSHTO, and this Chapter.

11.4.6. When difficult-to-weld material must be welded to effect a repair, use of global pre-heats and post-heats shall be considered. Refer to Alternative Pre-Heat Requirements of AWS.

11.4.7. Low hydrogen filler, fluxes, and low hydrogen welding practices shall be used for all repair, strengthening, or retrofitting of steel structures. The low hydrogen covering and flux shall be protected and stored as specified by AWS Standard. Flux cored welding or use of cored filler wires in the submerged arc process or shielding gas processes, are not considered as conforming to low hydrogen practice. These methods will not be permitted.

11.4.8. When the air temperature is below 50ºF (10ºC), all material to be welded shall be preheated to 210ºF (100ºC) (for known weldable steel) for a distance of 3 inches (80 mm) beyond and on the opposite side the weld and shall be sheltered from the wind.

11.4.9. When the air temperature is below 32ºF (0ºC), welding will not be permitted unless suitable hoarding and heating, approved by the Engineer of Record and SEPTA, is provided.

11.4.10. For older steel for which the chemical analysis is unknown, the preheat requirement shall be determined by carbon equivalent, however for material thickness up to 5/8 inches (16 mm), preheat of 390ºF (200°C) is generally sufficient.

11.4.11. All groove and butt welds for bridges and critical structures shall have NDT either by radiographic or ultrasonic inspection.

11.5. Repair of Cracks and Defects

11.5.1. An actively propagating fatigue crack, either load-induced or distortion-induced, may be temporarily repaired by drilling a hole in the member to encompass the crack tip, provided the remaining net section of the member has sufficient stress-carrying capacity. The hole size shall be at least equal to the thickness of the material, but not less than 9/16 inch (14 mm) diameter. The open hole shall be filled with a fully torqued high strength (A325) bolt.

11.5.2. Permanent repairs shall consist of measures to reduce the stress range in the case of load-induced fatigue cracking, and to eliminate the causes of the distortion in the case of distortion-induced fatigue cracking.

11.5.3. Tension members with cracks extending beyond the rivet head are generally replaced and compression members with cracks extending beyond the rivet head will generally be repaired by field welding or replacement. Where replacement is not practical, an alternative suitable repair procedure shall be developed. Cracks in rolled beams or plate girders are repaired using approved welding procedures developed for the particular case. Prior to weld repair, a crack stop hole shall be drilled.
at the end of the crack to reduce stress concentration and to avoid further crack growth during welding.

11.6. Heat Straightening

11.6.1. Heat straightening of damaged steel members shall be undertaken only after due consideration of the stability of the individual member, the stability of the overall structure, and possible redistribution of stresses as a consequence of the heat straightening process.

11.6.2. Severely distorted truss members are generally replaced when they cannot be cost effectively repaired. Steel girder sections can be repaired either by a heat straightening method or by partial replacement.

11.6.3. Heat straightening of damaged steel members shall not be undertaken by unskilled or inexperienced persons.


11.6.5. Heat straightening may consist of either flame straightening used alone, flame straightening with an auxiliary force, or hot mechanical straightening.

11.6.6. The temperature of the heated steel shall not exceed 1150°F (620°C) for carbon and low alloy steels, nor 1050°F for quenched and tempered steels.

11.6.7. Mechanisms to apply auxiliary forces during heat straightening shall be of the type that reduce the magnitude of these auxiliary forces as the member displaces.

11.6.8. Key points to consider during heat straightening are:
   - Grind out all notches prior to heat straightening.
   - Monitor, and ensure that the steel temperature during heating does not exceed limits.
   - Artificial cooling shall not be allowed until the steel has cooled below 600°F (315°C).

11.7. Bearings

11.7.1. Where expansion bearings are frozen in position by accumulated corrosion, they shall not be freed without prior investigation of the stability of the superstructure and substructure elements.

11.7.2. Where a bearing has been pounded into the bearing seat, the bearing may be restored to correct elevation by filling the void under the bearing with a suitable grout. If the restoration of the bearing shoe to correct elevation requires an extension above the seat, steel shim plates may be used.
11.8. Bullet indentation/bullet holes shall be drilled out to eliminate stress raisers and tear cracks when practical. The open holes shall be filled with fully torqued high strength A325 bolts.

11.9. Misaligned holes/open connection holes shall be reamed and a high strength A325 bolt installed and torqued if they are a structural connection – if not a structural connection, no action may be warranted. All open holes shall be filled with high strength bolts when structural considerations warrant.

11.10. Defects such as gouges, nicks, burrs, etc., on the surface of fracture critical members shall be repaired by grinding smooth or peening. No weld repair of such surface defects is permitted. Nicks and gouges up to 3/16 inch (5 mm) deep shall be removed by grinding provided that the net cross-sectional area after removal of the notch is at least 98% of the original cross-sectional area. Notch removal shall be accomplished by fairing to the edge of the material with a slope not steeper than 1:10. Grinding marks shall be parallel to the direction of rolling.

12. SPECIAL INSPECTIONS.

12.1. Perform inspections per the requirements of the IBC and other applicable codes.

12.2. Periodic special inspection of the installation and tightening of fully tensioned high strength bolts in slip critical connections and in connections subject to direct tension is required.

12.3. Continuous special inspection of all structural welding is required, except where periodic special inspection is permitted in FEMA 368 Chapter 3, IBC, AREMA, AASHTO, or AWS as applicable.
CHAPTER 10
METAL BUILDING SYSTEMS

1. INTRODUCTION

1.1. This chapter prescribes criteria for the design of metal building systems. A metal building system is an engineered product furnished by metal building manufacturers. The metal building can be selected from a catalog of standard designs or can be a custom design. Metal building systems, in general, consist of:

- Rigid frames which act as the primary vertical load carrying system and as a lateral force system in the transverse direction,
- Rod or angle x-bracing for the roof truss diaphragm and for vertical lateral bracing in the longitudinal direction,
- Girts to support wall system cladding and resist wind loads,
- Roof purlins to support a standing seam metal roof system and roof live, loads,
- An exterior cladding system

1.2. Many variations in framing systems are possible, and many different wall-cladding systems can be used including metal panels, brick veneer, masonry, and precast concrete wall panels.

1.3. Consideration for mechanical and electrical systems shall be addressed including compliance with the state and local requirements for building energy conservation (Commonwealth of Pennsylvania’s Act 222), and SEPTA’s Mechanical and Plumbing design criteria and guidelines.

2. METAL BUILDING OPTIMIZATION

2.1. The metal building system shall be optimized, based on ASCE/SEI 7 and IBC load and load combination requirements. The designer must determine if additional requirements related to displacement, drift, durability, and redundancy should be written into the specifications to assure the final design shall satisfy short and long term performance goals including function, durability, serviceability, and future expansion needs.

2.2. The major optimization occurs with respect to the rigid frames. These frames are constructed of relatively thin plates that are welded together. The frames use tapered webs with increased depth in the areas of high moments. Web thickness and flange size are varied as needed. The rigid frame members are designed with
bolted end connections for easy field assembly. Most often the flanges are weld connected to the web on only one side to reduce fabrication costs. The secondary members including girts and purlins are cold-formed with a high strength to weight ratio.

3. **BASIS FOR DESIGN**

3.1. Specifications for metal building systems usually require that design be in accordance with the Metal Building Manufacturers Association (MBMA), "Low Rise Building Systems Manual," except that design loads and load combinations shall be per IBC and this document.

3.2. Secondary members (purlins, girts, etc.) are normally light gage cold-formed sections for which design is governed AISI.

3.3. Certification. American Institute of Steel Construction, Inc. (AISC) certification is required of all metal building system manufacturers. However, SEPTA may waive this requirement for small storage type buildings with areas less than 1500 square feet. This is done on a case by case basis.

4. **STRENGTH AND SERVICEABILITY ISSUES.**

4.1. Typically metal building systems have the minimum strength required, and use high strength materials to keep strength to weight ratios at a maximum. This approach to design under certain conditions can lead to serviceability problems.

4.2. Lateral Drift: Special attention should be paid to building drift under wind and seismic loading conditions. The maximum allowable drift will depend on the type of exterior cladding. For rigid claddings, such as precast concrete, brick, or block masonry, the maximum drift should be limited to h / 600. This is much lower than the h / 60 limit commonly accepted for buildings with flexible metal cladding.

4.3. Earthquake loadings: Metal building systems with heavyweight cladding must have suitable lateral force resisting systems to resist the inertial forces generated by the cladding during earthquake ground motions. The usual tension-only type bracing conventionally used in metal building construction will not be adequate when heavyweight cladding is used. If rigid cladding is used, the roof diaphragm must also have sufficient stiffness to limit out-of-plane wall displacements so that the cladding will not fail when the building is subjected to earthquake ground motions.

4.4. Mechanical Equipment Loads: The roof purlin system commonly provided with metal building systems would not have the capacity to support hanging mechanical
HVAC units or rooftop units. Where the roof is required to support such units, special framing must be provided.

4.5. Roof In-Plane Load Resistance: Metal building systems are commonly constructed with a standing seam metal roof. Standing seam metal roof systems are incapable of resisting in-plane loads due to wind and earthquake forces. Therefore, a separate horizontal bracing system is required.

4.6. Serviceability Guidance: Metal building systems must meet the same serviceability requirements specified for steel framed buildings in Chapter 9, "Steel Structure Design Requirements".

5. DESIGN RESPONSIBILITY

5.1. Performance specifications are generally used to obtain metal building systems.

5.1.1. The Designer shall specify the metal building system including all framing elements, roofing system, exterior cladding, interior partition walls, and architectural finishes.

5.1.2. The Designer shall specify which design codes, loads, and load combinations are to be considered in the design.

5.1.3. Unusual loads such as unbalanced snow loads, and concentrated roof loads must be clearly defined.

5.1.4. If future expansion is required, this must also be conveyed so end bays can be designed without intermediate columns.

5.1.5. Architectural requirements such as "R" factors for insulation should also be included in the metal building specification.

5.2. Metal building manufacturer's typically design the building and furnish plans and specifications for building construction. The building manufacturer's design must include all framing elements and their connections, and all exterior wall and cladding systems including openings, framing around openings, and connections. All bays where roof and wall bracing is to be installed should be identified. All interior walls including connections, or separations, from the building frame system should be detailed on the contract drawings. The foundation design should be provided with the contract documents in order to provide a basis for bid. The foundation design must be reviewed after the building manufacturer submits the final design. The final design submitted by the manufacturer should describe all loads, load combinations, and foundation reactions.

5.3. With the use of gable bent type rigid frames, the foundation must be designed to resist lateral spreading forces. When spreading forces are large, direct tension ties between exterior footings may be necessary (See Chapter 5 Section 6). The foundation designer must carefully design and detail all foundation anchor systems.
to make sure they can transfer loads to the foundation, and make sure they do not intercept slab-on-grade control joints or otherwise interfere with other building features. The Designer should track the building though the metal building system design review, shop drawing review, and construction process to assure the metal building system actually supplied and erected on the site meets all design requirements. It may be required that certain features of the project, such as foundations, cladding, and connections be redesigned during the metal building system design review phase.

5.4. The Engineer of Record for the Project shall review and approve the building design.

6. SPECIAL INSPECTIONS

6.1. Periodic special inspections shall be provided as required by the IBC.

6.2. Periodic special inspections shall be provided during all welding of elements of the lateral force resisting system.

6.3. Periodic special inspections shall be provided for bolting, anchoring, and other fastening components of the lateral force resisting systems including struts, braces, and hold-downs.

6.4. Periodic special inspections shall be provided during the erection and fastening of exterior cladding to the metal building framing system.
CHAPTER 11
WOOD STRUCTURE DESIGN

1. INTRODUCTION

1.1. This chapter provides guidance to be used for the design of wood buildings and structures. Properties of wood and other considerations influencing design including design of plywood elements and built-up members, wood preservation, termite control, fire retardant treatment, and climatic influences shall be addressed in the design.

1.2. The use of wood or timber construction shall consider the type of occupancy and meet all fire protection criteria and requirements. Detailed design information on wood buildings is not provided because wood construction is generally limited to existing construction and small railroad station building construction since strict fire protection standards and other operational requirements preclude the use of wood construction for most other types of SEPTA buildings.

1.3. The design of timber for railroad and rail transit loadings shall be in accordance with AREMA Manual of Railway Engineering. The design of timber structures subjected to highway loadings shall be in accordance with AASHTO and PennDOT requirements. Timber bridge type structures over 20 feet of span length shall not be allowed for permanent structures without approval from the Chief Engineer.

1.4. For timber structures other than structures subjected to highway or rail transit loading, the National Design Specification for Wood Construction, by the National Forest Products Association shall be followed.

1.5. For sheathing and shoring, refer to Chapter 15 Section 6 for additional requirements.

1.6. For falsework, refer to Chapter 13 for additional requirements.

2. BASIS FOR DESIGN

2.1. The 2005 Edition (or latest) of the National Design Specification for Wood Construction (NDS) as modified by the IBC, shall be used for design of buildings and structures not addressed by either AREMA or AASHTO.

2.2. For plywood properties and design criteria, use current American Plywood Association published brochures.
2.3. The design of structural elements or systems constructed partially or wholly of wood or wood-based products shall be by allowable stress design or load and resistance factor design. The structural analysis and construction of wood elements and structures shall be in accordance with the applicable standards and the IBC.

2.4. The design and construction of wood structures to resist seismic forces and the material used therein shall comply with the requirements of FEMA 368, "NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures."

2.5. Design of metal plate connected wood trusses shall follow the requirements of ANSI/TPI/WTCA 4, "National Standard and Recommended Guidelines on Responsibilities for Construction Using Metal Plate Connected Wood Trusses and ANSI/TPI 1, "National Design Standard for Metal Plate Connected Wood Truss Construction"

2.6. A framing nailing schedule giving minimum nailing requirements should be in the building plans and specifications. The structural designer should design and detail connections needed for the building framing when the required connection capacity exceeds those provided by the schedule for nailing of framing in the plans and specifications.

3. SERVICEABILITY CONSIDERATIONS

3.1. The use of pressure treated wood shall be considered where appropriate. This shall be based upon the project needs and the service conditions following the American Wood-Preservers' Association (AWPA) use categories.

3.2. Fire Retardant Treatment. Recommendations regarding the use of fire retardant treatments are provided in the USDA Wood Handbook and the National Fire Protection Handbook. Fire-retardant treated wood should not be used for primary structure system applications. This includes, but is not limited to wood trusses, wood framing, and APA rated structural panels (including plywood).

Where fire retardant properties are required for primary structural elements or systems, consideration shall be given to fire retardant coatings systems manufactured specifically for wood surfaces.

3.3. All fasteners and hardware for use with pressure treated wood shall be either hot dip galvanized per ASTM A153, ASTM A653 class G185 or better, or stainless steel (304 or 316) as appropriate for the preservative used. For wood foundations, only stainless steel shall be used. All fasteners in exterior wood shall be either hot dip galvanized or stainless steel.
3.3.1 For wood decking, ceramic coated decking screws are permitted.
3.3.2 Nails are not permitted for fastening decking and railings.
3.3.3 The use of gypsum board/drywall screws is prohibited.
3.3.4 Power-driven nails shall be not be used in structural connections except when their use is designed and approved by an engineer.

3.4. Termite Control. Termite control measures shall be used in areas prone to termite infestation. Soil shall be treated with commonly accepted termite control products prior to construction.

3.5. The use of oriented strand board (OSB) for non-vertical applications is prohibited.

3.6. For floor and roof sheathing, APA structural rated plywood sheathing or Tongue and Grove lumber should be used. Specifically, for floors, use as a minimum, 23/32 inch (18mm) thickness APA rated plywood, 16 inches on center span rating, Exposure 1, Tongue and Grove, nailed. Ring or screw-shank nails shall be used.

4. WOOD TRUSSES

4.1. Truss drawings and calculations are required and shall be sealed by a Registered Professional Engineer.

4.2. The engineer’s drawings, specifications, and details should make it clear to the designer (manufacturer) of the truss system how the truss system and load-carrying systems supporting the trusses are coordinated. The engineer should:
  4.2.1. Provide a building layout showing truss bearing points, girder truss locations and bearing points, material specifications, special framing details, permanent bracing details, and nailing and framing instructions;
  4.2.2. Provide point load values and locations;
  4.2.3. Review load-carrying mechanism taking loads down to the foundations;
  4.2.4. Provide loading diagrams, including built-up loads from snow drifts;
  4.2.5. Check that the wood-truss design drawings match the site-specific requirements.

4.3. Temporary bracing locations and the erection sequence required to provide stability of individual members during construction is generally the responsibility of the truss manufacturer and/or contractor. The engineer shall review and verify that this information is provided with the shop drawings and that any and all project specific issues are addressed.

5. PLASTIC AND WOOD-PLASTIC COMPOSITE LUMBER
5.1. The use of plastic and wood-plastic composite (WPC) lumber are generally limited to non-structural and moderately structural applications such as decking boards, rails and balusters, wearing surfaces, and window and door components. Other uses are minor landscaping type retaining walls, shoreline structures, and fencing.

5.2. Design of plastic and WPC lumber generally follows wood design methods. Properties for plastic and WPC lumber shall be obtained from the applicable active ASTM standards.

5.3. The designer shall be familiar with the limitations of plastic and WPC products. The material mechanical properties are time dependent and subject to permanent deformations (creep) under sustained loads. Plastic lumber can also have significant dimensional changes due to temperature. Another critical issue is the relatively low stiffness and flexural strength.

5.4. Application of this material shall take into consideration building code issues such as heat retention, flame spread, and toxic smoke.

6. COATING SYSTEMS

6.1. For field applied coating systems, the season and ambient conditions, moisture content of the wood, and surface prep, including the methods employed to remove existing paint, all must be taken into consideration when selecting and specifying surface prep and coating.

6.2. Selection of the paint system shall take into consideration project specific requirements and the following:
   - Protection from Rot and Deterioration
   - Abrasion Resistance
   - Graffiti Resistance
   - Appearance
   - Gloss Retention
   - VOC Content
   - Slip Resistance
   - Fire Resistance

6.3. Coatings shall be specified as a system including surface preparation.
   6.3.1. The coating system shall be selected based upon the anticipated exposure.
   6.3.2. For exposed surfaces in public spaces, a urethane paint system is recommended.
7. **SPECIAL INSPECTIONS.**

7.1. Continuous special inspection during all field gluing of elements of the lateral force resisting system is required.

7.2. Periodic special inspections for nailing, bolting, anchoring, and other fastening of components within the lateral forces resisting system including drag struts, braces, and tie-downs is required.

7.3. An experienced individual shall be designated to inspect and verify that all lateral and permanent bracing for metal plate wood trusses are installed in accordance with the approved PE sealed plans.
CHAPTER 12
SPECIAL CONSTRUCTION

1. INTRODUCTION

1.1 This chapter covers the design requirements for aluminum structures, membrane structures, and other types of structures constructed using unique materials and unique construction methods not covered by the previous chapters.

1.2 All special construction must comply to the requirements of the National Fire Protection Association and the IBC.

1.3 The use of special construction is permitted whenever it appears necessary, advantageous, and economical. However, specifying new or untried materials or methods of construction should be avoided until the merits of the methods or materials have been established. New, unusual, or innovative materials, systems or methods previously untried may be incorporated into designs when evidence shows that such use is in the best interest of SEPTA from the standpoint of economy, lower-life-cycle costs, and quality of construction.

1.4 The use of special construction where not part of SEPTA standards or normal practice, is subject to the approval of the Chief Engineer – EM&C or designee. The Designer shall prove the merits of the products or system by certified laboratory results, by evidence of satisfactory installation under conditions similar to those anticipated for the proposed construction, and by demonstrating compliance with appropriate industry standards. The recommendation shall also contain justification and documentation supporting the new special construction method, including cost benefits, proposed special criteria and controls, performance history, and tests.

2. ALUMINUM STRUCTURES

2.1 Aluminum when used for structural purposes in building construction shall be designed in accordance with the Aluminum Association’s Aluminum Design Manual – 2005 (or latest). Part 1-A, "Specifications for Aluminum Structures - Allowable Stress Design" may be used for buildings, building components, miscellaneous structures, or bridges components (such as protective barrier). Part 1-B, "Specifications for Aluminum Structures - Load and Resistance Factor Design" may be used for Buildings and Similar Type Structures only. Approval under the provisions of Paragraph 1.4 is not required unless the aluminum structure is part of a unique structural system.
2.2 For aluminum structures, towers, and antennas, the one third increase in allowable stresses under wind loads permitted in the Aluminum Association Specifications for Aluminum Structures shall not be used.

2.3 Welding and welding design shall conform to AWS D1.2 – Structural Welding Code for Aluminum.

2.4 Dissimilar metals, (e.g., aluminum and carbon steel, stainless steel, zinc coated steel) should be isolated by appropriate means to avoid the creation of galvanic cells which can occur when dissimilar metals come in contact. Particular attention shall be given in the selection of the appropriate fasteners.

2.5 Concrete and cement grouts shall not be cast against aluminum structures.

2.6 Aluminum shall not be used in direct contact with pressure treated wood. A durable physical barrier such as rubber or asphalt roofing paper shall separate the surfaces.

2.7 The non-steel specific requirements of Chapter 9 should be followed.

3 MEMBRANE STRUCTURES

3.1 Membrane structures include membrane-covered frame structures, cable supported membrane structures, and air supported structures. Membrane structures are those which utilize an enclosure membrane acting in tension as a structural element. Membrane structures must either be noncombustible, or flame resistant.

3.2 Structures shall be designed to sustain dead loads, loads due to tension or inflation, and live loads including wind, snow and seismic loads. The use of membrane structures is particularly applicable to temporary construction, to situations requiring minimum structure weight, or to conditions requiring large, column-free spaces.

3.3 Membrane structures shall not be used for human occupancy.

4 GLASS FIBER REINFORCED CONCRETE, FIBER COMPOSITES AND REINFORCED PLASTICS

4.1 Although the use of glass fiber reinforced concrete (GRFC) is used in many instances for building cladding, the use of other fiber composites and reinforced plastics has been very limited with respect to building systems and components. These materials do offer unique advantages because of their high strength-to-weight ratio, because of the ease with which they can be molded into various
shapes, and because of the excellent resistance they provide against corrosion. Other properties such as creep, modulus of elasticity, coefficient of thermal expansion, and long term resistance to weathering and other environmental effects, however, may result in overall performance that does not measure up to the standards associated with the commonly used materials described in the other chapters of this document.

4.2 Glass Fiber Reinforced Concrete (GRFC). Glass Fiber Reinforced Concrete (GRFC) consists of cement aggregate slurry reinforced throughout with alkali resistant glass fibers. In building construction, GRFC is primarily used for architectural precast cladding. The cladding has an appearance similar to precast concrete, except it is much lighter which can help to reduce the cost of the building structural framing. GRFC is not used as a vertical load-bearing component, although it can resist wind loads, and seismic inertial forces due to its own weight. In addition to being lightweight, GRFC panels have high impact resistance and are noncombustible. When used, GFRC should be evaluated for its history of performance under the types of climatic conditions to which the building will be exposed. Climates with temperature extremes and with high rainfall and moisture conditions have in some cases have caused deterioration of GRFC thereby effecting cladding serviceability.

4.3 Reinforced Plastics and Fiber Composites. Construction using fiber reinforced plastic and fiber reinforced plastic composites is relatively new with respect to structural applications. Glass fiber reinforced plastic (GFRP) bars can be used in concrete beams and columns in order to prevent damage from the corrosive effects of salts, acids, and other aggressive elements. The ultimate strength of GFRP bars is about twice that of reinforcing steel, however the modulus of elasticity is only about 1/4 that of steel that could possibly cause serviceability problems related to increased deflection.

5 FRP STRUCTURAL REPAIR AND STRENGTHENING APPLICATIONS

5.1 FRP materials may be used to repair or strengthen concrete structures. Glass fiber reinforced plastic (GFRP) plates and fabric can be epoxy bonded to concrete or masonry to increase strength and ductility.

5.2 There are two basic types of FRP materials in use for concrete structure applications: E-glass or carbon fibers. Carbon fiber FRP is stronger, but is more costly than E-glass. FRP materials offer significant advantages over conventional concrete repair. Foremost is their ease of application without the use of heavy equipment or time consuming forming. Although long term data is not yet available, FRP repairs are expected to provide a longer service life than conventional concrete repairs.
5.3 FRP materials applied to sound concrete are considered to be a long term repair and the design life is the expected remaining life of the structural element. This would most often be the case of a seismic retrofit or the correction of an original design deficiency. The determination of sound concrete should include a finding that the half cell corrosion potential is less negative than -0.2 volts. The repair is considered temporary if the half cell potential is more negative than -0.2 volts. However, it is possible to remove chlorides and reduce corrosion potential through a procedure known as Electro-Chemical Chloride Extraction (ECE). ECE can be expected to be effective for approximately 15 years. Therefore, for long term repairs to be effective, the future ingress of chlorides must be addressed.

5.4 Concrete columns can be reinforced with an FRP wrap to improve concrete confinement and shear strength. FRP materials have been found to be more efficient in retrofitting round columns than rectangular columns, although FRP wraps can be applied to rectangular columns when the aspect ratio (length to width in cross section) does not exceed 1.5, corner chamfers are rounded to a radius of 1 inch (25 mm) and a reduced confinement force is accounted for in the design.

5.5 Reinforced concrete flexural members such as pier cap beams can also utilize FRP materials to improve bending and shear strength. FRP systems are designed to restore specific capacities (positive moment, negative moment, shear etc.), by taking into account fiber ratio, fiber orientation, manufacturing type and bonding materials. Deteriorated concrete can also be repaired with FRP's although this use is more problematic.

5.6 The application of an FRP wrap will not stop the corrosion of steel reinforcing bars in concrete containing chlorides where water continues to infiltrate. If the cause of the concrete deterioration is not addressed (e.g. leaking deck joints), the FRP repair should be considered a temporary fix that may provide an additional 5-7 years of service life for the structure. Measures to address the cause of concrete deterioration should accompany the use of FRP materials.

5.7 Long term repairs should be designed for a minimum service life of 20 years, or longer on a relatively new structure which does not exhibit any signs of distress. Appropriate strength reduction factors shall be used to account for the design service life. Trapped water can lead to future deterioration of the encased concrete and reinforcement. For this reason total encasement of a structural element should be avoided for permanent repairs.

5.8 All FRP wraps used on SEPTA structures shall be considered a structural repair that must be designed, reviewed, and administered accordingly. The use of FRP’s for short-term repairs alleviates long-term concerns of product durability and environmental degradation. Nonetheless, significant other concerns regarding FRP application, design procedures and review, product variability, surface preparation requirements, bond criticality, monitoring requirements and inspection limitations are to be considered in choosing FRP’s in lieu of conventional repairs.
5.9 Due to the wide variety of material types, and since their design and manufacture depends on the desired structural performance to be achieved, specifications are performance based. Many systems are patented and the Contractor/Engineer will require the services of the FRP manufacturer or supplier. Specifications shall require the Contractor's supplier to design the FRP repair to the loads, capacities and service life shown on the contract plans. The FRP system and materials should appear on PennDOT's Approved List of Materials and Equipment. Calculations and working drawings are required to be submitted to Bridges & Buildings Engineering and the Engineer of Record for review and approval.

5.10 Designers must show the required increased moment and shear capacities to be achieved for the components in question or, in the case of column wrapping, the confinement force and the minimum design life (if less than 20 years) on the contract plans. The FRP manufacturer's engineer shall design the FRP repair materials to meet these requirements. The designer should compute the additional strength required over the capacity of the existing concrete section. In the case of flexural members, designers shall not attempt to require the FRP material to totally replace the strength of the effective existing steel reinforcement. In all cases, designers shall not specify overly high reinforcement capacities to be carried by the FRP material as this would likely result in a non-ductile failure mechanism for the structural element. This is likely to be a concern if the reinforced capacity of the element is more than 125% of the original capacity.

5.11 Designers are referred to ACI 440, Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures, for recommended design procedures for FRP’s applied to concrete structures.

5.12 Working (shop) drawings shall include the type of FRP system, repair locations, relevant dimensions of the system, and the work plan including the necessary preparations of the existing structure. The drawings must be accompanied by the design calculations, the MSDS, and the manufacturer’s system data sheet identifying mechanical, physical, and chemical properties of all components of the FRP system; application guide, including the installation and maintenance procedures; and time schedule for various steps in the repair process. The installation procedure must clearly identify the environmental and substrate conditions that may affect the application and curing of the FRP system.

The necessary information for each FRP system may be different. Shop drawings for wet lay-ups may include, for example, fiber orientation, nominal thickness, aerial weight of dry fabric, number of layers, fiber volume or weight fraction, locations and lengths of lap splices, end details, and anchoring. Shop drawings for near surface mounted FRP may include, for example, locations and sizes of grooves and bars or strips. Shop drawings may also include necessary corner radii and surface conditions of the existing structure.
5.13 Protective coating should be applied on the surface of the FRP system. FRP materials are susceptible to degradation from ultraviolet radiation, particularly those that contain E-glass fibers or epoxy resin. Therefore, specifications shall require all FRP installations exposed to sun light to be coated with a UV protective coating system. Protective coating is also applied for aesthetic appeal and/or protection against impact, fire, chemical exposure, moisture, or vandalism. FRP systems are usually durable to weather conditions, sea water, and many acids and chemicals.

The coating shall be a non-vapor-barrier, flexible, waterproofing, and compatible with the FRP system. Mortar finish can provide protection against impact or fire. Weather-resistant paint of the family of urethane or fluorine or epoxide can provide protection against direct sunlight. It is expected that recoating will be required during the life of long term repairs.

6 FRP AND FIBERGLASS STRUCTURAL SHAPES

6.1 The use of FRP and fiberglass structural shapes is generally limited to highly corrosive environments.

6.2 The use of FRP and fiberglass grating and handrail systems is common practice for SEPTA railroad bridge walkways and subway pump rooms.

6.3 Due to the wide variety of material types, and since their design and desired structural performance depends on the manufacturer’s material properties, the design is often based upon the FRP manufacturer’s design guides and recommendations. This section outlines typical SEPTA minimum requirements.

6.4 Before the structural engineer begins any structural analysis, he or she shall be knowledgeable as to the environment in which the structure is to be installed. The environment dictates the type of resin to be used, and the different resins possess different structural properties. In essence, the use of a polyester resin in designing a fiberglass structure will have lower allowable stresses and higher deflections than would the use of a vinyl ester resin in the same environment.

6.5 The structural engineer shall consider that, because fiberglass is a plastic, it will undergo some decay and change of appearance due to prolonged exposure to outdoor weathering. In order to minimize this effect on fiberglass shapes, various options shall be considered based upon project and maintenance costs, conditions, and service life. These options include the use of UV stabilizers, surfacing veils, and coatings applied to the structural shape.

6.6 It should be noted that UV stabilizers generally will only retard the effect of weathering, eventually the profile will degrade. A condition called “fiber blooming” will occur on the surface of the profile, and this is coupled with a slight reduction in physical properties. Surfacing veils further enhance the profiles resistance to
weathering. A synthetic veil, when applied to the surface of the fiberglass pultrusion during the manufacturing process, enhances weatherability and corrosion resistance by adding resin thickness to the surface of the product, i.e., it provides for a resin rich surface. The optimum method of maintaining surface appearance during outdoor exposure is to apply a coating to the surface. Two-component, UV stabilized urethanes work very well with this application. A 1.5 mil dry film thickness coating will provide protection for many years with minimal change in appearance.

6.7 When designing beams which are subjected to concentrated loads, the structural engineer shall consider using web stiffeners to eliminate the effects of web crippling on the fiberglass shape. Stiffening can be achieved by bolting and/or epoxying angles, tees, or channels to the web of the beam being subjected to the concentrated loading.

6.8 An one-third (1/3rd) increase in allowable stress is generally not permitted on SEPTA projects for load combinations involving wind loads. An one-third (1/3rd) increase in allowable stress is not permitted when evaluating combined loadings involving operating environmental conditions.

6.9 When designing fiberglass structures that will be subjected to high heat exposure, the structural engineer is cautioned to consider the effect of temperature as it relates to the allowable stresses and to the modulus of elasticity. The result of higher temperatures on structural fiberglass is a reduction in modulus of elasticity and thus, a lowering of the allowable stresses. Vinyl ester resins are better in elevated temperatures than polyester resins.

6.10 As a minimum, all live load deflections of all beams and girders should be limited such that the deflection over length ratio (Δ/L) does not exceed 1/150. For cantilevered beams and girders, the deflection ratio should be limited to 1/100 ratio, or 1/4", whichever is greater. The structural engineer is to be aware that, due to fiberglass’ relatively low shear modulus, the total deflection of a fiberglass beam is actually comprised of two components: flexural deflection and shear deflection. When calculating deflections of steel beams, due to steel’s relatively high shear modulus, the shear deflection component is typically neglected. This is not the case in designing with fiberglass shapes.

6.11 Factor of Safety

6.11.1 The safety factors used in the various design equations are chosen to prevent “first deformation” of the part. First deformation is defined as the first visible deformation including local flange or web buckling, twisting, crushing, etc. Safety factors are to compensate for:

- allowable tolerances of the part
- uncertainty of the anticipated loading (magnitude, type or placement)
6.11.2 The recommended minimum safety factors used for design are:

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<td>Compression members, columns</td>
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<td>Beam shear</td>
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<tr>
<th>MODULII SAFETY FACTORS</th>
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<tr>
<td>Shear Modulus</td>
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6.11.3 The minimum safety factors noted in paragraph 6.11.2 are for static load conditions only. Safety factors for impact loads and dynamic loads are typically two times the static load safety factor. Long term service loads which result in creep deformations will require even higher safety factors to insure satisfactory performance. For creep effects, see “Structural Plastics Design Manual”, American Society of Civil Engineers, September 1981.

6.11.4 These recommended safety factors are not the only safety factors that may be used in design. The designer may choose to adjust the safety factors based on particular applications and considerations including margin of safety, costs, confidence of loads or materials, etc. Ultimately, the final selection of a safety factor is the Engineer of Record's responsibility.

6.12 Connections

6.12.1 The structural engineer must consider the fact that fiberglass structures are typically designed to be removable, thus all connections are to be bolted only, unless otherwise specified to be epoxied on the construction drawings. Epoxying a joint is analogous to welding a joint in steel--it is permanent. When a joint is epoxied, the flexibility of removal is lost. However, when bolting a connection, to ensure that the effects of vibration do not loosen the bolts, a thread locking compound such as "Locktite" (or equal) should be used, as this will help to prevent the nuts from loosening.
6.12.2 When designing a connection, the engineer shall decide if the joint is to be bolted only, or is the joint to be bolted and epoxied, or is the joint to be epoxied only.
CHAPTER 13
FALSEWORK AND SHORING

1. INTRODUCTION

1.1. This chapter prescribes criteria for the design of falsework and temporary shoring.

1.2. Temporary structures and shoring shall be designed and constructed in a manner that protects adjacent buildings, bridges, roadways, or railway, and existing traffic, while allowing inspection access for existing facilities and structures.

1.3. For the requirements of temporary sheeting and shoring of excavations and earthwork, see Chapter 15, Section 6.

1.4. Falsework is the temporary bents or supports required for the modifications to, the demolition of, or the installation of structures. Falsework is also the structural system that supports formwork. Formwork is considered to be the material or form that provides the shape to the concrete placement and the immediate structural system that supports the form.

1.5. Work platforms or debris platforms used for concrete removal or other demolition work shall be considered falsework. Falsework also includes temporary protection shields required to prevent any dust, debris, concrete, formwork, paint, or tools from falling onto SEPTA tracks or occupied spaces.

2. BASIS FOR DESIGN

2.1 Refer to ASCE 37, "Design Loads for Structures During Construction", for guidance.

2.2 For steel design, see Chapter 9.

2.3 For design of concrete formwork, follow ACI requirements and Chapter 6.

2.4 Existing structures shall be checked for all forces and stresses associated with all construction activities and temporary shoring. The actual current condition and age of the structure shall be considered in analyzing the structure.

3 RAILROAD AND RAIL TRANSIT REQUIREMENTS

3.1 SEPTA utilizes continuous welded rail (CWR) on its system. It is imperative to the safety of rail operations and to prevent rail buckling, that the lateral rigidity of the
track (which consists of the rail-tie structure and the ballast) remains unchanged and intact.

3.2 All existing structures and/or track shall be monitored for horizontal and vertical movement.

4 REVIEW AND APPROVAL OF FALSEWORK PLANS

4.1 All falsework plans and details shall be prepared and sealed by a Registered Professional Engineer.

4.2 The review of falsework plans shall be documented in a letter from the Design Engineer of Record (SER) for the Project directed to SEPTA and shall note any recommendations, inadequacies or revisions that may be required. Approval or disapproval of the falsework plans shall be by the Design Engineer of Record for the Project. All modifications to the design and/or "as constructed" falsework shall be made by and/or approved by the engineer of record who designed the falsework as well as the Design Engineer of Record for the Project.

4.3 In addition to any requirements of the Engineer of Record and the Project Documents, detailed falsework plans shall be submitted for review by SEPTA Engineering for the following structures:
- All structures over or under railroad, rail transit tracks, and public spaces
- All structures built over highways or streets carrying traffic
- All structures carrying traffic during construction
- All structures supporting platforms, passenger traffic, or the public
- All structures supporting permanent existing structures
- All structures requiring falsework plans as noted on contract plans

4.4 Work platforms or debris platforms used for concrete removal (typically for widening or replacement of bridges over trafficways, railroads, and other rail transit tracks) shall be considered falsework, and falsework plans and methods of support shall be submitted to SEPTA Engineering for review.

4.5 Drawings must include a detailed structure lifting operations procedure. Additionally, the drawings should have a jacking table that includes but not be limited to: jack location, jacking load, jack type and rating, effective cylinder area, jacking pressure, maximum allowable pressure, outside diameter, and stroke.

4.6 Falsework drawings shall be reviewed and considered satisfactory by the Design Engineer of Record for the Project before submission to SEPTA Engineering.

4.7 Any revisions to plans and installation shall be done by the plan originator or by his authorized representative.
5 GENERAL DESIGN CONSIDERATIONS

5.1 Jacks shall be placed so that the line of action is as nearly as possible, concentric with the gravity axis of the existing member(s). If jacks must be placed on an eccentric axis, an analysis of the effects of such eccentricity shall be made.

5.2 The rated capacity of a jack shall be a minimum of 50% greater than the computed required jacking force. All gauges shall be calibrated to a recognized national standard.

5.3 When choosing member sizes for jacking, strongbacks, or other temporary support, the allowable stress may be increased based on the Engineer's analysis and design and subject to SEPTA approval. Attention shall be paid to slenderness ratios and buckling allowables.

5.4 All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without deleterious settlement or deformation.

5.5 Screw jacks or hard-wood wedges to take up settlement may be required.

5.6 Minimum clearance requirements should be shown on the construction plans. The erected temporary protection shields or other falsework shall not infringe on any existing minimum vertical and horizontal clearance. The clearance envelopes required for SEPTA operations shall be indicated on the site specific work plans. Refer to Attachment 1 for SEPTA clearance diagrams.

5.7 The erected falsework shall maintain safe minimum clearance from all energized electrical and catenary lines per the National Electric Safety Code (NESC) and SEPTA requirements. All metallic components shall be bonded and grounded where adjacent to overhead catenary power or 3rd rail power, or other required by codes.

5.8 Falsework supports adjacent to trafficways shall be protected by concrete traffic barriers. Barriers should be located so that there is at least 2 foot clearance between the barrier and the falsework footings, mudsills, or falsework member.

5.9 Falsework supports shall be designed to resist vibration forces caused by passing vehicles or trains.

5.10 The importance of adequate diagonal and longitudinal bracing to the safety and stability of the entire shoring system cannot be overemphasized. Diagonal bracing must be provided in both vertical and horizontal planes to provide stiffness and prevent buckling of individual members of the falsework. Experience shows that most failures may be attributed to a lack of adequate lateral bracing (transverse or longitudinal) and a failure at one location may cause progressive failure for the
entire structure (domino effect). Special consideration should be given to open
deck rail structures and superelevated highway structures due to their inherent
lateral instability. Longitudinal bracing between bents founded on sills may be
required to provide stability from lateral forces.

5.11 The safe bearing capacity of the foundation material on which the falsework
supports will rest shall be determined and noted on the plans. Site drainage must
be adequate to prevent soil saturation and washout of the soil supporting the
falsework supports. Adequate containment for bedding materials shall be provided
and maintained.

5.12 Each falsework posts or shoring tower legs adjacent to roadways, railroads, or rail
transit tracks shall be mechanically connected to the supporting footing at its base
or otherwise laterally restrained, to withstand not less than 2 kips applied at the
base of the post or tower leg in any direction.

5.13 Posts or tower legs shall be connected to the falsework cap and stringer by
mechanical connections capable of resisting a load in any direction of not less than
1 kip.

5.14 For falsework spans over roadways, railroads, or rail transit tracks all falsework
stringers shall be mechanically connected to the falsework cap or framing.

5.15 When timber members are used to brace falsework bents which are located
adjacent to roadways, railroads, or rail transit tracks, all connections shall be bolted
through using ⅝ inch diameter or larger bolts.

6 DESIGN LOADS AND ANALYSIS

6.1 The minimum design loads on falsework shall be as noted below.

6.1.1 Dead Load - Minimum Densities
   - Concrete: 160 pcf (vertical, includes weight of reinforcement steel and
     placement loads) (normal wt.), 85 pcf (horizontal fluid pressure)
   - Timber: 50 pcf
   - Steel: 490 pcf
   - Formwork (light): 3-5 psf (heavy): 6-10 psf (min)
   - Timber and steel member densities from any appropriate manual may
     be used.
   - A density of 10 psf may be estimated for timber formwork down to the
     falsework.

6.1.2 Live Load
6.1.2.1 Concrete Deck Placement: The actual weight of equipment to be supported, applied as a concentrated load at point of application (screed rail, etc.) plus a uniform load of 20 psf applied over the entire area supported including the walkway. In addition, a load of 75 plf. shall be applied at the outside edge of the deck. (Note: This loading does not apply to superstructure supported formwork.

6.1.2.2 Falsework supporting rail transit and railroad tracks shall be designed for the same loads as the permanent structure unless expressly approved by the Chief Engineer. For vehicle loads see Chapter 3.

6.1.3 Temporary Protection Shields and Work/Debris Platforms shall be designed for the following minimum load and size criteria:

6.1.3.1 The horizontal shield shall he designed to carry a minimum live load of 100 pounds per square foot (psf) or the anticipated live load to be produced by the Contractor’s operations (which ever is greater) and a single concentrated load of not less than 2,000 pounds located to produce maximum stress. The horizontal protection shield, in plan view, shall cover not less than the area directly over the tracks plus 10 feet (10’) beyond the centerline of the outermost tracks.

6.1.3.2 The vertical shield shall be designed to carry a wind load of not less than 30 psf. The vertical shield shall extend a minimum of 6’-6” above the top of the adjacent surface such as a sidewalk or curb. Anti-climb wings shall be installed at each end, as necessary, to restrict access to SEPTA property.

6.1.4 Wind Load: A minimum of 20 psf exposed area (approx. 60 mph) wind load should be considered for falsework in exposed areas, elevated areas, and all bridge or bridge like structures.

6.1.5 For support of bridges or similar live load structures, design for lateral loads of not less than 2 percent of total dead load. Structures supporting rail transit and railroad tracks shall be designed for the same loads as the permanent structure.

6.1.6 The minimum vertical load to be used in the design of any falsework member shall be 100 psf measured over the total area supported by that member.

6.1.7 Loads on formwork shall be investigated for all members down to the main support members. For dead load, use the weight of the formwork plus the weight of the freshly placed concrete. For live load use 50 psf unless motorized carts are to be used in which case, 75 psf should be used over the deck area.
6.1.8 The minimum design value of combined dead load plus live load on the bridge or elevated deck (excluding walkway) shall not be less than 100 psf (125 psf if motorized carts are used.) The walkway and supports should be designed for a live load of 50 psf.

6.1.9 Design loads noted in calculations and on drawings shall clearly note whether they are factored or unfactored, note what is included (new vs. existing), and address live load impact.

6.1.10 Analysis must include loads that occur during jacking and loads that occur when the structure is in its shored position. The analysis must be consistent with the contractor’s intended work sequence.

6.1.11 In general, due to the condition of used material, the variance in quality of construction, unexpected construction loads, and the consideration of safety for construction personnel and the traveling public, it is SEPTA’s policy not to permit the use of used wood or timber materials and/or used steel where the steel material type and properties cannot be certified or otherwise documented.

6.1.11.1 If requested and justified, the use of used material will be reviewed on a project by project basis.

6.1.11.2 Used material must conform to the dimensions and material specified on the falsework plans.

6.1.11.3 Used material shall be free of splits, cracks, holes, etc. that will reduce the structural capacity. No. 2 Grade or better material is required.

6.1.11.4 Refer to Chapter 15 Paragraph 6.1.13 for limits on the allowable stresses for used materials.

6.1.12 Negative deflection may occur where falsework beams are continuous over a long span and a relatively short adjacent span. Beam lift-off can be prevented by loading the short span first, or by restraining the end of the beam. Cantilevered falsework spans will also produce an upward deflection which must be considered. Movement may be controlled by blocking of the main span.

6.1.13 Do not rely on friction for lateral support. Vibration, uplift, partial loading, etc., can reasonably be expected to reduce contact bearing during placement or erection.

6.1.14 Conservative values of allowable structural capacity shall be used for design of temporary structures. When the Contractor can certify and document his/her material is capable of supporting a greater stress, higher values may be used.
Timber – Maximum Allowable Stresses

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural F_b</td>
<td>1,200 psi</td>
</tr>
<tr>
<td>Horizontal Shear V</td>
<td>120 psi</td>
</tr>
<tr>
<td>Compression Perpendicular to Grain F_c┴</td>
<td>400 psi*</td>
</tr>
<tr>
<td>Compression Parallel to Grain F_c</td>
<td>850 psi</td>
</tr>
<tr>
<td>Modulus of elasticity of wood E</td>
<td>1,500,000 psi</td>
</tr>
<tr>
<td>Direct tension F_t</td>
<td>1,000 psi</td>
</tr>
</tbody>
</table>

* Reduce to 300 psi when moisture content is 19% or more (areas exposed to rain, concrete curing water, or green lumber)

Steel

For used steel, assumed F_y shall not exceed 30,000 psi unless otherwise documented

6.1.15 Where friction is used in calculations, the following coefficient of friction values are commonly used.

- Coefficient of Friction:
  - steel on steel 0.10
  - steel on wood 0.20
  - wood on wood 0.30

6.1.16 When checking the adequacy of a spread footing or sill, the following allowable bearing values shall not be exceed unless higher capacities are documented:

- Below average soil - 2,000 psf
- Average soil - 3,000 psf (Soil can be classified as average if it is firm enough to walk on without indentation of the heel of a shoe)
- Intact Pavement - 6,000 psf

7 MONITORING

7.1 All falsework, temporary shoring, and temporary structures supporting SEPTA railroad and rail transit tracks must be monitored on a continuous basis for movement and condition.

7.2 The monitoring points shall be set up not less than one week before operations begin.

7.3 Elevation and horizontal alignment readings to establish the initial baseline reading shall begin not less than two days prior to the start of work. Readings shall be taken just prior to the commencing of construction. Elevation readings will be
taken from the top of each rail of each track and alignment readings will be taken from gauge of each rail within the "zone of influence" the shoring or falsework.

7.4 For falsework and shoring supporting SEPTA structures, readings shall be taken immediately upon the falsework taking the structure load and on an hourly basis for the first 24 hours. Readings shall be taken every twelve hours for the next seven (7) days and then daily thereafter. If the track deviates to an unacceptable degree, work will be stopped and corrections will be made.

7.5 Allowable deviation from uniform profile in either rail at the mid ordinate of a 62-foot (62’) chord may not be more than one inch (1”). The difference in cross level between any two points less than 62 feet (62’) apart may not be more than 1 inch.

7.6 Stations shall be spaced at no greater than 15½-foot (15'-6'”) intervals. The number of stations required will be determined by the length of the excavation parallel to the tracks or the length of the section of structure being supported.

7.7 Readings must show the date, time, weather conditions and temperature. Each reading must also provide the following information: track number, compass direction, station number, base reading (with date), static elevation, change in elevation or alignment (recorded in hundredths and in inches), dynamic reading and total deflection in inches.

7.8 SEPTA requires that the track be maintained at all times within established criteria for the specific track classification. At the completion of the project the requirement for tamping and realigning the tracks, caused by the settlement from the construction activity, remains with the Contractor for the duration as specified by SEPTA in their initial review of the work plans. This tamping and track realignment will be performed by SEPTA at the sole expense of the contractor.
CHAPTER 14
CATENARY STRUCTURES

1 INTRODUCTION

1.1 This chapter prescribes criteria for the design and detailing of railroad and light rail catenary (support) structures. The design and construction of new and replacement catenary structures shall conform to the minimum design requirements specified here-in.

2 BASIS FOR DESIGN

2.1 Catenary support structures shall be structural steel with reinforced concrete foundations designed in accordance with AREMA Manual of Railway Engineering Chapter 33 Part 4.

2.2 The structure shall be detailed to accept SEPTA standard catenary hardware.

2.3 SEPTA's Right-Of Way Clearance Drawings delineate the minimum envelope that shall be maintained. No permanent obstructions that violate the minimum clearance requirements are permitted. Clearance requirements in Attachment I shall be followed.

2.4 Railroad trolley wire height shall be between 19'-0" minimum and 22'-0" maximum above top of rail but not less than the existing at the location of the new structure(s).

2.5 All structures shall be grounded per NESC and NEC code requirements. Ground wire connections shall be cadwelded.

2.6 All structural steel shall be either hot dip galvanized or weathering steel.

2.7 Calculations and drawings both shall include a loading diagram for each structure.

3 BASIC DESIGN LOADS

3.1 The basic loads applied to catenary structures shall be in accordance with AREMA. The loads include
  • dead weight of wires, wire supports, and the structure
  • curve pull forces and dead end loads
  • ice loads on the wires only
• wind loads on the wires and structure (design wind velocity of 80 mph) Refer to Chapter 3 Section 4.
• wire break loads
• live loads (from cat walks, ladders, etc)
• Other loads as may be specific to the location and structure.

3.2 Three basic climate and load conditions shall be reviewed:
• Icing Condition
• Operating Condition
• Design Condition

3.3 The AREMA specified overload factors shall be applied.

3.4 The design must account for an anticipated increase in wire size and tension in all wires. For design purposes, the maximum wire size used in any SEPTA system shall be used irregardless of the actual wire size at the location of the structure.

4 DESIGN AND ANALYSIS

4.1 Structural steel design shall be per AISC ASD or LRFD. An additional design margin of 5% shall be applied as required by AREMA in selecting sizes based upon allowable stresses.

4.2 The use of wood poles for permanent catenary structures is generally not acceptable and requires prior approval of the Chief Engineer except where the wood pole is an “in-kind” replacement (limited to Mile 9 on the R8 Fox Chase line and the escape track on the R1 Airport Line).

4.3 The columns shall be designed with a full moment base plate or direct embedment in a reinforced drilled concrete pier.

4.4 For steel structure design purposes, Design concrete compressive strength $f_c'$ shall be 3500 psi.

4.5 Normally, there are no special charpy requirements for the steel.

4.6 Design of anchor rods shall be in accordance with the ACI-318, Building Code Requirements for Reinforced Concrete (latest edition) and Chapter 16 of this document. Assume a maximum concrete strength $f_c'$ of 3500 psi for design purposes. When anchor rods are specified, they shall be galvanized. Anchor rods shall be threaded at the top end a distance sufficient to provide for leveling or raking of the structure. Only one length of anchor rod shall be used on each structure. Anchor rods/cluster shall be plainly marked to indicate the structure number, type, etc.
5 STEEL DESIGN DETAILS

5.1 Minimum plate thickness and member thickness is \( \frac{3}{8} \) inch.

5.2 Rust plates \( \frac{3}{8} " \) thick, shall be provided on the web and flanges of embedded steel members at the concrete interface. Rust plates shall extend not less than 6 inches on each side of the top of concrete.

5.3 Outstanding legs of angles shall face down.

5.4 All steel embedded in concrete shall be hot dip galvanized for the full length of the member.

5.5 Minimum diameter of anchor rods is 1½ inch. Each anchor bolt shall include two heavy hex nuts and a leveling nut. Provide plate washers were oversize holes are provided (recommended all locations, refer to Tables 16-2 and 16-3 for sizes). Welding on anchor rods will only be allowed in the bottom 12 inches. The minimum embedment length of anchor rods is 6'-0". The minimum number of anchor rods is six (6). Refer to Chapter 16 for additional requirements.

5.6 The detailing of members and assemblies should avoid pockets, crevices, faying surfaces or locations that can collect and retain water, damp debris, or moisture.

5.7 For weathering steel bolted connections, the faying surfaces of bolted connections shall have a one-coat paint system consisting of a high-quality air-drying rust-inhibitive shop-primer which is applied to a nominal dry film thickness of 1.5 to 2 mils. Only Type 3 A325 bolts shall be used with weathering steel.

5.8 For weathering steel columns, the bottom 18 inches of columns including the base plates shall have a paint system complying with the requirements of Chapter 9 paragraph 5.4.5.

5.9 The use of hollow steel (HSS or Tube Steel) columns for railroad and MSHL catenary structures require prior approval of the Chief Engineer or his/her designee.

5.10 Hollow steel members should be sealed to prevent entry of moisture. If this is not possible, provisions must be made to insure adequate drainage and ventilation.

5.11 Provisions for the attachment of a static wire shall be provided on the top of all columns.

5.12 The catenary structure number shall be permanently marked on the inbound and outbound faces of all columns at four feet above groundline using reflective paint or signs.
5.13 “Danger High Voltage” signs shall be installed on all columns.

5.14 Provisions for a two-hole, NEMA-drilled, copper clad grounding pad shall be provided on each steel column 30 inches above the base plate, or in cases of direct embedded poles, 30 inches above top of concrete or the groundline. Grounding pad face shall not be painted.

6 FOUNDATIONS

6.1 Design per ACI 318, AREMA including Chapter 33 Section 4.2.8, and Chapter 5 of this document.

6.2 Minimum embedment is 5'-0". Exclude the top 1'-0" of embedment when calculating embedment depth.

6.3 Minimum factor of safety against overturning shall be 2.0 and against sliding shall be 1.5.

6.4 Concrete shall slope away from the steel with a 1% to 2% slope.

6.5 Footings and caissons shall extend a minimum of 2'-0" above grade but not less than top of adjacent rail. Guy anchor foundations shall extend not less than 1'-0" above grade.

6.6 Concrete shall be a minimum of 4000 psi at 28 days, air entrained, and a minimum w/c ratio by weight of 0.45. For locations adjacent to platforms, parking lots, roadways, bridges, and sidewalks or in areas subjected to de-icing chemicals, use 4500-psi concrete with a minimum w/c ratio of 0.40 and a minimum of 6% air content.

6.7 For locations adjacent to platforms, parking lots, roadways, overhead highway bridges, sidewalks and in areas subjected to de-icing chemicals, all rebar shall be either hot dip galvanized or epoxy coated.
CHAPTER 15
EARTH RETAINING STRUCTURES

1 INTRODUCTION

1.1 Retaining walls shall be designed to withstand lateral earth and water pressures, the effects of surcharge loads, the self-weight of the wall, live loads, dead loads, and in special cases, earthquake loads in accordance with the general principles specified in this Chapter.

1.2 Retaining walls shall be designed for a service life based on consideration of the potential long-term effects of material deterioration on each of the material components comprising the wall. Permanent retaining walls should be designed for a minimum service life of 50 years. Permanent retaining walls supporting railroad and rail transit loads should be designed for a minimum service life of 100 years. Temporary retaining walls should be designed for a minimum service life of 5 years.

1.3 Retaining wall layout shall address slope maintenance above and below the wall. Provide returns into the retained fill or cut at retaining wall ends where possible. Any residual wall batter should be into the fill. Design and construction shall consider surface and subsurface drainage. A system shall be provided to intercept or prevent surface water from entering behind walls. A fence or pedestrian railing shall be considered at the top of walls over 5 feet high where access is open to the public. A fence or pedestrian railing with a minimum height of 42 inches above a standing surface shall be provided at the top of walls 30 inches or higher adjacent to walking surfaces.

1.4 The quality of in-service performance is an important consideration in the design of permanent retaining walls. Permanent walls shall be designed to retain an aesthetically pleasing appearance, and be essentially maintenance free throughout their design service life.

1.5 Loading docks shall be designed as retaining walls using at-rest soil values.

1.6 Temporary shoring walls shall be designed in accordance with the latest edition of the AREMA Manual of Railway Engineering where subjected to rail transit live loads and AASHTO Standard Specifications for Highway Bridges where subjected to other vehicle loads. In all other cases and locations, the requirements of OSHA along with applicable codes and specifications shall be followed.
1.7 Temporary sheeting and shoring shall be designed and constructed in a manner that protects adjacent buildings, bridges, roadways, or railway, and existing traffic, while allowing inspection access for existing facilities and structures.

2 WALL TYPES

2.1 Retaining walls are generally classified as gravity, semi-gravity (or conventional), non-gravity cantilevered, and anchored.

2.1.1 Gravity walls derive their capacity to resist lateral loads through dead weight of the wall. The gravity wall type includes rigid gravity walls, mechanically stabilized earth (MSE) walls, and segmental (prefabricated modular) gravity walls (SRW).

2.1.2 Semi-gravity walls are similar to gravity walls, except they rely on their structural components to mobilize the dead weight of backfill to derive their capacity to resist lateral loads.

2.1.3 Non-gravity cantilevered walls rely on structural components of the wall partially embedded in foundation material to mobilize passive resistance to resist lateral loads.

2.1.4 Anchored walls derive their capacity to resist lateral loads by their structural components being restrained by tension elements connected to anchors and possibly additionally by partial embedment of their structural components into foundation material. The anchors may be ground anchors (tiebacks), passive concrete anchors, passive pile anchors, or pile group anchors. The ground anchors are connected directly to the wall structural components whereas the other type anchors are connected to the wall structural components through tie rods.

2.1.5 Within the wall types above, many of the retaining wall systems available are proprietary. Their use requires appropriate contractual requirements.

2.2 Selection of the appropriate wall type is based on an assessment of the design loading, depth to adequate foundation support, presence of deleterious environmental factors, physical constraints of the site, cross-sectional geometry of the site both existing and planned, settlement potential, desired aesthetics, constructibility, maintenance, and cost.

- Rigid Gravity and Semi-Gravity Walls
- Non-Gravity Cantilevered Walls
- Mechanically Stabilized Earth Walls
- Anchored Retaining Walls
- Prefabricated Modular or Segmental Walls
2.3 Wall types proposed for use, shall have successfully been used in similar
geotechnical locations and environmental conditions.

2.4 Prohibited types of walls

2.4.1 Mechanically stabilized earth retaining walls are not permitted for railroad,
rail transit, and highway live load applications or where site construction or
excavation can be reasonable anticipated near the anchorage zone of the
wall.

2.4.2 Timber walls will not be permitted for permanent retaining walls.

2.4.3 Metal walls, including bin walls and sheet pile walls, and recycled material
walls are not permitted for permanent retaining walls supporting rail transit
loads. The use of these type walls for other applications are generally not
permitted unless approved by Chief Engineer – EM&C.

2.4.4 The use of prefabricated modular or segmental walls where the individual
units are small, typically less than 100 lbs, is only permitted for landscaping
applications, walls less than 10 feet in height, and wall not subjected to rail
transit or highway surcharge loads.

3. BASIS FOR DESIGN

3.1. Retaining walls shall be designed in accordance with the applicable standards and
references outlined in this document.

3.1.1. Where adjacent to a railroad embankment and/or subject to railroad live
loads, design in accordance with the latest edition of the AREMA Manual of
Railway Engineering.

3.1.1.1. For SEPTA’s railroad system, design for a Cooper E-80 live load.
3.1.1.2. For light rail, design for a Cooper E-65 live load.
3.1.1.3. For retaining walls up to 20 feet in height, the design earth
pressures shall be computed per AREMA Manual’s empirical
method.
3.1.1.4. Retaining walls above 20 feet in height, shall be designed on the
basis of specific soils information relating to the backfill material in
accordance with the AREMA Manual.

3.1.2. Design per AASHTO Standard Specifications for Highway Bridges where
subjected to vehicle loads from parking lots or roadways. Mechanically
Stabilized Earth Walls shall be designed to the more severe requirements
of AASHTO LRFD Bridge Design Specifications.
3.1.3. Segmental retaining walls shall be designed per the National Concrete Masonry Association’s (NCMA) “Design Manual for Segmental Walls” as modified by AASHTO or AREMA as applicable.

3.1.4. The Service Load Design Method shall be used for the design of retaining walls except where noted otherwise.

3.1.5. Anchored walls shall be designed and constructed using FHWA RD-82-046, FHWA RD-82-047, and FHWA-IF-99-015 as guidelines. Anchors shall be encapsulated with plastic sheathing. Proof load tests for anchors shall be provided in accordance with the above FHWA guidelines. Shotcrete if permitted by SEPTA Bridges & Buildings Department in writing, shall be designed per ACI and shall meet the aesthetic requirements set in the Project Scope.

3.1.6. Soil Nail Walls may be used when top-down construction is warranted. Soil nail walls shall not be used if ground water seepage may be a problem. Design and construction shall use FHWA-RD-89-93, FHWA-SA-93-086, and FHWA-SA-96-069 as guidelines. Load testing for nails shall be provided in accordance with the above FHWA guidelines. Shotcrete if permitted by SEPTA Bridges & Buildings Department in writing, shall be designed per ACI and shall meet the aesthetic requirements set in the Project Scope.

3.2. Retaining walls shall be designed to provide adequate structural capacity with acceptable movements, adequate foundation bearing capacity with acceptable settlements, and acceptable overall stability of slopes adjacent to walls. The tolerable level of lateral and vertical deformations is controlled by the type and location of the wall structure and surrounding facilities.

3.2.1. Bearing Capacity: The bearing capacity of wall foundation support systems shall be estimated using procedures described in Chapter 5 and current engineering practice. See Chapter 5 for additional information.

3.2.2. Settlement: The settlement of wall foundation support systems should be estimated based on soil and rock parameters measured directly or inferred from the results of in-situ and/or laboratory tests.

3.2.3. Overall Stability: As part of the design, the overall stability of the retaining wall, retained slope and foundation soil or rock shall be evaluated for all walls using limiting equilibrium methods of analysis.

3.2.4. Global stability shall be performed on Mechanically Stabilized Earth (MSE) and SRW walls over 4 feet in height. Pullout resistance shall be performed on Mechanically Stabilized Earth (MSE) over 6 feet in height.
3.3. The recommended minimum factor of safety for the design of retaining walls shall be per Table 15-1.

3.4. The design of MSE and Modular walls near or in bodies of water shall account for soft saturated soils and scour. For all modular walls, a mechanical connection to the wall facing for soil reinforcement (where required) shall be provided; friction connections relying on gravity alone will not be acceptable.

3.5. Passive pressure resistance to sliding from soil in front of the wall shall not be considered in the design.

3.6. Use free draining backfill material, weep holes, or other devices to reduce hydrostatic loads on retaining walls.

3.7. In all cases, the subsurface conditions and soil/rock properties of the wall site shall be adequately characterized through in-situ exploration and testing and /or laboratory testing.

**TABLE 15-1**

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>FS (2) Based on Wall Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conventional Segmental Walls</td>
</tr>
<tr>
<td>Base Sliding</td>
<td>1.5</td>
</tr>
<tr>
<td>Overturning</td>
<td>2.0</td>
</tr>
<tr>
<td>Bearing Capacity</td>
<td>3.0</td>
</tr>
<tr>
<td>Internal Shear Capacity</td>
<td>1.5</td>
</tr>
<tr>
<td>Global Stability</td>
<td>1.5</td>
</tr>
<tr>
<td>Tensile Overstress</td>
<td>N/A</td>
</tr>
<tr>
<td>Pullout</td>
<td>N/A</td>
</tr>
<tr>
<td>Facing Shear Capacity</td>
<td>N/A</td>
</tr>
<tr>
<td>Connection</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Notes:**

1) A minimum factor of safety of 1.3 can be used for the design of walls in landscaping and minor non-critical locations with static loads.

2) A minimum factor of safety of 1.0 shall be used for the design of walls for seismic loads.
3.8. Special exploration, testing and analysis may be required for retaining walls constructed over soft deposits or for sites where excess pore water pressures may develop during a seismic event.

3.9. Retaining walls shall be designed for a pressure of not less than 40 pounds per square foot per foot of wall height plus surcharge.

3.9.1. Walls with level backfill which support public roadways should be designed with a minimum live load surcharge equivalent to 2 foot surcharge.

3.9.2. Retaining walls and other structures providing lateral support to sidewalks should be designed with a uniform live load equivalent to one foot of earth surcharge.

3.9.3. The lateral pressure need only be applied to the upper 10 feet of the retaining structure and may be ignored where highway live load is used or when the sidewalk falls outside a distance from the wall equal to half the height.

3.9.4. Live load (other than railroad and rail transit) may be neglected if vehicles do not come within 10 feet and a distance from the wall equal to half the wall height.

3.10. The minimum depth of foundations is 3’-0” for all rigid walls and segmental retaining walls designed per AREMA. For segmental retaining walls (SRW), this can be measured to the base of the flexible granular leveling pad but in no case shall be less than 2’-0” to the base of the segmental wall unit.

3.10.1. For segmental retaining walls (SRW), the minimum wall embedment depth shall be measured vertically and comply with the NCMA Design Manual as modified herein. The minimum requirement for SEPTA is 1’-0” except for walls within the railroad or rail transit ROW, as noted above.

3.10.2. SRW walls shall be designed for the total height including embedment.

3.10.3. The primary benefit of wall embedment is enhanced stability. The depth of embedment should be increased whenever the following special conditions are present:

• Large settlement potential
• Weak bearing capacity of underlying soils
• Steep slopes near or below the toe of the wall
• Potential for scour at the toe of the wall for waterfront and submerged wall applications
• The maximum depth of seasonal soil volume change extends below the bearing pad or base of wall.
• Seismically active locations
3.11. Soil, Rock, and Other Problem Conditions: Geologic and environmental conditions can influence the performance of retaining walls and their foundations, and may require special consideration during design. To the extent possible, the presence and influence of such conditions shall be evaluated as part of the subsurface exploration program.

3.12. Tolerable Deformations

3.12.1. Tolerable vertical and lateral deformation criteria for retaining walls shall be developed based on the function and type of wall, anticipated service life, and consequences of unacceptable movements (i.e., both structural and aesthetic). Allowable total and differential vertical deformations for a particular retaining wall are dependent on the ability of the wall to deflect without causing damage to the wall elements or exhibiting unsightly deformations. The total and differential vertical deformation of a retaining wall should be small for rigid gravity and semi-gravity retaining walls, and for soldier pile walls with cast-in-place concrete facing. For walls with inclined tieback anchors, any downward movement can cause significant distressing of the anchors.

3.12.2. SRW/MSE walls can tolerate larger total and differential vertical deflections than rigid walls. The amount of total and differential vertical deflection that can be tolerated depends on the wall facing material, configuration, and timing of facing construction. A cast-in-place concrete facing has the same vertical deformation limitations as the more rigid retaining wall systems. However, the cast-in-place facing of an MSE wall can be specified to be constructed after an appropriate settlement period so that vertical as well as horizontal deformations have time to occur. An MSE wall with welded wire or geosynthetic facing can tolerate the most deformation. An MSE wall with multiple precast concrete face panels cannot tolerate as much vertical deformations as flexible welded wire or geosynthetic facings because of potential damage to the precast face panels and unsightly face panel separation.

3.12.3. Horizontal movements resulting from outward rotation of the wall or resulting from the development of internal equilibrium between the loads applied to the wall and the internal structure of the wall must be limited to prevent overstress of the structural wall facing and to prevent the wall face batter from becoming negative. In general, if vertical deformations are properly controlled, horizontal deformations will likely be within acceptable limits. For MSE walls with extensible reinforcements, reinforcement serviceability criteria, the wall face batter, and the facing type selected (i.e. the flexibility of the facing) will influence the horizontal deformation criteria required.
3.12.4. Where a wall is used to support a structure, tolerable movement criteria shall be established. Where a wall supports soil on which an adjacent structure is founded, the effects of wall movements and associated backfill settlement on the adjacent structure shall be evaluated.

4. MINIMUM REQUIREMENTS

4.1. All structural elements of the retaining wall must be completely detailed and included on a comprehensive set of drawings. The drawings must be to scale, showing all dimensions. Drawings should include:
   - Elevation of retaining wall showing all construction, control and/or expansion joints.
   - Sections and details showing the following, minimum, when applicable:
     - Wall and footing dimensions.
     - Typical expansion and control joint.
     - Reinforcing steel size and spacing.
     - Reinforcing steel cover dimensions.
     - Drain pipe size and weep hole spacing.

4.2. The following information shall be included in the design documents:
   - Code and code year used for the design
   - General notes including, but not limited to the following, when applicable:
     - Concrete compressive strength.
     - Concrete masonry and mortar specifications.
     - Reinforcing steel grade.
   - Drainage specifications.
   - Lateral earth pressure and soil type used in design.

4.3. Load testing for soil nails and rock anchors shall be provided in accordance with the FHWA guidelines noted in Section 3 above.

4.4. Soil reinforcement for MSE and SRW walls shall be galvanized, epoxy coated steel or geogrids meeting creep requirements of AASHTO Standard Specifications for Highway Bridges. Design shall account for any item projecting through the soil reinforcement. Avoid placing culverts and utilities perpendicular to soil reinforcement within the reinforced soil mass. Soil reinforcement shall be protected from corrosion of metal due to stray electrical currents. Requirements for stray current control shall follow the project standards as defined by SEPTA.

5. DRAINAGE
5.1. Any water that accumulates behind abutment back walls and retaining walls must be drained to prevent settlement of the embankment or failure of the wall. This is accomplished through footing drains, weep holes and geosynthetic drains.

5.2. Granular backfill behind the walls is essential to carry the water to footing drains and weep holes.

5.3. Footing drains are preferred instead of weep holes to drain walls that are visible to the public. A perforated drain pipe is installed behind the footing with outlets located to minimize aesthetic impacts.

5.4. Weep holes may be used in walls that are not generally visible to the public, such as in back walls for stream crossings, ROW and Yard retaining walls. Additional drainage for perched abutments where the granular backfill material extends below the abutment is not required.

5.5. Geosynthetic drains provide drainage of the fill immediately behind the walls without the necessity of placing stone backfill. These drains are available in various thicknesses and capacities.

6. TEMPORARY SHEETING AND SHORING

6.1. A complete description of the shoring system including all members, materials, spacing, etc. is required to be provided for all projects.

6.2. SEPTA requires that a registered professional engineer review the Contractor’s plans for temporary structures in connection all shoring plans supporting: railroad and rail transit tracks; buildings: bridges and roadways; and areas open to the public.

6.3. When shoring plans are designed by firms specializing in temporary support systems and soil restraint (including sloping), good engineering judgment is to prevail for review. SEPTA recognizes that shoring designed by such firms will often be less conservative than would shoring designed by conservative use of this document.

6.4. Any revisions to plans shall be done by the plan originator or by his/her authorized representative. Minor revisions may be made on plans but the revisions should be initialed and dated by the person making the changes.

6.5. Temporary shoring wall may be one of the following types unless otherwise approved by in plans:
6.5.1. Steel sheet pile wall – braced, tieback, or cofferdam – this is the recommended method where subjected to railroad and rail transit live loads. Alternate methods such as steel soldier piles with lagging proposed for railroad and rail transit live loads require prior approval of the Chief Engineer – EM&C or designee.

6.5.2. Steel soldier piles with lagging – braced or tieback – tiebacks shall not be under the tracks unless specifically approved by SEPTA Track Department on a case by case basis.

6.5.3. Trench boxes or similar devices – This type of shoring is not permitted where subjected to railroad and rail transit live loading.

6.6. Basis of Design

6.6.1. Temporary shoring walls shall be designed to resist all dead and live loadings (earth pressures, hydrostatic pressures, traffic loads, point loads, line loads, and surcharge loads) that the retaining system may experience during the service life of the structure. See paragraph 3 for additional requirements and rail transit loads.

6.6.2. The designer of shoring is responsible for the external stability of all temporary shoring walls including any geotechnical investigation necessary to verify the external stability. Temporary shoring walls are not required to resist seismic forces from earthquake events.

6.6.3. Design Life: All temporary shoring walls shall be designed for a minimum of 3 years design life. Temporary shoring walls that will be in use for more than 5 years shall be designed as permanent retaining wall structures.

6.6.4. Soil Design Parameters: Temporary shoring walls shall be designed using appropriate soil properties relative to the anticipated service life. Temporary shoring that will be in-place for a period where excess pore pressures have not dissipated (typically less than 4 to 6 months) shall be designed using total (undrained) soil shear strength parameters. Effective (drained) soil shear strength (drained) parameters should be used when temporary shoring walls are in service sufficiently long (typically more than 4 to 6 months) for excess pore pressures to dissipate.

6.6.5. Any loads, including normal construction loads, that are adjacent to the excavation or trench should be identified and shown on the plans with all pertinent dimensions; examples are highways, railroads, existing structures, etc. The lateral pressures due to these loads will then be added to the basic soil pressures. The type of loading will also effect the type of shoring that can be accepted (an adjacent building will necessitate restriction of movement in the shoring system for example). The minimum surcharge is to be used where not exceeded by above loading considerations.

6.6.6. When lumber (timber) type is listed or shown on the shoring plan without allowable stress values, the “National Design Specification for Wood Construction” shall be used as a guide. If the specific lumber grading is
not included, low allowable stress values shall be used. When shoring plans do not specify stress limitations or list type of lumber (timber), the following stress limitations shall not be exceeded:

- **Horizontal Shear**: \( V = 140 \text{ psi} \)
- **Compression Perpendicular to Grain**: \( F_{c\perp} = 450 \text{ psi}^* \)
- **Compression Parallel to Grain**: \( F_c = 1,600 \text{ psi} \)
- **Modulus of elasticity of wood**: \( E = 1,600,000 \text{ psi} \)
- **Direct tension**: \( F_t = 1,200 \text{ psi} \)
- **Flexural**
  
  - \( F_b = 1,800 \text{ psi} \) reduced to \( 1,500 \text{ psi} \) for members with a nominal depth for 8 inches or less

* Reduce to 300 psi when moisture content is 19% or more (areas exposed to rain, concrete curing water, or green lumber)

6.6.7. The use of used material will be reviewed on a project by project basis. Used material must conform to the dimensions and material specified on the falsework plans. Used material shall be free of splits, cracks, holes, etc. that will reduce the structural capacity. No. 2 Grade or better material is required. Conservative values of allowable structural capacity shall be used for all used materials unless the Contractor can certify (and document) that the material is capable of supporting a greater stress.

**Timber – Maximum Allowable Stresses**

- **Flexural**: \( F_b = 1,200 \text{ psi} \)
- **Horizontal Shear**: \( V = 120 \text{ psi} \)
- **Compression Perpendicular to Grain**: \( F_{c\perp} = 400 \text{ psi}^* \)
- **Compression Parallel to Grain**: \( F_c = 850 \text{ psi} \)
- **Modulus of elasticity of wood**: \( E = 1,500,000 \text{ psi} \)
- **Direct tension**: \( F_t = 1,000 \text{ psi} \)

* Reduce to 300 psi when moisture content is 19% or more (areas exposed to rain, concrete curing water, or green lumber)

**Steel Shapes and Plates**

- **Fy**: \( 30,000 \text{ psi} \)

6.7. Railroad And Rail Transit Requirements

6.7.1. SEPTA utilizes continuous welded rail (CWR) on its system. It is imperative to the safety of rail operations and to prevent rail buckling, that the lateral rigidity of the track (which consists of the rail-tie structure and the ballast) remains unchanged and intact. The shoulder width and height shall not be modified without express written approval of SEPTA.
6.7.2. Footings for new construction (all piers, columns, walls or other facilities) shall be located and designed so that any temporary sheeting and shoring for support of adjacent track or tracks during construction shall not be closer than ten feet (10'-0") from the centerline of the nearest track or the toe of the ballast slope, which ever is greater.

6.7.3. Shoring protection shall be provided when excavating adjacent to an active railroad track and structures. When the track is on an embankment, excavating the toe of the embankment without shoring may affect the stability of the embankment. Therefore, excavation of the embankment toe without shoring will not be permitted.

6.7.4. Preferred protection is the cofferdam type that completely encloses the excavation. Where dictated by conditions, partial cofferdams or shoring with open sides away from the track or structure may be used. Cofferdams shall be constructed using interlocking steel sheet piling driven prior to excavation or steel soldier piles with timber lagging. Consideration for the use of soldier piling and lagging shall be made if the required penetration of steel sheet piling cannot be obtained and when dry, non-running, stable material will be encountered. Wales and struts shall be provided as needed.

6.7.5. All existing structures and/or track shall be monitored for horizontal and vertical movement.

6.7.6. The following shall be considered when designing shoring:

6.7.6.1. Shoring adjacent to tracks or track support structures shall be designed to resist not less than a vertical live load surcharge of 1800 pounds per square foot (psf), in addition to active earth pressure. The surcharge shall be assumed to act on a continuous strip, 8'-6" wide. Lateral pressures due to surcharge shall be computed using the strip load formula shown in AREMA Manual for Railway Engineering.

6.7.6.2. Allowable stresses in materials shall be in accordance with AREMA Manual for Railway Engineering, Chapter 7, 8, and 15.

6.7.6.3. The sheeting shall be designed to support all lateral forces caused by the earth, railroad and other surcharge loads. The railroad loading to be applied is a Cooper E-80 loading plus impact. This loading consists of 80 Kip axles spaced five (5) feet on centers. For rail transit and light rail applications, a Cooper E60 loading may be used.

6.7.7. Use K (at-rest earth pressure) for design of all braced and tieback excavations.

6.7.8. The allowable stresses for the sheet piling and other steel members (wales, struts, etc.) shall be in accordance with AREMA Chapter 15, Part 1. These allowable stresses may be increased 10% due to the temporary nature of the installations. A factor of safety of at least 1.5 must be used on temporary sheeting for the embedment length (i.e. multiply calculated embedment depth by 1.5).
6.7.9. The maximum allowable flexural stress for all timber used for shoring adjacent to railroad and rail transit tracks shall be 1,700 psi.

6.7.10. Deflection design criteria is as follows:
- 1/2" maximum deflection for shoring fifteen (15) feet from the centerline of the nearest track.
- 1" maximum deflection for shoring greater than fifteen (15) feet from the centerline of the nearest track.

6.7.11. A minimum distance of 10 feet from centerline of the track to face of nearest point of shoring shall be maintained.

6.7.12. Soil or rock anchors shall not be used under the track bed unless specifically approved by SEPTA Track Department on a case by case basis.

6.7.13. Where soil or rock anchors are used, all anchors must be tested. Testing shall be in accordance with industry standards with ten percent (10%) of the anchors "Performance Tested" and all others "Proof Tested". All tieback anchor stresses are to be in accordance with AREMA.

6.7.14. Drilled or augured piers do not require additional shoring if concreted the same day. If excavation is left open overnight or if the excavation requires casing, the casing shall either be withdrawn during concrete placement or the exterior of the casing shall be pressure grouted to fill any voids.

6.7.15. Refer to Figure 15-1 for details.
FIGURE 15-1
SHORING REQUIREMENTS FOR RAILROAD AND RAIL TRANSIT
CHAPTER 16
ANCHOR RODS

1 INTRODUCTION

1.1 This chapter prescribes criteria for the design of anchor rods (bolts). The design and construction of cast in place and drilled and grouted anchor rods shall meet the minimum design requirements specified here-in.

1.2 Anchor rods (bolts) are commonly used to transfer shear and tension loads between cast-in-place concrete and precast concrete members and between cast-in-place concrete and structural steel shapes.

2 BASIS FOR DESIGN

2.1 Unless special circumstances dictate otherwise, design anchor systems for a ductile failure. A ductile failure requires embedment sufficient to ensure that failure will occur by yielding of the steel rather than by failure of the surrounding concrete.

2.2 The design and detailing of the reinforcement steel in the concrete shall account for the tension and shear loads from anchor rods. Additional confinement reinforcement steel may be required. Anchor rods shall be located to the interior of confinement reinforcing steel.

2.3 Unless otherwise noted or addressed, the provisions of ACI 318 Appendix D, “Anchoring into Concrete” and the IBC should be followed to the extent applicable.

2.4 All post installed concrete anchors (structural and non-structural applications) located subway and railroad tunnels must be designed based upon exposure to extreme high temperatures in the case of fire in the tunnel.

2.5 All post installed concrete anchors located on or adjacent to rail transit structures must consider the affect of vibration in the structure caused by the trains.

2.6 Design of anchors must consider seismic and wind loads, high cycle fatigue, impact, and dynamic loadings.

3 MECHANICAL AND EXPANSION ANCHORS

3.1 The use of expansion anchors for permanent structural applications in SEPTA facilities is generally limited to non-structural interior applications unless otherwise
approved by the Chief Engineer – EM&C or his/her designee. Undercut anchors are not subject to this restriction.

3.2 The use of other types of mechanical anchors may be appropriate for the conditions cited above and will be reviewed on a project by project basis.

3.3 The engineer shall review anchor design features, failure modes, test results and installation procedures prior to selecting a specific mechanical anchor for an application.

3.4 Mechanical anchors in tension zones of concrete members shall be rated for that application assuming cracked concrete.

3.5 Expansion anchors shall not be installed in concrete where there is obvious signs or cracking, or deterioration.

3.6 Exterior applications shall use stainless steel or hot dip galvanized anchors.

4 ADHESIVE (CHEMICAL) ANCHORS

4.1 Adhesive Anchor Systems (adhesive bonding material and steel bar anchors or inserts installed in clean, dry holes drilled in hardened concrete) are used to attach new construction to existing concrete structures. Anchors may be reinforcing bars or threaded rods depending upon the application. The adhesive bonding material is a two-component epoxy, polyester, or vinylester resin adhesive.

4.2 Epoxy adhesive anchors should not be used in structural elements that are required to be fire resistant. Generally stainless steel anchors have better performance than carbon steel anchors where exposed to fire or extreme high temperatures. Cement grout may be substituted in these applications.

4.3 Adhesive anchors should not be installed in wet or damp conditions (unless specifically approved for that use by the manufacturer) or in concrete where there is obvious signs or cracking, or deterioration.

4.4 No specific design codes are currently available for adhesive anchors. Therefore, design should be based on the manufacturer’s recommendations, and testing should be required to assure the installed anchors meet strength requirements.

4.5 Rods shall be AISI Type 316 stainless steel where exposed to cleaning or de-icing chemicals or agents. Other locations shall be either AISI Type 304 or 316 stainless steel or hot dip galvanized steel. Stainless steel anchors shall also be specified by the ASTM and/or minimum design strength (Fy or Fu)
4.6 Adhesive Anchors shall be installed in accordance with manufacturer's recommendations for hole diameter and hole cleaning technique.

4.7 Installation of Adhesive Anchor Systems in saturated, surface-dry holes; i.e., holes with damp surfaces but with no standing water, is not pre-approved or recommended SEPTA. However, in the event such a condition is encountered during construction, the SEPTA may consider approving continued installation, but only on an adjusted, case-by-case basis. The damp hole strength of adhesive anchor systems is assumed to be approximately 75% of the dry hole strength unless the manufacturer has specific published damp hole strength data.

4.8 Do not use Adhesive Anchor Systems to splice with existing reinforcing bars in either non-prestressed or prestressed concrete applications unless special testing is performed and special, proven construction techniques are utilized.

4.9 Adhesive Anchor Systems are permitted for horizontal, vertical, or downwardly inclined installations. Overhead or upwardly inclined installations of adhesive anchors are generally not recommended.

4.10 Design Adhesive Anchor Systems for a ductile failure. In order to produce ductile failure, the following embedments may be assumed:

4.10.1 For Anchors in Tension: The embedment length necessary to achieve 125% of the specified yield strength or 100% of the specified tensile strength, whichever is less.

4.10.2 For Anchors in Shear: An embedment equal to 70% of the embedment length determined for anchors in tension.

4.10.3 In circumstances where ductile failure is not required, the design may be based upon the design strength of either the steel anchor or the adhesive bond, whichever is less.

4.11 Building and canopy column anchor rods shall not be less than ¾ inch in diameter for interior applications and 1 inch for exposed exterior applications. Anchor rods subjected to tension shall not be less than 1 inch in diameter. For bridges and catenary support structures, anchor rods shall not be less than 1¼ inch in diameter.

5 EMBEDDED ANCHOR RODS

5.1 Design Recommendations

5.1.1 The use of J type anchor rods are not permitted where subjected to tension and are generally not used on SEPTA projects.
5.1.2 Recommended service load stress allowable for the four types of anchor rods are as noted in Table 16-1.

5.1.3 The allowable tension for high-strength and alloy steel bolts will probably be unachievable due to fatigue or anchorage limitations. Anchor rods for signal bridges, catenary structures, light poles, transmission line poles, and other similar structures should be limited to a design tension of 27 ksi and shear of 16 ksi, for these reasons.

<table>
<thead>
<tr>
<th>TABLE 16-1</th>
<th>Recommended Service Load Stress Allowable For Anchor Rods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mild steel (Minimum Fy = 36 ksi)</td>
</tr>
<tr>
<td>Tension</td>
<td>18 ksi</td>
</tr>
<tr>
<td>Shear</td>
<td>11 ksi</td>
</tr>
<tr>
<td>Fatigue</td>
<td>8 ksi</td>
</tr>
</tbody>
</table>

5.1.4 Fatigue allowables are based on Category E, redundant for 2,000,000 cycles. The stress area, through the threads, should be used in all cases. Allowable stress may be increased for certain load groups as permitted by AASHTO or AREMA specifications.

5.1.5 Shear due to torsion in the anchored member should be added to the shear caused by transverse forces.

5.1.6 Bending stresses due to unsupported anchor rod length may be ignored if projection is no more than five times the bolt diameter and leveling nut along with double nuts (top) are provided and securely tightened. Jam or lock nuts shall not be used as the second nut.

5.1.7 Allowable tension should be commensurate with anchorage strength. Most authorities emphasize the desirability of allowing "ductile" failure by sufficient anchorage strength to develop the yield or even the ultimate strength of the bolts. This is a virtual impossibility for anchor rods in columns or walls such as commonly required for Anchor rods for signal bridges, catenary structures, light poles, transmission line poles, bridge railings, and other similar structures. Certainly, the anchorage should
develop the service load tension in the bolts. Preferably, a reasonable factor of safety should be provided.

5.1.8 Where specifications are unclear regarding the combination of tension and shear in anchor rods, it is prudent to utilize a method similar to the requirements for structural steel connection bolts.

5.1.9 For severe tension or fatigue conditions, consideration should be given to prestressed anchorage. Regular post-tensioned systems should be used. Prestressing anchor rods by turning the nut is of doubtful value.

5.1.10 Concern over fatigue may require a prestressed anchor bolt design. Because of fatigue concerns, the allowable stress in anchor rods for sign supports, towers, pole structures, tall light poles, and similar structures should be limited to the specification factor times 55 ksi yield stress. This limits the effectiveness of higher grade bars and rods

5.2 Detailing Requirements

5.2.1 Anchor rods with calculated tension, shall be anchored with embedded nuts and plates that can also serve as a template as well as increase the pullout resistance.

5.2.1.1 Nuts should be tack welded to the template to prevent floating during concrete placement.
5.2.1.2 Double nuts shall be provided and securely tightened.
5.2.1.3 Jam or lock nuts shall not be used as the second nut.
5.2.1.4 Leveling nuts should be used.
5.2.1.5 The minimum recommended embedment length is 24 times the rod diameter (24d).
5.2.1.6 The minimum recommended edge distance is 6 times the rod diameter (6d).

5.2.2 The recommended material for anchor rods is ASTM F1554 Grade 36 or 55, weldable. The use of Dywidag®, rebar, or similar rods is not permitted for fatigue applications.

5.2.3 Anchor rods that resist no uplift may be anchored by J-bolts but their use is not recommended.

5.2.4 Anchorage zone concrete reinforcing should be given careful attention. Supporting members must be able to resist the forces delivered by the anchor rods. Vertical reinforcing must have sufficient development length to resist stresses delivered by the anchorage plate. Confinement reinforcing is beneficial, and transverse reinforcing can improve the shear
strength of the anchorage. All anchor rods shall be confined by reinforcement.

5.2.5 Construction problems are caused primarily by mislocated anchor rods. For bridge superstructures, anchor rods are often set in preformed holes in the concrete to allow for variation in bent locations or beam length. Templates are a virtual necessity for anchor bolt groups, such as for catenary structures and tall poles. Prestressed anchor rods present an added construction difficulty.

5.2.6 Base plate should be provided with oversized holes to allow for construction tolerances. Plate washers shall be provided to cover the oversize holes and slotted holes. Refer to paragraph 5.2.13 and Tables 16-2 and 16-3.

5.2.7 All building and canopy column base plates must be designed and fabricated with a minimum of four (4) anchor rods. For all base plates/anchor bolt connections subjected to tension, catenary structures, high mast lighting, and similar structures it is recommend that eight (8) anchor be provided but not less than six (6) shall be provided in any case.

5.2.8 The drawings shall show the minimum edge distances from the anchor rod centerline to the edge of the base plate and edge of concrete.

5.2.9 Building and canopy column anchor rods shall not be less than ¾ inch in diameter for interior applications and 1 inch for exposed exterior applications. Anchor rods subjected to tension shall not be less than 1 inch in diameter.

5.2.10 For bridges and catenary structures, anchor rods shall not be less than 1¼ inch in diameter.

5.2.11 For bridges, anchor rods shall be embedded not less than 12 inches. For bridges subjected to uplift, the anchor rods shall be designed to engage the weight of masonry not less than 1.5 times the uplift.

5.2.12 Carbon steel anchor rod assemblies shall be hot dip galvanized.

5.2.13 The minimum thickness of washers subjected to tension should be one-third the diameter of the anchor rod. When the anchor rod transmits tension, the washer size must be sufficient to transmit the force to the base plate. Where anchor rods are subjected to tension and/or have oversized holes, the minimum thickness should be per Table 16-2.
5.2.14 The minimum diameter (or length and width for a non-circular washer) should be 1-in. larger than the hole diameter for oversize holes. The hole size shall be 1/16 inch larger than the anchor rod diameter. See Table 16-3 for recommended sizes.

<table>
<thead>
<tr>
<th>Anchor Rod Diameter</th>
<th>Calculated Minimum Thickness per Paragraph 5.2.13 (Inches)</th>
<th>Minimum Plate Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hundredths</td>
<td>Fraction</td>
</tr>
<tr>
<td>1/2</td>
<td>0.167</td>
<td>3/16</td>
</tr>
<tr>
<td>5/8</td>
<td>0.208</td>
<td>3/16</td>
</tr>
<tr>
<td>3/4</td>
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<td>5/8</td>
</tr>
<tr>
<td>2</td>
<td>0.667</td>
<td>11/16</td>
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</table>
### Table 16-3
Recommended Minimum Washer Size For Oversize Holes

<table>
<thead>
<tr>
<th>Anchor Rod Hole Diameter</th>
<th>Minimum Washer Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Circular Washer Diameter</td>
</tr>
<tr>
<td>5/8</td>
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<tr>
<td>2 1/4</td>
<td>3 1/4</td>
</tr>
</tbody>
</table>
CHAPTER 17
COMMUNICATION AND ANTENNAE SUPPORT TOWERS

1 INTRODUCTION

1.1 This Chapter prescribes criteria for the design of antenna support towers and structures. Towers may be self-supporting or wire-guyed type. The equipment and/or control buildings are typically pre-engineered concrete units placed at the base of the tower.

1.2 This Chapter applies to all new towers as well existing towers that are either being modified or have a change in loading.

2 BASIS FOR DESIGN

2.1 Steel tower structures supporting electronic/communications equipment shall be designed in accordance with the latest version of the ANSI/TIA/EIA-222 specification, referred to as “TIA/EIA STANDARD” except as modified herein. For additional requirements, refer to Chapter 3, Section 17.

2.2 Antenna towers and antenna supporting structures shall be designed for fastest mile wind speed of 80 mph. The Engineer of Record shall verify the local code requirements. If the minimum design wind speeds specified by local codes is greater than 80 mph, they shall be converted to the fastest-mile wind speeds at 33 feet above ground level and used in conjunction with the TIA/EIA Standard.

2.3 Communication towers shall be designed as Category III structures that are essential facilities.

2.4 For aluminum towers, and antennas, the one third increase in allowable stresses under wind or seismic loads permitted in the Aluminum Association Specifications for Aluminum Structures shall not be used. Refer to Chapter 12 Section 2 for additional requirements.

2.5 Ice load calculations are required. The minimum density of ice shall be considered to be 56 pcf. Unless more stringent codes apply, the minimum ice loadings shall be calculated based upon the following conditions:
2.5.1 ½ inch radial ice load and fastest mile wind speed of 80 mph
2.5.2 1 inch radial ice load and fastest mile wind speed of 31 mph

2.6 Load combinations shall be per the TIA/EIA Standard as modified below.

2.6.1 For load combination D+Wo (paragraph 2.3.16), the 1/3 increase in allowable stress noted in paragraph 3.1.1 is not permitted.
2.6.2 Load combination D+0.75W,I+I shall be checked for both icing conditions listed in paragraph 2.4 above. Reducing the calculated wind pressure by any other factor is not permitted.

2.7 The current TIA/EIA Standard is based on Allowable Stress Design (ASD), which should be used for consistency on all tower structures. Upon adoption of the ANSI/EIA/TIA-222-G, comply with the new standard that will be based upon limit states design. The design load combinations in the new code shall be used upon adoption.

3 DESIGN DETAILS

3.1 The Engineer shall provide a site plan that establishes the maximum and minimum guy radii, shows foundation locations and loads, and requirements of the Geotechnical Engineer.

3.2 Geotechnical investigations shall be performed in accordance with Annex I of the TIA/EIA Standards.

3.3 Either fixed ladders (preferred) or step bolts shall be specified as the access climbing facility. A climbing device consisting of safety belts and properly attached cables or Safe-T-Climb rail system shall be provided as a minimum. Ladder cages and platforms are not recommended for tower structures due to size and weight constraints. Fall protection shall comply with OSHA requirements.

3.4 Anchor rods shall comply with the requirements of Chapter 16.

3.5 All structural steel, fasteners, components, and anchor rod assemblies for the tower structure shall be hot dip galvanized. Where painting is required for marking purposed, refer to the requirements for a duplex coating system in Chapter 9 Section 5.

4 EQUIPMENT AND CONTROL BUILDINGS

4.1 All buildings shall be designed based upon the loadings and criteria set forth in this document.
4.2 The roof of all equipment and control building(s) located under or adjacent to a tower structure shall be designed to withstand the impact of a 30 pound piece of ice falling from the top of the tower.
COMMENTARY
CHAPTER 1

C1-1. Each design objective of a project is significantly important, yet it is just one aspect of what it takes to achieve a successful project. A truly successful project is one where project goals are identified early on and where the interdependencies of all building or structural systems are coordinated concurrently from the planning and programming phase. Further, all SEPTA design objectives including but not limited to: minimal disruption to transit operations and passengers, accessibility, aesthetics, cost effective, functional/operational, historic preservation, productive, secure/safe, and sustainable and their interrelationships must be understood, evaluated, and appropriately applied.

C1-2. While this document is written to primarily address the structural design of a project, its concepts and goals are applicable to all aspects and disciplines associated with a project.

C1-3. The purpose of this document is to facilitate the proper use of design criteria, to ensure that repetitive deficiencies in design will be eliminated, and to ensure that all aspects of structural design are properly covered and coordinated. This document is not intended to be rigidly restrictive except in the use of building and other design codes, and for special design considerations unique to SEPTA.

C1-4. In compiling this document, SEPTA has relied upon many and varied sources, both public and private, railroads, transit agencies, and DOT’s, as well as SEPTA’s own experience.

C1-5. The structural inspection and maintenance practices of SEPTA along with the requirements and recommendations of APTA, FRA, and AREMA in these regards affect the serviceability and performance objectives of each project. The Designer should be familiar with these documents and their requirements.

C1-6. The events of September 11, 2001 have brought terrorism to the forefront as a design consideration, especially for transit facilities. Structural engineers who work on these projects, or those nearby that could suffer collateral damage in an attack, must now be familiar with the principles of blast effects analysis and design, as well as resistance to progressive collapse. These phenomena are highly sensitive to nonstructural factors such as standoff distance within the site, facade configurations and connections, and the presence of reentrant corners or transfer girders at the building perimeter.
C1-7. Role of Structural Engineer

C1-7.1. The Council of American Structural Engineers (CASE) defines a structural engineer as: "An engineer with specialized knowledge, training, and experience in the sciences and mathematics relating to analyzing and designing force-resisting systems for buildings and other structures." A structural engineer usually has one of two roles on a project, as identified by CASE:

- The Structural Engineer of Record (SER) "perform[s] or supervise[s] the analysis, design, and document preparation for the building structure and has knowledge of the requirements for the load carrying structural system." The SER is responsible for the design of the primary structural system, which is "the completed combination of elements which serve to support the building's self-weight, the applicable live load which is based upon the occupancy and use of the spaces, [and] the environmental loads such as wind, seismic, and thermal."

- A Specialty Structural Engineer (SSE) "performs structural engineering functions necessary for the structure to be completed and who has shown experience and/or training in the specific specialty." The SSE "is usually retained by a supplier or subcontractor who is responsible for the design, fabrication, and (sometimes) installation of engineered elements or by the general contractor or subcontractor(s) responsible for construction related services." Common examples of such elements are precast or tilt-up concrete, open web steel joists, pre-engineered cold-formed steel or wood trusses, and metal building systems.

C1-7.2. Every project should have a single designated SER who establishes the project specific structural design criteria and concepts for the project, but may delegate the detailed design of certain portions to SSE by communicating this information and other requirements on the construction documents (drawings and specifications). In such cases, the SSE subsequently prepare calculations and construction documents of their own for the delegated work and submit them to the SER, who verifies that they comply with the specified requirements and are consistent with the project as a whole. Without the SER, it is difficult to ensure adequate coordination of design work that is performed by multiple SSE. This problem often arises in design-build situations when various subcontractors supply their own design services, but there is no SER to review the documents that they produce and harmonize them with each other.
C1-7.3. It is important that the SER be involved in the project as early as possible, before concepts for architectural, mechanical, and electrical systems have been finalized. The SER can provide valuable input into these decisions, addressing such factors as:

- **Type of construction**—The selection of the structural system (frame, bearing walls, etc.) depends on the function and dimensions of the building, as limited by the building code and any zoning restrictions, as well as the local availability and relative cost of each material (reinforced concrete, precast concrete, reinforced masonry, structural steel, cold-formed steel, wood, etc.).

- **Column locations**—A uniform grid facilitates repetitive member sizes, reducing the cost and increasing the speed of construction. Bay dimensions may also be optimized to minimize material quantities while efficiently accommodating specific space requirements, such as parking garages and partition layouts.

- **Bracing or shear wall locations**—Horizontal forces due to wind, earthquakes, etc. must be transferred down from the superstructure to the foundations. The most efficient means of accomplishing this is usually to provide vertical bracing or shear walls oriented in each principle direction, which must be coordinated with functional and aesthetic requirements for partitions, doors, and windows.

- **Floor and roof penetrations**—Special framing is often required to accommodate stairs, elevators, mechanical chases, exhaust fans, and other openings.

- **Floor-to-floor heights**—Adequate space must be provided for not only the structure itself, but also raised floors, suspended ceilings, ductwork, piping, lights, and cable runs for power, communications, computer networks, etc. This may affect the type of floor system (reinforced concrete beams, joists, or flat plates; structural steel beams or open web steel joists; cold-formed steel or wood joists or trusses) that is selected.

- **Exterior cladding**—The building envelope not only defines the appearance of the facility, but also serves as the barrier between the inside and outside worlds. It must be able to resist wind and other weather effects while permitting people, light, and air to pass through openings such as doors, windows, and louvers.
• **Equipment and utility arrangements**—Large equipment (air handling units, condensers, chillers, boilers, transformers, switchgear, etc.) and suspended utilities (ductwork, piping, light fixtures, conduits, cable trays, etc.) require adequate support, especially in areas subject to seismic activity that can induce significant horizontal forces.

C1-7.4. Early SER involvement is especially critical for fast-track and design-build projects, when it is often necessary to issue the structural construction documents well in advance of those prepared by other disciplines. Even in conventional design-bid-build situations, the structural system is the first to be constructed, providing the underlying framework for the rest. Close coordination among all members of the design team is essential throughout the design process.

C1-7.5. The structural engineer is concerned with providing not only adequate strength for the structure, but also serviceability. Beams that deflect excessively under their design loads can cause problems with floor and ceiling finishes, especially those that include brittle materials. A light and inexpensive framing system may exhibit uncomfortable vibrations when subjected to human foot traffic. If high winds cause considerable lateral movement, unacceptable cracks may develop in exterior walls and interior partitions.

C1-7.6. The SER should continue to be involved in a project until construction is complete. No set of documents is perfect; review of submittals and firsthand observations at the site may reveal conflicts between disciplines or misinterpretations by the contractor at a point in time when it is still possible to correct them with minimal cost and schedule impacts.

C1-8. Structural engineers have a uniquely significant responsibility for protecting the public relative to the other design disciplines. Architectural, mechanical, and electrical system failures usually result in unattractiveness, poor functionality, discomfort and/or inconvenience. A structural system failure almost always has more serious consequences, even in the best cases, there are often substantial costs associated with correcting what is or could become a life-threatening situation.
CHAPTER 2

C2-1. The design methods and stress allowances or load factors for the various structural materials shall be according to the current editions of the applicable codes, specifications, and standards listed in this document except where these codes, standards, and specifications are modified or expanded by this or other SEPTA criteria.

C2-2. Although OSHA does not have jurisdiction over railroads where FRA rules and regulations govern, the requirements of OSHA shall be followed in design of all facilities. Where there is a conflict between OSHA and FRA rules and regulations, the more stringent requirements shall be followed.

C2-3. Where as all the objectives and goals of a project may be achieved by the design, the project can not be successful if installation is defective, improper, or less than what was required by the design document. Inspection and oversight of the installation is critical to the success of the project and meeting all of SEPTA goals for the life of the project. The Engineer of Record must be cognizant of these requirements and address these as applicable in the design documents. Field modification and changes to the approved (PE Sealed) design and waiving of specification and drawing requirements shall not be taken lightly. The Engineer of Record and SEPTA Engineering must be made aware of any and all changes affecting either the design or the approved project goals.

C2-4. The structural systems and materials to be selected for the design of buildings and facilities for SEPTA installations must be suitable for permanent-type construction, capable of carrying the required loads, compatible with fire protection requirements, and achieving architectural and functional concepts. Materials may be of any of those listed in this document, or any combination, selected for desirability, economy, general availability, low maintenance costs over the design life of the building or facility, and resistance to fire and vandalism. At the inception of the design, the structural system layout should be concurrently developed with the architect to assure an overall effective plan.

C2-5. Transit facilities are often subjected to extreme conditions and excessive use and abuse. When determining materials and design features, this must be taken into consideration. Materials and designs that are well suited for commercial and educational facilities may not hold up to these conditions.

C2-6. Layout of public facilities must consider crime deterrent features and eliminate any blind or hidden corners.
C2-7. Often due to budget or other project constraints, existing structures are modified in lieu of replacement, reconstruction, upgrading, or major modification. These projects must take into consideration the remaining useful life of the entire structure upon completion of the project. A new bridge superstructure with a 100 year service life built on piers and abutments with only an estimated 50 years remaining service life results in a project with a 50 year design life, not 100 years.

C2-8. All SEPTA buildings must have complete lateral force resisting structural systems. The structural systems shall be capable of withstanding design wind and earthquake ground motion while, (1) remaining within prescribed limits of strength and deformation and (2) providing adequate energy dissipation capacity.

C2-9. The performance objectives of the project must be considered. Canopy structures that are narrow and/or tall often do little to protect SEPTA’s customers from the weather. Improperly configured canopies and screens often create maintenance issues by trapping snow and rain on stairs and escalators instead of protecting them from the elements.
CHAPTER 3

C3-1. Traditionally, the elevated portions of the Market Frankford Subway Elevated (MFSE), has been designed per AASHTO standards in lieu of AREMA, which governs railroads. The engineer is cautioned when using AASHTO for rail transit applications. The engineer **MUST** have a clear understanding of rail transit loads, loads from rail vehicles, their interaction with and load path through the structure. In the past, lack of understanding has resulted in inadequate designs and premature failures of structures.

C3-2. The anticipated method of construction and the loads subjected to a structure by and during construction (and demolition) must be addressed. Failure of bridges and other structures during construction and demolition has been an industry problem.

C3-3. Multiple culverts and spans placed in a stream or drainage watercourse must be avoided. Multiple pipes are easily blocked by floating debris. Multiple pipes or cells also tend to promote sediment build up in one or more of the openings. Multiple culverts and spans create a significant recurring maintenance expense and blockage could lead to failure.

CHAPTER 4

C4-1. SEPTA has poor track record with the durability of unreinforced masonry walls and buildings. These structures are unreinforced or have only the minimum reinforcement required by code. These structures do not perform when subjected to vehicle or equipment impacts, often with near catastrophic results. They also develop cracks and have shifting of the CMU units.

CHAPTER 5

C5-1. When designing a foundation system, the engineer must take into consideration proximity to active railroad and rail transit tracks. The depth and method of excavation and duration of open excavation have significant cost and operational impact. The least expensive foundation system in terms of material and labor may not necessary have the lowest project cost. Impact on SEPTA operations and
the costs associated with service interruptions must be considered in determining the most effective foundation system.

C5-2. Waterproofing of underground and below grade spaces is critical. Water infiltration at SEPTA facilities has resulted in high maintenance expenditures, low service life, and safety concerns to SEPTA’s customers and workers.

C5-3. In the past, elevator and escalator pits were often overlooked as a sources of water infiltration and lacked adequate waterproofing. Water at these locations has a detrimental affect on operations, equipment reliability, and service life.

C5-4. Proper and positive grading and sloping away from building walls and doorways/entrances is critical. Where site conditions will not allow for grading away from the building, adequate drainage facilities shall be provided. Trench drains, drain pipes, scuppers, and other drainage devices shall account for debris and trash buildup, ease of cleaning, and should be oversized to allow for minimal maintenance.

Figure C5-1 - Drainage Not Directed Away From Building
CHAPTER 6

C6-1. The importance of the design of sidewalks including layout, material selection, subbase preparation can not be overlooked. There are a significant number of tripping and falling lawsuits brought against SEPTA each year that are directly related to sidewalks.

C6-2. Attention to rebar detailing and placement is important. Proper development length must be maintained especially in repairs and rehabilitation of existing structures. Proper concrete clearance over the rebar must be maintained to insure adequate corrosion protection.

C6-3. To maintain the safety of exterior walking surfaces, SEPTA relies heavily on the use of de-icing chemicals. All concrete for walking surfaces and adjacent vertical and other surfaces must take this into consideration with the design and material selection meeting the ACI requirements for SEVERE EXPOSURE. Additionally, interior and exterior concrete slabs for station platforms may be subjected to harsh chemical cleaning agents and must also be designed based upon severe exposure.

Figure C6-1 – Exposed Epoxy Coated Rebar with Inadequate Cover and Development Length
CHAPTER 8

C8-1. Masonry building wall elevations and details are often shown on architectural drawings and not on structural drawings. The structural engineer must closely review and coordinate these drawings to insure that adequate reinforcement and structural design requirements are addressed.

CHAPTER 9

C9-1. The engineer must be aware of the requirements of the OSHA Steel Erection Standard (29 CFR Part 1926 Subpart R) and its affect on steel design as well as steel erection.

C9-2. Corrosion of steel and failure of coating systems is the greatest issue SEPTA has with newer construction. The designer must aware of the work of all disciplines on the a project and their affect on the steel.

C9-3. Expansion joints in a structure must be honored through out the entire structure and the work of all disciplines. Often the location of structural expansion joints are ignored and spanned over rigidly with railings, guard rails, pipe, and conduit. This can result in an adverse affect on the overall serviceability and service life of the structure.

Figure C9-1 - HSS Roof Member Failed After Less Than 10 Years In Service
Figure C9-2 - HSS Member Failed After Less Than 10 Years In Service

Figure C9-3 – Improperly Prepared Duplex Painting System
Paint Over Galvanizing Failed within Two Years
CHAPTER 11

C11-1. While the design of new wood structures has limited application at SEPTA, SEPTA does have numerous existing timber and wood structures, primarily associated with railroad stations. The renovation of these structures must take into consideration current code requirements.

C11-2. Power nailers have found their way into the toolboxes of most construction crews. They make the task of repetitive nailing easier. The nails that these guns use are not as large or as strong as the common or spiral nails that are often required for structural connections. Construction crews are often not aware of this. Power-driven nails should be used in structural connections only when their use is designed and approved by an engineer. The nailing schedule should include shank diameter in addition to pennyweight size and length.

C11-3. Fastener dimensions, spacing and count per connection are important. But so are other fastener properties. Requirements for corrosion resistance vary with the connection, building location, local code and materials. If nail shanks or staple legs are not "stiff" enough, the nailed or stapled connection won't have the
The 2003 International Building Codes specifies and requires that fasteners meet minimums published in an ASTM standard.

C11-4. Problems associated with manufactured wood trusses have arisen in the past due to poor communications, unclear responsibilities, or lack of knowledge in the field. This can result in improper installation and erection of trusses, or damage to trusses on site. Experience has shown that there are a number of critical elements in the construction of a building containing wood trusses that require specific attention to detail or adherence to standards.

C11-5. Deterioration of metal truss gusset plates is a major concern in buildings that contain high humidity and corrosive environments. Normal galvanized steel plates exposed to moisture, condensation and ventilation air containing chemical or other corrosive gases, will corrode rapidly. The truss plates show the greatest deterioration near the building air exchange openings - typically at the heel and peak joints of the truss. These are the areas of greatest air mixing and temperature change, producing high humidity and condensation problems. Unfortunately, these are also very critical joints in the structural integrity of the truss.

C11-6. For metal plate wood trusses, failure to properly install compression web lateral bracing and the anchorage for that bracing can reduce the truss capacity by as much as 90%. It is critical that all lateral and permanent bracing be properly installed and the installation verified. This installation review should be performed after mechanical and electrical trades have completed their work.

C11-7. Coating systems for wood structures are critical to the serviceability and service life of the structure. The selection of the coating system and the implementation are equally important.
C13-1. When temporary shoring of an existing structure, the engineer must address the load path through the new and existing structures including the foundation. Follow all loads through the structure to assure all the structural elements and connections along the load path have sufficient strength and stiffness to maintain structural integrity. This must be clearly addressed in the calculations.

C13-2. All temporary support structures must be protected form the affects of vehicles, weather, erosion, and other detrimental situations. A formal written inspection and monitoring system for both the temporary and permanent structures needs to be used.
CHAPTER 16

C16-1. Edge distance is critical for all anchor rods whether embedded or installed in existing concrete. The designer of the steel structure must work closely with the concrete designer to insure that adequate cover and lateral reinforcement is provided.

C16-2. The designer of post installed concrete anchors must be aware of the conditions under which the anchors will be installed and exposed to under the service life of the structure. The appropriate type of adhesive is contingent upon the site conditions, position or location in the structure, and ambient conditions at the time of installation. Certain types of mechanical anchors are not approved for safety related and structural applications. Anchors located in rail transit tunnels must take into account fire in the tunnel. These issues are not solely limited to the structural engineer and structural applications. They affect anchors used by all disciplines.
Figure C16-1 – Concrete Failure at Anchor Rod
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Structural Engineering
Right-of-Way Design and Construction Standards

by Southeastern Pennsylvania Transportation Authority
(215) 580-8215

Structural Engineering
ROW Design and Construction Standards
MARCH 2004

To: Distribution
From: Robert L. Lund Jr., P.E..
Manager of Structural Engineering
Infrastructure Bridges & Buildings Engineering

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Revision: 3

Purpose
This document outlines the requirements for structural related construction and activities on, over, within, or adjacent to SEPTA railroad, rail transit, and other facilities. The intent of this document is to provide general guidelines and safeguards to design and construction organizations performing work along SEPTA’s right of way.

Contact
For more information regarding any section in this document, please contact the Structural Engineering - Bridges & Buildings Group, Infrastructure Department. Southeastern Pennsylvania Transportation Authority
1234 Market Street, 13th Floor
Philadelphia, PA 19107
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ATTACHMENT 1 – Right-of-Way Clearance Drawings
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Introduction
Scope, Policy, and General Requirements

This document outlines the requirements for construction and/or related activities on, over, within, or adjacent to property owned or controlled by SEPTA. The intent of this document is to provide general engineering guidelines and safeguards to design and construction organizations performing work along SEPTA's right of way and/or railroad/transit facilities. This document does not represent all legal or contractual requirements, which are or may be associated with construction and/or related activities. SEPTA reserves the right to require additional information and clarification and to make unilateral changes to this document at any time, at its sole discretion.

A. SCOPE

SEPTA owns and uses its right-of-way for the primary purpose of operating a transit and railroad system. Therefore all work shall be done in a manner such that transit and railroad operations and facilities are not interfered with, interrupted, or endangered. In addition, any facilities that are a result of the proposed work shall be located to minimize encumbrance to the right-of-way so that SEPTA will have unrestricted use of its property and/or Right of Way for current and future operations. The Sponsor of the project shall be ultimately responsible for assuring that its agents, consultants, contractors, and sub-contractors fully comply with the requirements contained herein.

B. DEFINITIONS

The following terms and conditions shall apply to any project, which requires performance of work on the right-of-way or other property of SEPTA.

SEPTA  - Southeastern Pennsylvania Transportation Authority

SEPTA PROPERTY - All rights of way and property owned and/or controlled by the SEPTA.

OWNER - The individual, utility, government, or corporation having title to the structure to be constructed upon, over or adjacent to railroad property
owned or controlled by the SEPTA.

UTILITY - Public or private entities with electric power, telephone (including fiber optics), telegraph, cable television, water, gas, oil, petroleum products, steam, chemicals, sewage, drainage, irrigation and similar lines which may or may not be regulated by the Pennsylvania Public Utilities Commission (PUC).

GOVERNMENT - Federal, State, Town, City, County and other forms of government.

CORPORATION - Any firm duly incorporated under laws of a state government.

INDIVIDUAL - Any party not defined by "Owner, Utility, Government or Corporation".

CONTRACTOR - The individual, partnership, firm, corporation or any combination thereof, or joint venture, contracting with a Utility, Government, Firm, Company, Corporation, or Individual for work to be done on, over, under, within, or adjacent to SEPTA Property.

OWNER OR ITS CONTRACTOR - As used in this document, does not affect the responsibilities of either party for work conducted on, over, under, within or adjacent to SEPTA Property.

SPONSOR – The entity responsible for and/or performing the work.

C. RIGHT OF ENTRY ON SEPTA PROPERTY

No entry upon SEPTA property shall be permitted without the proper authorization by SEPTA to the Sponsor in the form of an agreement or a proper right of entry prepared by SEPTA. The issuance of a right of entry does not constitute authority to proceed with any construction work. Construction cannot begin until a formal agreement between SEPTA and the Sponsor is executed, and the Sponsor receives permission from SEPTA’s representative to proceed with the work, has obtained the required safety training, has the needed protection is in place. These requirements are separate from this document and are not addressed herein.
D. EXCEPTIONS

Exemptions or exceptions to any provisions contained in this document must be authorized by SEPTA's Chief Engineer - Infrastructure or designee. Requests for exemptions and/or exceptions will be considered only where it is shown that extreme hardship and/or unusual site-specific conditions provide justification and where alternate measures can be prescribed in keeping with the intent of this document. All requests for exceptions shall be fully documented including design data, cost comparisons, and other pertinent information.

E. GENERAL REQUIREMENTS

The sponsor shall plan and conduct the work in such a manner as to safeguard the operations, facilities, right-of-way, and property of SEPTA. All work affecting the above items shall be subject to the approval of SEPTA. The sponsor’s operations adjacent to, over, or under SEPTA's tracks, facilities, right-of-way, and property shall be governed by SEPTA's standards and by such other requirements as specified by SEPTA so as to insure the safe operation of SEPTA’s transit system and facilities, prevent delay to trains and buses, and insure the safety of all concerned, including the sponsor’s forces.

All work shall be planned, arranged, and conducted so that there will be no interference with or damage to SEPTA operations, including train and surface operations, tracks and rails, signal, telephone and telegraphic services, or damage to the property of SEPTA, or to poles, wires, and other facilities of tenants on SEPTA’s right-of-way. SEPTA may require additional protection be installed to protect rail or other facilities from damage or disturbance caused by the Sponsor’s activities.

The work plan shall account for storage of materials so as to prevent trespassers from causing damage to trains or SEPTA property. Whenever work is likely to affect the operations or safety of trains, the method of doing such work shall first be submitted to the SEPTA for approval but such approval shall not relieve the Contractor from liability.
F. ENGINEERING AND INSPECTION

SEPTA, at its sole discretion, may assign an engineer or inspector for the general protection of SEPTA property, interests, and operations during the construction of the project. This inspection service shall be supplied at the sole cost and expense of the Sponsor.

G. SUBMITTALS - PLANS AND SPECIFICATIONS

1. Scope: It is the intent of the SEPTA to eliminate or minimize any risk involved with construction or related activities on, over, under, within or adjacent to SEPTA property. Therefore, SEPTA approval of construction plans and specifications for all phases of a proposed project affecting SEPTA Property is required.

2. All plans are to be individually folded or rolled and where more than one plan is involved, they shall be assembled into complete sets before submission to the SEPTA.

3. Plans: The plans are to show all the work which may affect SEPTA Property, and contain a location map and plan view of the project, with appropriate cross sections and sufficient details. The proposed construction or related activities must be rotated with respect to top of rail (vertical) and centerline of track (horizontal). The plan must also include railroad stationing, property lines, right-of-way, and subsurface soil conditions. The subsurface information is to be in the form of boring logs with the borings located on the plan view.

   Each plan shall bear an individual identifying number and original issue date, together with subsequent revision dates. Revisions shall be clearly identified on the plans so that it is readily apparent as to what revisions were made and when.

4. Design calculations shall be complete with a cover sheet, index, list of assumptions, governing codes and regulations, specifications used, design loads and load combinations, and design criteria used. All pages shall be numbered and initialed by both the originator and the checker. The calculations shall include fully identified, dimensioned, and annotated diagram(s) of each member or structure.

   When computer calculations are included, provide a synopsis of the computer program(s) including: documentation or certification(s) of the
program, required input, method of solution, output generated, extent of previous usage, and the name of the author of the program(s).

5. Plans and Calculations must be stamped by a Professional Engineer (or Registered Architect) registered in the State where the work is located.

6. Submission Review: The Sponsor is advised that the SEPTA’s initial review process requires a minimum twenty (20) workday period.

7. Examination Of Plans Or Property: The Contractor/Sponsor shall have no claim for any differences between SEPTA plans and the actual conditions encountered in the field.

8. Identification of Underground Utilities: It is the Sponsor’s responsibility to locate and identify all underground utilities prior to performing work. The Sponsor shall provide to SEPTA, a copy of the PA One Call notification and all responses associated with the notification.

9. Upon completion of the Project, as-built plans off all permanent installations shall be provided to SEPTA in electronic format on CD ROM using either Adobe® Acrobat® or AutoCAD format.
Section 1
Temporary Sheeting and Shoring

The design and construction of temporary sheeting and shoring shall conform to the following minimum design and submittal requirements. The term “temporary” is based upon a limited service life that is typically until construction of a permanent structure (i.e. embankment, bridge abutment, etc.) is completed.

A. DESIGN – GENERAL

1. A temporary shoring wall may be one of the following types unless otherwise approved by in plans:
   a. Steel sheet pile wall – braced, tieback, or cofferdam
   b. Steel soldier piles with lagging – braced or tieback
   c. Trench boxes or similar devices - This type of shoring is not permitted where subjected to railroad or rail transit live loading.

2. Temporary shoring walls shall be designed to resist all dead and live loadings (earth pressures, hydrostatic pressures, traffic loads, point loads, line loads, and surcharge loads) that the retaining system may experience during the service life of the structure.

3. The temporary shoring walls shall be designed in accordance with the latest edition of the AREMA Manual of Railway Engineering where subjected to railroad or rail transit live loads and AASHTO Standard Specifications for Highway Bridges where subjected to other vehicle loads.

4. Tieback anchors under the tracks shall not be used.

5. The Contractor shall be responsible for the external stability of all temporary shoring walls including any geotechnical investigation necessary to verify the external stability. Temporary shoring walls are not required to resist seismic forces from earthquake events.

6. Design Life: All temporary shoring walls shall be designed for a minimum of 3 years design life. Temporary shoring walls that will be in use for more than 5 years shall be designed as permanent retaining wall structures.

7. Soil Design Parameters: Temporary shoring walls shall be designed using appropriate soil properties relative to the anticipated service life. Temporary shoring that will be in-place for a period where excess pore pressures have not dissipated (typically less than 4 to 6 months) shall
be designed using total (undrained) soil shear strength parameters. Effective (drained) soil shear strength (drained) parameters should be used when temporary shoring walls are in service sufficiently long (typically more than 4 to 6 months) for excess pore pressures to dissipate.

8. The temporary shoring wall shall be constructed in a manner that protects adjacent buildings, bridges, roadways, or railway, and existing traffic, while allowing inspection access for existing facilities and structures. The Sponsor shall be responsible for any damages or retrofit to adjacent structures that result from the construction of the temporary shoring wall.

9. All existing structures and/or track shall be monitored for horizontal and vertical movement. Refer to Section 9 for additional requirements.

10. Existing ROW drainage shall be maintained or otherwise addressed in the design and work plan.

B. RAILROAD AND RAIL TRANSIT REQUIREMENTS

1. SEPTA utilizes continuous welded rail (CWR) on its system. It is imperative to the safety of rail operations and to prevent rail buckling, that the lateral rigidity of the track (which consists of the rail-tie structure and the ballast) remains unchanged and intact. The shoulder width and height shall not be modified without express written approval of SEPTA.

2. Footings for new construction (all piers, columns, walls or other facilities) shall be located and designed so that any temporary sheeting and shoring for support of adjacent track or tracks during construction shall not be closer than ten feet (10'-0") from the centerline of the nearest track or the toe of the ballast slope, which ever is greater.

3. Shoring protection shall be provided when excavating adjacent to an active railroad track and structures – refer to attached Drawing 1S-51232. Shoring will not be required if the following conditions are satisfied:

   a. When the track is on level ground or in a cut section, is on stable soil, and the excavation does not encroach upon a 1 ½ horizontal: 1 vertical theoretical slope line starting 1’-6” below top of rail and at 10’-0” minimum from centerline of the track.

   b. When the excavation is outside of the zone of influence of an existing foundation.

   c. Shoring is not required by OSHA.
When the track is on an embankment, excavating the toe of the embankment without shoring may affect the stability of the embankment. Therefore, excavation of the embankment toe without shoring will not be permitted.

4. Preferred protection is the cofferdam type that completely encloses the excavation. Where dictated by conditions, partial cofferdams or shoring with open sides away from the track or structure may be used. Cofferdams shall be constructed using interlocking steel sheet piling driven prior to excavation or steel soldier piles with timber lagging. Consideration for the use of soldier piling and lagging shall be made if the required penetration of steel sheet piling cannot be obtained and when dry, non-running, stable material will be encountered. Wales and struts shall be provided as needed.

5. The following shall be considered when designing shoring:
   a. Shoring adjacent to tracks or track support structures shall be designed to resist not less than a vertical live load surcharge of 1800 pounds per square foot (psf), in addition to active earth pressure. The surcharge shall be assumed to act on a continuous strip, 8'-6" wide. Lateral pressures due to surcharge shall be computed using the strip load formula shown in AREMA Manual for Railway Engineering.
   b. Allowable stresses in materials shall be in accordance with AREMA Manual for Railway Engineering, Chapter 7, 8, and 15.
   c. The sheeting shall be designed to support all lateral forces caused by the earth, railroad and other surcharge loads. The railroad loading to be applied is a Cooper E-80 loading plus impact. This loading consists of 80 Kip axles spaced five (5) feet on centers. For rail transit and light rail applications, a Cooper E60 loading may be used.
   d. Use K (at-rest earth pressure) for design of all braced and tieback excavations.
   e. The allowable stresses for the sheet piling and other steel members (wales, struts, etc.) shall be in accordance with AREMA Chapter 15, Part 1. These allowable stresses may be increased 10% due to the temporary nature of the installations. A factor of safety of at least 1.5 must be used on temporary sheeting for the embedment length (i.e. multiply calculated embedment depth by 1.5).
   f. Deflection design criteria is as follows:
      • 1/2" maximum deflection for shoring fifteen (15) feet from the centerline of the nearest track.
      • 1" maximum deflection for shoring greater than fifteen (15) feet from the centerline of the nearest track.
C. GENERAL REQUIREMENTS AND SUBMITTALS

1. The contractor shall submit the following drawings and calculations for SEPTA review and approval.
   a. Detailed drawings of the shoring systems showing sizes of all structural members, details of connections, and distances form centerline of track to face of shoring.
   b. Drawing shall show a section showing height of shoring and track elevation in relation to bottom of excavation.
   c. Provide calculations of the shoring design.
   d. A Licensed Professional Engineer registered in the State where the work is located shall prepare the drawings and calculations and shall bear his/her seal and signature.

2. A construction procedure for temporary shoring shall be shown on the drawing.

3. The contractor shall provide a copy of PA One Call location of underground utilities or similar document for locations in New Jersey or Delaware.

4. SEPTA’s Structural Engineering and Civil/Track Engineering groups shall approve shoring plans.

5. Where physical conditions of design impose insurmountable restrictions requiring the placing of sheeting closer than specified above, the matter must be submitted to SEPTA for approval of any modifications.

D. A minimum distance of 10 feet from centerline of the track to face of nearest point of shoring shall be maintained.

E. Where soil or rock anchors are used, all anchors must be tested. Testing shall be in accordance with industry standards with ten percent (10%) of the anchors "Performance Tested" and all others "Proof Tested". All tieback anchor stresses are to be in accordance with AREMA.

F. Exploratory trenches, three (3) feet deep and fifteen (15) inches wide in the form of an "H" with outside dimensions matching the outside of sheeting dimensions are to be hand dug, prior to placing and driving steel sheeting, in areas where railroad underground installations are known to exist. These trenches are for exploratory purposes only and are to be backfilled with the backfill compacted immediately. Absolute use of track is
required while driving sheeting within fifteen (15) feet from centerline of a live track.

G. Cavities adjacent to the sheet piling, created by the driving of sheet piling, shall be filled with sand and any disturbed ballast must be restored and tamped immediately in accordance with applicable specifications and standards.

H. Sheet piling shall be cut off at the top of tie during construction. After construction and backfilling has been completed, piling within ten (10) feet from centerline of track, or when bottom of excavation is below a line extending a 1:1 slope from end of tie to point of intersection with sheeting, shall be cut off eighteen (18) inches below existing ground line and left in place.

I. Safety railing or fencing shall be installed when temporary shoring is within 12 feet of track or adjacent to SEPTA facilities, shops, yards, or stations. Installation shall not interfere with required clearances or foul the tracks. Any excavation adjacent to track or structures shall be covered and ramped and provided with barricades as required by SEPTA. A lighted walkway with a handrail, approved by SEPTA, must be provided adjacent to the track for any excavation within ten (10) feet of the centerline.

J. Excavation adjacent to tracks may require installation of track bridge and/or lateral restraint trusses. For long shallow excavations parallel to the tracks, track bridges are generally required. The Sponsor will be responsible for SEPTA costs associated with the installation, maintenance, and removal of temporary support systems.

K. Refer to Sections 9 and 10 for monitoring requirements during driving of sheeting and piles and during excavation activities.

L. Documentation of existing conditions prior to start of work and site conditions upon completion of work shall be provided. This may include but not be limited to: surveys, photographs, and as-built drawings.

M. Excavated fill material shall not foul or contaminate track ballast.

N. Drilled or augured piers do not require additional shoring if concreted the same day. If excavation is left open overnight or if the excavation requires casing, the casing shall either be withdrawn during concrete placement or the exterior of the casing shall be pressure grouted to fill any voids.
Section 2
Blasting

A. In general, blasting on, over, under, or within SEPTA property and Right of Way is prohibited. Blasting adjacent to SEPTA Property will be permitted only in special cases where it is demonstrated to the SEPTA's Chief Engineer – Infrastructure, that there is no practicable alternative to perform the work. In such cases when blasting is permitted, the Contractor must submit a detailed blasting program to the SEPTA for approval prior to the commencement of any work. The blasting program must contain the following information:

1. Site plan with location of nearest SEPTA structure or facility.
2. Plan of each blast showing hole spacing and delay pattern.
3. Diameter and depth of each hole.
4. Amount of explosives per hole.
5. Total pounds of explosives per day.
6. Total amount of explosives per blast.
7. Type of non-electric delays to be used.
8. Amount of stemming in each hole.
9. Type of explosive to be used.
10. Soil and rock profile in blast zone.
11. Scaled distance to the nearest SEPTA facility.
12. Type and location of seismograph to be used.
13. Size of blasting mats to be used.
14. Safety precautions to be followed.
15. Protection of SEPTA structure and facilities from dust and debris.
16. Copies of all approvals and permits.
17. Copy of license.

B. The following general requirements are to be adhered to:

1. Obtain the services of a qualified vibration and blasting consultant to monitor the blasting.
2. Use a non-electric detonation system whenever possible. If electric caps are used, a check must be made for stray currents, induced current and radio frequency energy to insure that this hazardous extraneous electricity is at an acceptable safe level.
3. Provide an open face for maximum relief of burden.
4. Limit the maximum peak particle velocity to 1 inch per second for underground facilities and 2 inches per second for all other facilities.

C. The contractor shall provide for a pre-blast and post blast survey, including photographs. An inspection of all nearby SEPTA facilities shall be made to determine any changes that may occur due to blasting operations.

D. The contractor shall coordinate all blasting with the SEPTA in advance to determine when the charges may be set. The contractor is advised that the SEPTA uses two-way radios for train control. These radios cannot be turned off at any time.
Section 3
Temporary Protection Shields for Demolition and Construction

The design and construction of temporary protection shields must adhere to the following minimum requirements:

A. The construction of temporary protection shields will be designed to prevent any dust, debris, concrete, formwork, paint, or tools from falling on SEPTA property below.

B. The temporary protection shields shall be erected prior to the start of work.

C. SEPTA will determine whether or not sufficient protection has been provided to perform the work over any particular area.

D. The temporary protection shields shall remain in place until all work over SEPTA property and/or tracks has been completed and shall be removed only when permitted by SEPTA.

E. To minimize the inconvenience to the users of any properties below and adjacent to the project, the Contractor will be required to complete the actual erection and removal of the temporary shields within time limits acceptable to SEPTA.

F. The erected temporary protection shields shall not infringe on any existing minimum vertical and horizontal clearance. The clearance envelopes required for SEPTA operations shall be indicated on the site specific work plans.

G. The erected temporary protection shields shall maintain safe minimum clearance from all energized electrical and catenary lines per the National Electric Safety Code (NESC) and SEPTA requirements. All metallic components shall be bonded and grounded.

H. The Contractor will be required to obtain the approval of SEPTA before commencing any work beneath the shield. In certain areas, depending on the nature of the work, SEPTA may require a specific method of protection.
I. Protection shields shall be designed for the following minimum load and size criteria:

1. The horizontal shield shall be designed to carry a minimum live load of 100 pounds per square foot (psf) or the anticipated live load to be produced by the Contractor’s operations (whichever is greater) and a single concentrated load of not less than 2,000 pounds located to produce maximum stress. The horizontal protection shield, in plan view, shall cover not less than the area directly over the tracks plus 10 feet (10’) beyond the centerline of the outermost tracks.

2. The vertical shield shall be designed to carry a wind load of not less than 30 psf. The vertical shield shall extend a minimum of 6'-6" above the top of the adjacent surface such as a sidewalk or curb. Anti-climb wings shall be installed at each end, as necessary, to restrict access to SEPTA property.

J. Prior to the start of construction, the Contractor will be required to submit the details of the temporary protection shield to SEPTA, who will review and approve the details only as to the methods of erection and as to whether or not the proposed installation will provide the level of protection required at the various locations. It is the Contractor’s responsibility to design these protections so that they are in conformance with all existing laws, regulations and specifications that govern this type of work. Shield plans must include a material list and shall be designed by a Professional Engineer registered in the State where the work is located. The drawings and calculations must bear his/her seal when they are submitted to SEPTA.

K. The temporary protection shields shall be attached to the structure in accordance with the site specific work plans. Drilling into or welding SEPTA structural members is not permitted in members scheduled to remain in place.

L. If during the actual construction, SEPTA deems that the shield is not providing the desired level of protection or that the Contractor has failed to properly maintain the shield, all work at the affected location shall cease until corrective measures acceptable to SEPTA are instituted.

M. All temporary shields shall be constructed using new material.
Section 4  
Erection, Hoisting, and Demolition Requirements

The design, set-up, and use of cranes on, over, or adjacent to SEPTA tracks and facilities shall conform to the following minimum design and submittal requirements.

A. A plan showing the locations of cranes, horizontally and vertically, operating radii, with delivery or disposal locations shown. The location of all tracks and other railroad facilities should also be shown.

B. Crane rating sheets showing cranes to be adequate for 150% of the actual weight of the pick. A complete set of crane charts, including crane, counterweight, and boom nomenclature is to be submitted. Also provide copy of all crane certifications.

C. Plans and computations showing weight of picks must be submitted. Where beams are being removed over SEPTA facilities, the weight shall include the weight of concrete or other material that will be included in each pick.

D. Calculations shall be made from plans of existing and/or proposed structure showing complete and sufficient details with supporting data for the demolition or erection of the structure.

E. If the Sponsor can prove to SEPTA that plans do not exist and weights must be calculated from field measurements, the field measurements are to be made under the supervision of the Registered Professional Engineer submitting the procedure and he shall include sketches and estimated weight calculations with his procedure. If possible, field measurements shall be taken with an SEPTA representative present. Weights shall include the weight of concrete, or other material, that will be included in the lifts.

F. If the procedure involves either the cutting of steel or the bolting of joints which would affect SEPTA operations, a detailed staging plan with estimated durations will be required.
G. A location plan showing all obstructions such as wires, poles, adjacent structures, etc. must be provided to show that the proposed lifts are clear of these obstructions.

H. The method of attachment shall be detailed in the erection/lifting plan. A data sheet shall be prepared and submitted listing the type, size and arrangements of slings, shackles, or other connecting equipment. Include copies of catalog or information sheets for specialized equipment. All lifting components shall be adequate for 150% of the lift.

I. A complete procedure is to be included, indicating the order of lifts and any repositioning or rehitching of the crane or cranes. This procedure shall include contingency planning for dropped loads.

J. Demolition shield submittals shall conform to Section 1 of this document and must include a plan showing the details of the shield, a written installation and removal procedure and design calculations verifying the capacity of the shield.

K. Temporary support of any components (overhead or undergrade) or intermediate stages is to be shown and detailed.

L. Lifts over SEPTA facilities shall not take place when wind speeds reach or exceed 25 mph.

M. A time schedule (by hour and day) of the various stages must be shown as well as a schedule for the entire lifting procedure.

N. All erection or demolition procedures, plans, and calculations submitted shall be prepared, signed, and sealed by a Professional Engineer, registered in the State where the work is located.

O. All equipment working near or adjacent to overhead wires or 3rd rail power shall be grounded.

P. The name and experience of the employee supervising the operation must be supplied to SEPTA.

Q. Lifts that have the potential to come into contract with any SEPTA overhead catenary, signal or feeder wires, or third rail power shall not be made unless the lines have been deenergized, grounded, and a qualified SEPTA Power Department Protection Person is present.
Section 5
Crane Operations over Subway and Railroad Tunnels and Other Underground Facilities

The design, set-up, and use of cranes on or over SEPTA subway tunnels and underground facilities shall conform to the following minimum design and submittal requirements.

A. A plan showing the locations of cranes, horizontally and vertically, operating radii, with delivery or disposal locations shown. The location of all tracks and other railroad facilities should also be shown.

B. Crane rating sheets showing cranes to be adequate for 150% of the actual weight of the pick. A complete set of crane charts, including crane, counterweight, and boom nomenclature is to be submitted. Also provide copy of all crane certifications.

C. Plans and computations showing weight of picks must be submitted.

D. Maximum outrigger loads shall be noted along with crane matting details and surcharge pressures from lift.

E. Calculations showing loads on SEPTA underground facilities from the lift.

F. Copies of all City of Philadelphia permits and approvals. These must be provided to SEPTA prior to SEPTA’s review of the lift.

G. A location plan showing all obstructions such as wires, poles, adjacent structures, etc. must be provided to show that the proposed lifts are clear of these obstructions.

H. The Sponsor shall provide a complete procedure which shall indicate the order of lifts and any repositioning or rehitching of the crane or cranes.
I. The Sponsor shall provide a time schedule (by hour and day) of the various stages must be shown as well as a schedule for the entire lifting procedure.

J. All erection or demolition procedures, plans, and calculations submitted shall be prepared, signed, and sealed by a Professional Engineer, registered in the State where the work is located.
APPLICATION FOR CRANE PLACEMENT
OVER SUBWAY AND RAILROAD TUNNELS

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INCLUDE STREET ADDRESS AND CROSS STREETS

CRANE PICK INFORMATION

DATE(S) START ______________ END ______________
CONTRACTOR ___________________________ RIGGER ___________________________
CRANE ___________________________ GROSS WGT OF CRANE _____________ lbs
AXLE LOADS _____________ lbs AXLE SPACING __________________________
PICK ___________________________ GROSS WGT OF PICK ______________ lbs
MAX OUTRIGGER REACTION ______________ lbs OUTRIGGER SPACING ______________________
REASON FOR CRANE LIFT: _______________________________________________________________
CITY OF PHILADELPHIA APPROVAL YES NO

REQUESTER INFORMATION

CONTACT NAME: __________________________________________
COMPANY NAME: _________________________________________
ADDRESS: ______________________________________________

TELEPHONE No. _______________ FAX No. ______________________
EMAIL: ______________________
### REQUESTOR’S REQUIRED SUBMITTAL CHECKLIST

- [ ] A plan showing the locations of cranes, horizontally and vertically, operating radii, with delivery or disposal locations.
- [ ] Crane rating sheets showing cranes to be adequate for 150% of the actual weight of the pick.
- [ ] Copy of all crane certifications.
- [ ] A complete set of crane charts, including crane, counterweight, and boom nomenclature.
- [ ] Plans and computations showing weight of picks.
- [ ] Maximum outrigger loads shall be noted along with crane matting details and surcharge pressures from lift.
- [ ] Calculations showing loads on SEPTA underground facilities from the lift.
- [ ] Copies of all City of Philadelphia permits and approvals including application for street closure.
- [ ] A location plan showing all obstructions such as wires, poles, and adjacent structures.
- [ ] Complete procedure indicating the order of lifts and any repositioning or rehitching of the crane or cranes.
- [ ] A time schedule (by hour and day) of the various stages as well as a schedule for the entire lifting procedure.
- [ ] All erection or demolition procedures, plans, and calculations signed, and sealed by a Professional Engineer.

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**PA ONE CALL**  
**SERIAL NUMBER______________________________**

*This Section to be completed by Requestor*

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**SEPTA APPROVAL**  
**WO#99128**

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**REVIEWING ENGINEER/DATE**  
**MANGER OF STRUCTURAL ENGINEERING/DATE**
Section 6
Overgrade Bridge Requirements

The design and construction of overhead bridges shall conform to the following minimum design and submittal requirements.

A. CLEARANCES

1. SEPTA’s Right-Of Way Clearance Drawings delineate the minimum envelope that shall be maintained. No permanent obstructions that violate the minimum clearance requirements are permitted
   - Railroad clearance requirements are as per Drawing 2-W-24864
   - STD Routes 100, 101, and 102 clearance requirements are as per Drawing 2-W-36398
   - CTD Broad Street Subway clearance requirements are as per Drawing 2-W-37104
   - CTD Market Frankford Subway Elevated Line clearance requirements are as per Drawing 2-W-36650

2. The minimum vertical clearance above the top of the higher rail shall be twenty-three feet (23'-0") at all times. In areas where the railroad has overhead electrification with a catenary wire, and areas which are likely to be electrified, the minimum vertical clearance must be twenty-four feet six inches (24'-6") above the top of the higher rail.

3. The minimum horizontal clearance measured from the centerline of track to the near face of the obstruction must be twenty feet (20'-0") for tangent track and twenty-one feet (21'-0") for curves. Horizontal clearances shall not be less than existing.

4. Whenever practicable, bridge structures must have the piers and abutments located outside of the railroad right of way. All piers located less than twenty-five feet (25'-0") from the centerline of track require a crash wall designed in accordance with specifications outlined in the current AREMA Manual – Refer to Paragraph E in this Section.

5. All piers should be located so that they do not interfere with ditches. Where special conditions make this impossible, an explanation of these conditions must be submitted with the drainage plans for review by SEPTA.

6. The permanent clearances should be correlated with the methods of construction so that temporary construction clearances will not be less than the minimum allowed. Temporary construction clearances less than
the minimum can be reviewed by SEPTA on a case-by-case basis and require approval of the Chief Engineer – Infrastructure.

7. Bridge structures shall provide sufficient lateral and vertical clearance for anticipated future tracks, reinstallation of removed tracks, changes in track centers, and raising of tracks for maintenance purposes. The locations of these tracks shall be determined by inquiry to SEPTA.

8. The profile of the top of rail should be examined to determine if the track is in a sag at the location of the bridge. If the track is in a sag, the vertical clearance from the track to the bridge should be increased sufficiently to allow raising the track to remove the sag.

9. Vertical and horizontal clearances must be adjusted so that the sight distance to railroad signals is not reduced from what is existing.

10. All proposed temporary clearances which are less than those listed above must be submitted to SEPTA for review and must be approved by SEPTA prior to construction.

11. Clearances are subject to the requirements of the Commonwealth of Pennsylvania PUC and must be approved by both the Commonwealth and SEPTA if less than those prescribed by law.

B. DRAINAGE

1. Maintaining the existing drainage and providing for future drainage improvements is of the utmost importance. SEPTA will give special attention to reviewing drainage details.

2. Drainage plans must be included with the general plans submitted to SEPTA for approval. These plans must include hydrologic and hydraulic studies and computations showing the frequency and duration of the design storm used, as well as the method of analysis such as Soil Conservation Service or the Rational method. SEPTA uses storms with a 100-year recurrence interval as the minimum design storm.

3. Lateral clearances must provide sufficient space for construction of the required track ditch parallel to the standard roadbed section. If the ditch cannot be provided, or the pier will interfere with the ditch, then a culvert of sufficient size must be provided.

4. Ditches and culverts must be sized to accommodate all increased run-off due to the construction and the increased size must continue to the natural outlet of the ditch. Ditches must be designed in accordance with good drainage engineering practices and must meet all state and local codes and ordinances.

5. No scuppers or other deck drains, roadway drainage, catch basins, inlets or outlets are permitted to drain onto SEPTA property. Any variation of this policy must have the prior approval of SEPTA. If an exception is ultimately
granted, maintenance of such should not be SEPTA’s. Drainage from scuppers and deck drains must be conveyed through pipes, preferably to a point of which is off SEPTA property. If the drainage must be conveyed into a railroad ditch, calculations must be provided to SEPTA which indicate the ability of the ditch to carry the additional run-off. Additional drainage may require the installation of a pipe or pipes, new ditch or repprofiling the existing ditch.

6. The design shall address maintaining good drainage of SEPTA’s Right-of-Way during the course of the construction activities. After completion of construction, all drainage ditches shall be cleaned of all debris and reshaped and sloped as needed.

C. EROSION CONTROL

1. Embankment slopes on SEPTA property adjacent to the track must have a slope of 2:1 or less and be paved for a minimum of two (2) feet beyond the outside edge of the bridge foundation structure. The purpose of the pavement is to minimize erosion of the embankment material and to reduce deterioration of the sub-grade material by drainage water. The pavement shall consist of a prepared sub-base and/or filter fabric with grouted riprap on the surface.

2. The general plans for the bridge should indicate the proposed methods of erosion control during construction and must specifically address means to prevent silt accumulation in ditches and culverts and to prevent fouling the track ballast and sub-ballast. If the plans do not show erosion control, the contractor must submit a proposed method of erosion control and must have this method approved by SEPTA prior to beginning any grading on the site.

3. Existing track ditches must be maintained at all times throughout the construction period. Silt fences shall be provided to protect the railroad ditches. After the construction has been completed, all erosion control devices must be removed and the ditches must be restored.

4. SEPTA’s approval of drainage and erosion control plans will not relieve the Sponsor submitting these plans from ultimate responsibility for a satisfactory plan.

5. All disturbed areas shall be seeded and mulched.

D. CATENARY REQUIREMENTS

1. Catenary supports shall not be attached to new overhead bridges. Independent support structures shall be provided. Refer to Section 7 for requirements.
2. Where there are high voltage electric lines or catenary wires located above, adjacent to, or below the new structure, exposed steel shall be bonded and grounded per NEC and NESC requirements.
3. Where catenary wires are below the structure, the bridge shall have solid protective barriers with “Danger Live Wire” signs.

E. CRASH WALLS

1. AREMA Manual of Railway Engineering, Chapter 8, Article 2.1.5 Pier Protection, describes the requirements for crash walls. Provide crash walls when the face of the pier is closer than 25'-0" from the centerline of the nearest track, measured perpendicular to the track, unless the size of the pier satisfies the criteria for piers of heavy construction. A pier is considered heavy construction if it has a cross-sectional area equal to or greater than that required for a crash wall and the larger of its dimensions is parallel to the tracks.
2. Crash walls for piers from 12 feet to 25 feet clear from centerline of the track shall have a minimum height of 6 feet above the top of rail.
3. Piers less than 12 feet clear from the centerline of track shall have a minimum crash wall height of 12 feet above top of rail.
4. Crash walls shall be at least 2'-6" thick and at least 12 feet long.
5. For multi-column piers, the crash wall shall connect the columns and extend at least 4 feet beyond the outermost column, parallel to the track.
6. Crash walls shall be anchored to the footings and columns as applicable and shall extend at least 4 feet below the lowest surrounding grade.
7. Consideration should be given to providing protection for bridge piers located more than 25 feet from the centerline of the track as conditions warrant. In making this determination, account shall be taken of such factors as horizontal and vertical alignment of the tracks, embankment height, use of tracks for other than transit operations, and an assessment of the consequences of serious damage in the case of a collision.

F. BARRIERS

1. Where catenary wires are below the structure, the bridge shall have a solid barrier per PennDOT’s Standard Protective Barrier design.
2. In non-electrified territory and third rail power territory, it is the recommended that a solid barrier per PennDOT’s Standard Protective Barrier be provided directly above the tracks. SEPTA may permit chain link fencing with a 1-inch (1") mesh as a substitution for the solid barrier on a case by case basis.
G. DRAWINGS

1. The distance from the nearest milepost at the intersection of the track and centerline of the bridge shall be shown. If an existing bridge is being replaced at the same location, note the milepost of that bridge.
2. Horizontal and vertical clearances shall be marked on the General Plan and Elevation.
3. Plans for bridges must show dimensioned locations of all utilities that might be located on the railroad right of way.
4. Plans submitted to SEPTA shall contain as a minimum the following information:
   - Roadway name or Route Number.
   - SEPTA bridge number
   - Owner of the bridge
   - Skew angle to the railroad centerline
   - Foundation type and elevation of bottom of footing
   - Geotechnical information including soil boring logs and report
   - Pile type and depth (if applicable)
   - Top of rail elevation for all tracks
   - Drainage modifications
   - Elevation and cross sections of existing and new structures
   - North arrow
   - Clearance information dimensioned in English Units
   - Catenary support structure(s) including location, details, and loading diagram(s)
5. A complete set of as-built survey, design, engineering, and fabrication drawings shall be provided to SEPTA upon completion of the project.

H. GENERAL REQUIREMENTS

1. Piers, abutments, and columns located within SEPTA’s right-of-way shall have an anti-graffiti coating consisting of a three-coat system subject to SEPTA’s approval.
Section 7
Catenary Structure Design Requirements

The design and construction of new and replacement catenary structures shall conform to the following minimum design and submittal requirements.

A. GENERAL

1. Catenary support structures shall be structural steel with reinforced concrete foundations designed in accordance with AREMA Manual of Railway Engineering Chapter 33 Part 4.
2. The structure shall be detailed to accept SEPTA standard catenary hardware.
3. SEPTA’s Right-Of Way Clearance Drawings delineate the minimum envelope that shall be maintained. No permanent obstructions that violate the minimum clearance requirements are permitted
   • Railroad clearance requirements are as per Drawing 2-W-24864. Catenary structures shall not be less than 12'-0” from centerline of nearest track.
   • STD Routes 101 and 102 clearance requirements are as per Drawing 2-W-36398.
4. All calculations and design drawings shall be sealed by a Professional Engineer (structural) registered in the State where the work is located.
5. Fabrication drawings shall be submitted for review.
6. All calculations and drawings shall be submitted to SEPTA for review and approval.
7. As built design and fabrication drawings and fabrication and construction inspection records shall be provided to SEPTA for record purposes.
8. Steel fabricator shall be AISC Quality Certified for Category I work or has a minimum of 5 years demonstrated railroad catenary support structure fabrication experience.
9. Trolley wire height shall be between 19'-0” minimum and 22'-0” maximum above top of rail but not less than the existing at the location of the new structure(s).
10. All structures shall be grounded per NESC and NEC code requirements. Ground wire connections shall be cadwelded. Tubular and HSS columns shall be provided with a NEMA 2 hole ground lug.
11. All structural steel shall be either hot dip galvanized or weathering steel. 
12. Calculations and drawings shall include a loading diagram for each structure.

B. DESIGN CODES AND REFERENCES (latest editions)

1. AREMA Manual of Railroad Engineering 
3. AWS D1.1 – Structural Welding Code 
5. International Building Code (IBC) 
6. ACI 318 – Building Code Requirements for Structural Concrete 
7. ASCE 7– Minimum Design Loads for Buildings and Other Structures

C. BASIC LOADS

1. The basic loads applied to catenary structures shall be in accordance with AREMA. The loads include 
   • dead weight of wires, wire supports, and the structure 
   • curve pull forces and dead end loads 
   • ice loads on the wires only 
   • wind loads on the wires and structure (design wind velocity of 80 mph) 
   • wire break loads 
   • live loads (from cat walks, ladders, etc) 
   • Other loads as may be specific to the location and structure.

2. Three basic climate and load conditions shall be reviewed: 
   • Icing Condition 
   • Operating Condition 
   • Design Condition

3. The AREMA specified overload factors shall be applied.

D. DESIGN AND ANALYSIS

1. Design shall be per AISC ASD or LRFD. An additional design margin of 5% shall be applied as required by AREMA in selecting sizes based upon allowable stresses. 
2. The columns shall be designed with a full moment base plate or direct embedment in a reinforced drilled concrete caisson.
E. MATERIALS

<table>
<thead>
<tr>
<th>W- Shapes</th>
<th>ASTM A588 Grade 50 weathering steel or ASTM A992 Grade 50 Hot Dip Galvanized</th>
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<td>Anchor Bolts or Rods</td>
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F. STEEL DESIGN DETAILS

1. Minimum plate thickness and member thickness is 3/8 inch.
2. Rust plates shall be provided on the web and flanges of embedded steel members at the concrete interface. Rust plates shall extend not less than 6 inches on each side of the top of concrete.
3. Outstanding legs of angles shall face down. The flanges of back to back angles (or other shapes), when not in contact, shall have a minimum separation of 3/8 inches to permit air circulation.
4. All steel embedded in concrete shall be hot dip galvanized for the full length of the member. Galvanizing shall be a minimum of 2.0 oz/sf.
5. All anchor rods (bolts) shall have two nuts. Minimum diameter of anchor rods is 1½". The minimum embedment length is 48 inches. A minimum of 6 anchor bolts shall be provided.

6. The detailing of members and assemblies should avoid pockets, crevices, faying surfaces or locations that can collect and retain water, damp debris, or moisture.

7. For weathering steel bolted connections, the faying surfaces shall have a one-coat paint system consisting of a high-quality air-drying rust-inhibitive shop-primer which is applied to a nominal dry film thickness of 1.5 to 2 mils.

8. Hollow steel members should be sealed to prevent entry of moisture. If this is not possible, provisions must be made to insure adequate drainage and ventilation.

9. Attachment for static wire shall be provided on the top of all columns.

10. The catenary structure number shall be permanently marked on the inbound and outbound faces of all columns using reflective signs or reflective paint.

11. SEPTA furnished “High Voltage” signs shall be installed on all columns.

G. FOUNDATIONS

1. Design per ACI 318 and the International Building Code

2. Minimum embedment is 5'-0". Exclude the top 1'-0" of embedment when calculating embedment depth.

3. Minimum factor of safety against overturning and sliding shall be 1.5

4. Concrete shall slope away from the steel with a 1% to 2% slope. Footings and caissons shall extend a minimum of 2'-0" above grade but not less than top of adjacent rail. Guy anchor foundations shall extend not less than 1'-0" above grade.

5. Concrete shall be a minimum of 4000 psi at 28 days, air entrained with a minimum 6% air content, and a minimum w/c ratio by weight of 0.45. For locations adjacent to platforms and sidewalks or in areas subjected to de-icing chemicals, use 4500-psi concrete with a minimum w/c ratio of 0.40 and a minimum of 6% air content.

6. All rebar shall be hot dip galvanized or epoxy coated.
Section 8
Attachments or Modifications to Existing Catenary Structures

The design and construction of attachments to or modifications to existing catenary structures shall conform to the following minimum design and submittal requirements.

A. Additions to or modifications to existing catenary structures require review and approval of SEPTA.

B. Calculations and design drawings shall be submitted documenting the adequacy of the structure to take the additional loading and for any required reinforcement of the existing structure. The calculations shall address all existing loads as well as additional loads.

C. Calculations and design drawings shall be sealed by a Professional Engineer (structural) registered in the State where the work is located.

D. Catenary support structures shall be checked in conformance with AREMA Manual of Railway Engineering Chapter 33 Part 4 and Section 7, Catenary Structure Design Requirements, of this document.

E. All calculations and drawings shall be submitted to SEPTA for review and approval.

F. Calculations shall take into consideration the existing condition of the structure including the foundations. A copy of the field inspection report shall accompany the calculations.

G. All attachments shall be bonded to the existing structure and/or tied into the existing structure ground system per NEC and NESC. Grounding and bonding attachments shall be cadwelded.

H. As built design and fabrication drawings and fabrication and construction inspection records shall be provided to SEPTA for record purposes.
Section 9
REQUIREMENTS FOR MONITORING DURING PILE DRIVING AND/OR EXCAVATING OPERATIONS

Pile driving and excavation on or adjacent to SEPTA’s property and/or right of way shall conform to the following minimum design and submittal requirements.

A. Pile driving will be on a continuous basis for each pile driven. Once a pile is started, it will be driven or cut off at an elevation not to exceed the plane across the top of the rails of any track within 8’-6” plus 2” for each degree of curvature from centerline of track to the closest edge of the edge or excavation.

B. The monitoring points shall be set up not less than one week before the pile driving or excavation operations begin. The designated SEPTA coordinator shall be notified.

C. Elevation and horizontal alignment readings to establish the initial baseline reading shall begin two days prior to the start of work. Readings shall be taken just prior to the commencing of construction/excavation. During active construction hours, readings shall be taken at the beginning of every hour. Readings during the inactive construction hours shall be taken every twelve hours. Readings shall be taken once a day at 10:00 am for a minimum of seven calendar days after the completion of the driving or backfilling of the excavation, whichever is longer. Initial readings immediately after any surfacing operations shall serve as new baseline figures. All future readings shall be compared to the adjusted baseline. If the track deviates to an unacceptable degree, work will be stopped and corrections will be made at the Sponsor’s expense.

D. Elevation readings will be taken from the top of each rail of each track and alignment readings will be taken from gauge of each rail within the “zone of influence” the excavation.

E. A SEPTA engineer must be on-site during pile driving within SEPTA’s ROW.
F. Allowable deviation from uniform profile in either rail at the mid ordinate of a 62-foot (62') chord may not be more than one inch (1’"). The difference in cross level between any two points less than 62 feet (62’) apart may not be more than 1 inch.

G. The readings will be faxed and e-mailed to SEPTA on a daily basis and all information is to be presented in legible print. Additional readings may be required by SEPTA.

H. Stations shall be spaced at no greater than 15½-foot (15’-6”) intervals. The number of stations required will be determined by the length of the excavation parallel to the tracks. There will be four additional stations on each end of the pile driving/excavation operation along the track. Extra stations may be required by SEPTA.

I. Readings must show the date, time, weather conditions and temperature. Each reading must also provide the following information: track number, compass direction, station number, base reading (with date), static elevation, change in elevation or alignment (recorded in hundredths and in inches), dynamic reading and total deflection in inches.

J. Station “0” will be located at the centerline of the project with Stations 1, 2, 3, etc., being to the right and Stations -1, -2, -3, etc., being to the left when standing on the near track and looking at the work. In multiple track areas the stations as determined herein are to be carried across each track located within any part of the zone of influence.

K. At each monitoring station a dynamic load measurement will also be taken. The dynamic load measurement device will consist of a wooden stake placed firmly in the ballast and in initially in contact with the bottom of the rail. The loaded measurement is the resultant gap between the bottom of the rail and the top of the stake caused by the deflection of the rail under the load of a passing train. Based on field observations of the excavation, and at the option of SEPTA, this requirement may be reduced.

L. Elevation readings taken from the top of rail for static measurement and the dynamic reading shall be combined and the sum compared to the adjusted baseline. This reading will demonstrate the difference in elevation caused by the excavation.
M. SEPTA requires that the track be maintained at all times within established criteria for the specific track classification. At the completion of the project the requirement for tamping and realigning the tracks, caused by the settlement from the construction activity, remains with the Sponsor for the duration as specified by SEPTA in their initial review of the work plans. This tamping and track realignment will be performed by SEPTA at the sole expense of the contractor.
Section 10
REQUIREMENTS FOR EXCAVATING
ADJACENT TO UNDERGROUND
FACILITIES

Excavation over or adjacent to SEPTA’s subway tunnels and other SEPTA underground structures shall conform to the following minimum design and submittal requirements.

A. For monitoring requirements, refer to Section 9 - Requirements For Monitoring During Pile Driving Or Excavating Operations.

B. All exposed waterproofing shall be protected. Damaged or disturbed waterproofing shall be replaced. SEPTA shall inspect all exposed structures prior to waterproofing and again prior to backfilling. The waterproofing and waterproofing protection shall conform to SEPTA standards.

C. All means and methods including extent of all excavation and shoring shall be submitted to SEPTA for review. The design and construction of temporary sheeting and shoring shall conform to the requirements of Section 1 - Temporary Sheeting And Shoring.

D. A location plan showing the existing structure(s) along with all above ground and underground utilities and structures must be provided.

E. Provide calculations showing loads on SEPTA facilities as well as any temporary supports that may be required. Calculations shall also be submitted showing that the foundation and stability of SEPTA’s existing structures is not affected by the excavation, any temporary construction, or by the permanent construction.

F. Submit copies of all City of Philadelphia or other local government permits and approvals.

G. All procedures, plans, and calculations submitted shall be prepared, signed, and sealed by a Professional Engineer, registered in the State where the work is located.
H. The Sponsor is responsible for the design and construction of any and all repairs to damage to SEPTA facilities at no cost to SEPTA.
SECTION 11
REQUIREMENTS FOR ATTACHMENTS TO BRIDGES

SEPTA may permit utility or other attachments to new and existing bridges if the proposed addition is “a practical arrangement and considered to be in the public interest” and will not have a negative impact on SEPTA operations and maintenance, present and future. The following information has been established as a guide for the preparation of plans and for the review of plans for the proposed attachment.

A. LOCATION

1. The location of a utility crossing or attachment on a structure should be selected to avoid conflict with existing utilities or future utilities for which provisions have been made. The attachment shall not block or otherwise impact existing signs, utilities, or other attachments to or components of the bridge.

2. Adequate access for maintenance and inspection of the planned installation and of the structure itself must be kept in mind.

3. Placement of utilities or attachments on bridge decks, ties, or walkway areas, or attachments to railings or parapets, are not permitted. Also prohibited are exposed installations at the outside faces of the structure where subject to bridge strikes or where aesthetics are of a concern.

4. Existing underclearances shall be preserved. All elements of the attachment or utility crossing shall be positioned to clear a line defined by connecting the points of intersection of the centerline of web at the bottom of the bottom flange beams flanking the installation. Familiarity with the structural framework is necessary to avoid conflicts with bearing seats, cross frames, intermediate and end diaphragms and lateral bracing.

5. For bridges with an underclearance of less than 14'-6”, any attachment to the bridge must allow for installation of a 48”x24” bridge clearance sign if an existing sign is not present.

6. Proper clearance shall be maintained from all power or communication lines.
B. INSTALLATION AND PLAN REQUIREMENTS

A. Joints in bridge decks unusually define locations where differential movements can occur between adjacent spans resulting from temperature changes and traffic loads. Appropriate devices must be provided at these locations to accommodate similar movements in bridge attachments.

B. Galvanized structural steel should be utilized for supports where existing structural elements cannot be used to carry loads. Sizes of proposed structural shapes should be provided.

C. Specify the type, size and location of connections. High strength bolts (ASTM A325 preferred) shall be used.

D. Drilled in concrete anchors shall be stainless steel, epoxy adhesive type. The use of expansion anchors is not permitted.

E. Welding to existing structures is prohibited.

F. For new structures, welding to bottom flanges or lower one-third height of web of simply supported stringers is not permitted. Welding is also prohibited in areas of negative moment area for continuous beams and on all fracture critical members.

G. Placement of anchor bolts or other inserts into deck slabs is prohibited.

H. Provide ducts for electrical and communication cables.

I. The project location should be defined on a small scale location map on which the site can be seen in relationship to major points of reference; such as, SEPTA Stations, highways, municipalities, bodies of water, county lines, etc.

J. Identification of the route, bridge number, municipality, county, applicant, and proposed bridge attachment should be placed in the title block located in the lower right hand corner.

K. Provide a plan view with a North reference arrow, an elevation and a cross section of the structure and detailing and necessary dimensions to identify and locate existing and proposed structural members that are in relationship to the bridge attachment and to verify clearances. Additional sections should be shown, as required, to completely convey the extent of the work and/or modifications proposed.

L. The outside diameters and thickness of pipes, and weights of pipe or conduit and materials carried should be shown on the plans. If manufactured fittings, connectors, supports, etc. are used, their identity and spacing should be indicated on the plans and catalog cuts with dimensions should be traced on to the plans.

M. All metallic structures shall be bonded/grounded per the National Electric Safety Code (NESC) and the National Electric Code (NEC) where near energized lines or otherwise required by code. All attachments shall be cadwelded.
C. PROHIBITED INSTALLATIONS

1. Pipes carrying flammable substances or non-flammable substances that by their nature might cause danger if escaping on or near railroad/transit facilities or personnel are not permitted to be attached to bridge superstructures. Attachment to substructure will be reviewed on a case-by-case basis.

D. DESIGN REQUIREMENTS

1. Calculations and drawings shall be submitted for review and approval and shall be sealed by a Professional Engineer registered in the State where the work is located.
2. Structural integrity of the bridge components shall be preserved. The loads, in particular the dead load and wind loads, of the proposed attachment shall not cause undue stresses. Loads on the structure including wind loads shall be in conformance with the American Society of Civil Engineers Standard ASCE - 7, and the International Building Code (IBC) latest edition.
3. Design shall conform to AREMA or AASHTO as applicable, and all applicable federal, state, and local rules, regulations, and codes. The calculations shall clearly note all loads, design assumptions, and codes used.
4. Site-specific structural calculations shall be provided and shall include verification that the existing structure can withstand imposed additional loadings. The calculations shall take into account the existing condition of the structure.
5. The basic wind speed for design shall not be less than 90 mph.

E. SIGNS

1. All utilities or pipelines shall be prominently marked with signs showing the following minimum information:
   • Name and address of owner
   • Contents of pipe or conduit
   • Pressure if a pipe
   • Emergency phone number

2. The owner/utility shall maintain all attachments and signs.
SECTION 12
REQUIREMENTS FOR BILLBOARDS AND SIGN STRUCTURES

SEPTA may permit installation of billboards and other advertising sign structures on SEPTA property and/or Right of Way. The following information has been established as a guide for the preparation of plans and for the review of plans for the proposed attachment.

A. DESIGN

1. Loads on the structure including wind loads shall be in conformance with the American Society of Civil Engineers Standard ASCE 7 and the International Building Code (IBC) latest editions.
2. Design shall conform to all applicable federal, state, and local rules, regulations, and codes. The calculations shall clearly note all loads, design assumptions, and codes used.
3. Site-specific structural calculations shall be provided and shall include the foundation.
4. Site-specific geotechnical investigation or documentation of soil assumptions shall be provided.
5. The basic wind speed for design shall not be less than 90 mph.

B. DRAWINGS

1. Three (3) sets of the drawings of the sign and structure must be submitted and should include:
   • Site plan showing all SEPTA facilities. Provide dimensions to nearest SEPTA structures and railroad tracks.
   • Details of the support structure and foundation(s).
   • Fabrication requirements and codes.
   • Rebar and anchor rod size, number, and spacing.
   • The sign showing the type of material and method of attachment to the support structure.
   • If the sign is electrical, the kVA rating and power source must be shown.
   • Grounding and lightning protection.
   • All underground utilities clearly noted.
C. GENERAL REQUIREMENTS

1. Calculations and drawings shall be sealed by a Professional Engineer registered in the State where the work is located.
2. A minimum of 3 ft clearance shall be maintained from any fire hydrants and roadways.
3. Proper clearance shall be maintained from all overhead power or communication lines.
4. Location shall not interfere with SEPTA operations, activities, site distances, or any future expansion.
5. Copies of all permits and PA One Call shall be submitted for information.
6. The sponsor remains responsible for the inspection, maintenance, and removal of the structure.
7. All steel shall be protected from corrosion by galvanizing, painting, the use of weathering steel (were aesthetics are not of a concern), use of stainless steel, or other appropriate methods. The lower three feet (3 ft) of steel supports shall be provided with additional corrosion protection.
Structural Engineering
ROW Design and Construction Standards

ATTACHMENT 1

RIGHT-OF-WAY CLEARANCE DRAWINGS
EM&C
Computer-Aided Design & Drafting Standards

David Doler
EM&C Drafting Administrator

October 2007

Engineering, Maintenance & Construction Division
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Section 1.0 - General

The criteria herein has been compiled for the purpose of establishing, defining, and clarifying procedures and CADD Standards to be used in in-house EM&C engineering activities and by consultants in preparing CADD based contract documents for SEPTA. The intent of this document is to provide guidelines to assure that all project drawings have a uniform appearance and reflect high quality drafting workmanship. Each engineer, project manager, designer and drafter shall be responsible for ensuring that these criteria are implemented by both in-house forces and by third-parties tasked with the development of design content for SEPTA and that all drawings show the information completely and clearly without unnecessary embellishment.

1.1 References
The original “Transit Design Manual” developed by the City of Philadelphia and SEPTA “Drafting Standard” developed in June 1989 has been used as the foundation to specifically tailor CADD standards for SEPTA EM&C engineering efforts. Additionally, layering conventions have been established from the American Institute of Architects’ CADD layering guidelines with further expansion and refinements derived from the U.S. DOD TriCADD, MilSpec and National Institute of Building Sciences CADD practices models. Applicable references from the CADD Standards manuals of AMTRAK and New Jersey Transit have been incorporated into this document to insure consistency with interfacing agencies.

1.2 Interpretation
The listed criteria, rules and procedures set forth in this document shall be read together and interpreted as a whole in order that all provisions may be considered inclusive. In cases of conflict between any of the criteria, rules or procedures listed, the most stringent requirement shall govern. When an issue arises that is not addressed within this document or adequate interpretation cannot be achieved, contact the SEPTA EM&C Drafting Administrator.

1.3 Standards Compliance
CADD requirements discussed in this document shall be incorporated into the drafting presentation. The A/E may be required to provide CADD examples as described in this document representing product output for review by SEPTA for adherence to these criteria at a time prior to any submittal of contract documents.

The examples and final contract documents shall be 100% compatible with the criteria set forth in this document. The A/E must facilitate communications with all parties to assure that drawings submitted by contractors and subcontractors are in accord with the criteria set forth in this document.

1.4 Definitions

A/E – Architect or Engineer

AEC – “Architecture, Engineering & Construction”.

As-Built Drawings - Drawings marked up in the field to reflect changes to the design documents. These could be compiled by an engineer, designer or drafter or by the field personnel for inclusion in the record drawings.

B&B - Buildings and Bridges (A section within EM&C)

Bid Drawings - The drawings issued to the prospective contractors for the purpose of bidding the project work.

CADD - Computer-Assisted Design and Drafting. As applied to SEPTA it refers to all AutoCAD versions through 2008.

Conformed Drawings – Post-bid project drawings which have been combined with drawings and changes stemming from addenda or requests for clarifications during the estimating and bidding process.

Contract Drawings - The drawings incorporating all the addenda issued during the bid process.

EM&C - Engineering Maintenance and Construction Division within SEPTA.

Preliminary Drawings - 35%, 60% and 90% drawings prepared during the design phase or in preparation of final drawings during the design phase.

Project Drawings - Preliminary, bid, contract, conformed, as-built drawing or record-set drawings.

Record Drawings - A complete set of drawings that incorporate the as-built revisions into the design documents, including addenda and design revisions. These are compiled from the as-built drawings submitted by the contractor, as a record of the work. Since these are not confirmed in the field by the designer they are not “as-built” but a compiled record. Record drawings represent a complete drawing set, not just the sheets that changed. These drawings will not be signed, but will be stamped or otherwise marked as “record drawings”

SEPTA - Southeastern Pennsylvania Transportation Authority

Shop Drawings - Drawings made by the manufacturer or vendors showing detailed fixture, assembly and product construction methods, materials and dimensions as applicable to the installation.

The Consultant - The design firm under contract with SEPTA.
Section 2.0 – Drawing and Electronic Submission Media

2.1 Drawing Sheet Size
Except for special drawings, such as survey maps or where the size of the drawing is determined by other agencies, all project drawings shall be printed onto 3 mil double matte, 22" X 34" Architectural ‘D’ conventional size or when metric dimensioning rules are established, 841 mm X 594 mm A1 metric polyester drafting film (Mylar) (non-Diazo type) with 1/2" (15 mm) right, top and bottom and 1-1/2" (40 mm) left borders. The field prints should be run on paper suitably sized to accommodate the original format.

The submittal of drawings for design review on Architectural C or Architectural B (11X17) is prohibited unless specific authorization has been received from the SEPTA Project Manager.

2.2 Cover Sheet
All parties shall complete the cover sheet to satisfy the project requirements in accordance with information provided by the Project Manager. The size and orientation of the cover sheet shall be consistent with the project drawing set. A second cover sheet may be developed if the list of sheets exceed the space available on the first cover sheet, or when needed for symbols, notes, and abbreviations.

2.3 Preliminary Drawings
High quality Velum or Translucent Bond paper may be substituted for Mylar as the plotting media for preliminary, study and work drawings. In-house engineering shall produce preliminary drawings on Translucent Bond paper only. Mylar production is limited to final drawings for signatures.

2.4 Bid and Contract Drawings
Plotting media for these drawings shall be 3 mil double-matte, drafting film (Mylar) (Non-Diazo type). If approved by the SEPTA EM&C Drafting Administrator, these drawings may be printed on vellum and reproduced onto polyester or mylar based drafting film by permanent Xerox-technology methods. Due to inadequate permanency, Inkjet technology is not acceptable.

2.5 As-Built and Record Drawings
Revise the original contract CADD Drawing files to reflect all field changes made during construction. Plot new Mylar sheets.

2.6 Shop Drawings
High quality vellum or archival quality Diazo process blueprints may used by manufacturers or vendors as the printing media for shop drawings.

2.7 Electronic Media
All digital files shall be delivered in a format compatible with generic PC class computers utilizing the Microsoft Windows 2000, XP or Vista operating system.

All digital drawing shall be in the AutoCAD native 2000, 2002 or 2006 format. Non-AutoCAD produced .dwg source files are unacceptable unless the intended format is approved by the SEPTA Drafting Administrator.

Submissions in electronic format shall be provided on ISO9660 formatted CD-R disks. DVD or R/W media is not acceptable. Electronic submittal shall have an ASCII format (standard text) drawing index file included. This file shall contain Project Name, SEPTA project number and a descriptive list of the drawings with associated filenames and creation date. Media shall be labeled with indelible ink indicating project name, SEPTA project number and submission date.

AutoCAD drawings must have all utilized fonts, symbols, linetypes, external references, standard drawing templates, symbols, plot configuration sources and third-party customization files included without directory dependency.

AutoCAD external references shall be bound to the parent drawing.

2.8 Written Transmittal
A written transmittal sheet shall accompany the electronic media and contain a description of the drawing set and certification that the media is free from all known computer viruses including the name of the virus scanning software used and the date that the media was scanned. The basic structure for organizing drawing sets is based on the traditional practices of architectural/engineering disciplines.

Section 3.0 – Drawing Organization, Content and Identification

The following standard for drawing organization shall apply for all SEPTA projects produced by the Buildings and Bridges Engineering department.

3.1 UCS Global Origin
The standard AutoCAD User Coordinate System origin of 0,0,0 shall be used in all instances and shall be oriented so that X point to the direct right and Y points to the direct top of the sheet. Any 3D work shall be oriented to conform to the “Right-Hand Rule” of XYZ axis alignment.

3.2 Units of measurement
Architectural units of measurement with at 1/16" precision shall be used in all instances.
3.3 Z-Axis flattening
Unless approved by the EM&C Drafting Administrator, all 3D entities shall be flattened to achieve Z=0.

3.3 Model and Layout Space
A drawing file may contain both ‘Model’ and ‘Layout (Paper) space environments. Model space contains the physical components of a building such as walls, doors, columns, ductwork, piping, etc. Model objects and entities are drawn at full scale. Model space may also contain dimension and text annotation as long as they are not sheet specific information. All objects in model space must comply with the standards set forth in this document. Layout space contains selected view(s) of the model space environment along with the drawing titleblock. Layout space is a combination of referenced model space views, scale-independent details or schematics and annotation data in a final, plot-ready format.

3.4 Prohibited practices
Adhesive overlays, manual revisions and splicing on plotted output is prohibited. Design drawings using these practices will not be accepted.

3.5 Identification of Sheet Series
All general notes, symbols and abbreviations common to all drawings shall be placed on the G series drawings. The minimum required sheets to best represent the design criteria shall be used when creating drawings. Minor design elements not within the scope of an intended sheet may be included in other drawings as required. Sheets may contain combinations of discipline/drawing types as determined by the architect or engineer. Additional sheet series identifiers may be applied as needed with the approval of the Project Manager or Drafting Administrator.

<table>
<thead>
<tr>
<th>Drawing Series Starting Sheets</th>
<th>Code</th>
<th>Description</th>
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</thead>
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<td>001</td>
<td>MD01</td>
<td>General Mechanical</td>
</tr>
<tr>
<td>002</td>
<td>E001</td>
<td>Equipment</td>
</tr>
<tr>
<td>003</td>
<td>HVAC01</td>
<td>Heating, Ventilating and A/C</td>
</tr>
<tr>
<td>0501</td>
<td>P01</td>
<td>Plumbing</td>
</tr>
<tr>
<td>0502</td>
<td>F01</td>
<td>Fire Protection</td>
</tr>
<tr>
<td>0503</td>
<td>E01</td>
<td>Electrical</td>
</tr>
<tr>
<td>0504</td>
<td>EL03</td>
<td>Lighting</td>
</tr>
<tr>
<td>0505</td>
<td>ET01</td>
<td>Electric Traction</td>
</tr>
<tr>
<td>0506</td>
<td>SD01</td>
<td>Signals</td>
</tr>
<tr>
<td>0507</td>
<td>CM01</td>
<td>Communications</td>
</tr>
<tr>
<td>0508</td>
<td>WD01</td>
<td>Track</td>
</tr>
</tbody>
</table>

3.6 Identification of Filenames
CADD Files generated internally by the Building and Bridges Engineering Department and project support groups (Civil, Track, Electrical, etc.) shall be named and stored on the in the following format -

The above format is applicable to third party with the exception of the year and project code that shall be replaced with the assigned SEPTA project number.

3.7 Title Blocks
Title blocks sheets measure 34” X 22” with a 1-1/2” left boundary available for set binding. Drawing title blocks can be acquired for third party usage through the EM&C Drafting Administrator. The drawing file name and storage path (when applicable) must be indicated in the locations shown above. Project Drawings with plan views will have north arrow displayed in the upper right corner. Drawings with more than one plan view will have all plans oriented to match one common north arrow. North arrow will be oriented towards the top of the page of to the left when necessary.

Sheets smaller than 22” X 34” are not acceptable for construction / contract or as-built drawings. Reduced size and 11”X17” sets may be used in project manuals or specifications. 8-1/2”X11” sheets may only be used for inclusion in project manuals and for detail presentation.
At a minimum, title blocks must indicate the following information –

- Descriptive project name
- Building or facility name and location
- Division (owner) name
- SEPTA Project number
- Third-party GEC design firm name
- CADD drawing name
- Drawing number and sheet identifier
- Drawn-by name
- Engineer/Architect’s name and number-seal
- Location of the drawing
- File name and path
- Date drawn
- Scale factor
- Revision number and description
- Drawing completion status: ‘PRELIMINARY’, review percentage or ‘FINAL’

3.8 Cover Sheet
The cover sheet shall identify the project title, SEPTA project number, division and data pertinent to the full description of the project. If the cover sheet also contains specific project data such as table of contents, abbreviations, etc. it should be identified with the drawing designator G01.

3.9 Orientation
All plan view drawings in a set shall be oriented in the same general direction. The plan view shall be oriented so that true north is toward the top of the drawing or to the left side.

3.10 Drawing Element Organization
Project drawings shall be carefully organized so that the designer’s intent can be easily read. Related ideas should be grouped together in an orderly arrangement. The drawings shall be laid out with ample space between drawing items to ensure sufficient space for unanticipated details which may be required. General orientation of drawing elements shall allow for reading from top down beginning at the upper left corner unless element sizes require arrangement to conserve drawing area space. Title symbols shall be horizontally and vertically aligned whenever possible. Ideally floor plans should be shown on one sheet. If required, the floor plan can be subdivided into convenient segments with match lines provided to reference where the plan is continued. Civil plans may orient the drawing in a manner that will allow the site plan to fit within the sheet boundary at the appropriate scale. Orient the site plan in the same manner as the floor plan whenever possible. Every plan view shall have a north arrow orientation. True north should be adjusted to the building grid and plan north parallel to the sheet orientation. Display throughout the drawing set must stay consistent.

3.11 Sheet specific orientation maps, notes, symbol legends and abbreviations
Each detail sheet may be provided with specific notes, symbols and abbreviations related to that particular drawing oriented along the right side of the drawing beginning at the top in the order with the site map and north arrow in the upper right corner.

3.12 Indicating scale on drawings
Drawings are created at full scale and plotted to the selected scale when only model space is represented. Where paper space is utilized, plotting is done at full scale with views into Model Space zoom-scaled to the appropriate value to depict a desired plot scale. The scale chosen should be large enough to allow the drawing to display its graphical, textual and dimensional contents clearly. Scale should also be represented graphically using the appropriate bar scale symbols where needed. Scale is to be expressed in the same unit of measurement as used in the drawing(s). Maintain the same scale factor on a single sheet view or indicate the scale used for each model space view, detail, elevation, section, etc. Appropriate architectural graphic scale indicators

Section 4.0 – Graphical Elements

4.1 General reference title organization
The detail number shall be shown in the upper half of the circle. The sheet on which it is drawn shall be shown in the lower half. In the title, the file on which the detail is referenced shall be shown outside the circle, to the right. The circle shall be 1/2” in diameter. Text within the circle shall be 1/8” high. Detail name text shall be 3/16” high. All other text shall be 3/32” high.
4.2 Section Symbols
In all cases a section shall be designated by capital letters. Whenever practical, sections shall be listed consecutively, A, B, C, etc., from left to right and from top to bottom on the sheet on which they are drawn. Section identification lines preferably should not be continuous between their limits. The word "similar" should be expanded to explain how it is similar, such as (similar, but opposite hand) or (similar except as noted and called out). In designating a similar section, always use a different letter, as B above, and not the initial letter with an accent, e.g., A. The use of the word "same" is to be avoided. When a section is taken such that it is similar to one already shown either on the same sheet or on a separate sheet, the new section need not be drawn but may be referred to in the existing section view by stating that the new section is similar per the example.

4.3 Detail Symbols
In all cases, details shall be designated by numerals. Whenever practical, details shall be listed consecutively 1, 2, 3, etc., from left to right and from top to bottom on the sheet on which they are drawn. Details will be identified by encircling the area to be clarified and connecting this area with the detail symbol (See below). Care shall be taken to ensure that the orientation of the detail drawing is identical to that of the plan elevation, etc. where it is identified. Whenever practical, a detail drawn on the sheet on which it is identified shall be drawn in the immediate vicinity of its identification symbol.

4.4 Elevation Symbols
Elevations shall be designated using the symbol shown below. The figure on the left is used for one elevation with the darkened corner facing in the direction of the elevation shown. The figure on the right is used for two or more elevations with the multiple corners and letters showing the elevations taken.

4.5 Column Balloons
Column balloons shall be 3/8" diameter with centered 1/8" letter. Distance from column centerline to base of column balloon shall be no less than 5/8" unless required to accommodate drawing information. Column balloon text shall not be rotated.

4.6 North Arrow
North arrows shall be 1/2" in diameter and are to be incorporated into any drawing that depicts design elements of building orientation. The location of the symbol shall be in the upper right corner of the drawing unless conditions prohibit.

4.7 Bar Scales
The Blueline (Diazo) or Xerographic reproduction process can introduce shrinkage to the copy process. Bar scale symbols are typically used to provide a convenient length standard for manual scaling of a reproduced drawing to compensate for copy shrinkage where a scale factor has been indicated.

4.8 General Text
All lettering shall be of sufficient size, weight, and clarity so that it can be easily read from a print that has been reduced to one-half the size of the original drawing. On any one sheet, uniformity shall be maintained. Minimum letter size shall be 3/32" height (3 mm).

4.9 Text Formats
Capitalize proper nouns, specific titles, trade names, and the first letter of each sentence of notation, when using lower-case lettering.
4.10 Lettering Type
Unless otherwise specified, all lettering within any drawing shall be the following AutoCAD fonts:

<table>
<thead>
<tr>
<th>Use</th>
<th>Font</th>
<th>Size</th>
<th>Case</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titles</td>
<td>romand</td>
<td>3/16</td>
<td>Upper</td>
<td>1</td>
</tr>
<tr>
<td>Sub Titles</td>
<td>romans</td>
<td>5/21</td>
<td>Upper</td>
<td>1</td>
</tr>
<tr>
<td>General Notes</td>
<td>romans</td>
<td>3/32</td>
<td>Upper</td>
<td>.85</td>
</tr>
<tr>
<td>Dimensions</td>
<td>romans</td>
<td>3/32</td>
<td>Upper</td>
<td>.85</td>
</tr>
<tr>
<td>Sketch</td>
<td>romans</td>
<td>1/8</td>
<td>Upper</td>
<td>1</td>
</tr>
</tbody>
</table>

Lower case slant lettering may be used on civil drawings to denote existing elevations. Oblique angle shall be 10 degrees. Underline all titles with a single line having the same weight as the lettering used. Use double spacing to separate successively numbered notes. When 50% of each note is two (2) or more lines long. Where fractions occur in dimensions, a space shall be placed between the whole number and the fraction (Example: 6 1/2") All lettering shall be horizontal, unless related to dimensioning where it shall be parallel to the dimension line.

4.11 Annotation abbreviations
The abbreviation of words on project drawings shall be held to a minimum to ensure clarity and to lessen the chance that the abbreviated word could be misinterpreted. All abbreviations must be first approved by SEPTA’s Project Manager and should be described on Contract Drawings G01. When the cover is not used abbreviations and symbols should be described on drawings, A01, S01, C01, M01, or E01, as applicable. Graphic symbols and abbreviations shall be in accordance with, but not limited to the following:

(b) Structural Steel Detailing: AISC “Steel Construction Manual” and AISC “Structural Shop Drafting Text Book.”
(d) Mechanical Symbols: ASHRAE Standards accepted practice.
(e) Electrical Symbols: IEEE Standards and current accepted practice.
(f) Per the latest edition of “Architectural Graphic Standards” as published by the American Institute of Architects.
(g) U.S. Dept. of Defense Tri-Services Technology Center AEC CADD Standards release 1.4
(h) Architectural Graphics Standards as published by the AIA.

4.12 Linework
All linework shall be sufficient size, weight and clarity to be easily read from a print which has been reduced to one-half the size of the original drawing. Similar lines denoting a structural outline, a centerline, etc., shall have even thickness and uniformity whenever and wherever they are shown within a set of project drawings.

Line color is primarily used to improve the clarity of the drawing on the computer monitor. In AutoCAD it is common to use color to depict the desired lineweight on the plotted sheet.

Lineweight chart
For the best possible reproduction, linework shall be kept dense, clean and sharp. All linework must be kept separated to prevent its running together on a reproduction. In general, a drawing should consist of four line densities; heavy, medium, light, and extra light. However, light lines must not be too light or they will tend to disappear on the reproduction. Arrow heads must always be kept clear and plotted 3/32" or 3 mm and filled solid. Line weight densities shall be used to differentiate new, existing and demolition work per entity layer assignment. All drawings shall have layers by name, color, line weight, and line type, see CADD Layer Standards section for Layer - Linetype - Lineweight associations. All lettering and numbering must be kept clear of linework. Text and leaders must never be drawn through a dimension. AutoCAD standard linetypes must be used in all drawing work unless custom linetype files (.lin) extension are included with the electronic drawing package submittal.

<table>
<thead>
<tr>
<th>Color</th>
<th>Lineweight</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td>.003</td>
</tr>
<tr>
<td>YELLOW</td>
<td>.005</td>
</tr>
<tr>
<td>GREEN</td>
<td>.007</td>
</tr>
<tr>
<td>CYAN</td>
<td>.010</td>
</tr>
<tr>
<td>BLUE</td>
<td>.012</td>
</tr>
<tr>
<td>MAGENTA</td>
<td>.015</td>
</tr>
<tr>
<td>WHITE</td>
<td>.018</td>
</tr>
</tbody>
</table>

4.13 Standard Drawing Templates
SEPTA-standard AutoCAD templates are available through the Infrastructure Drafting Administrator.

Section 5.0 – Dimensions, Scale and Units of Measure

5.1 Architectural Dimensions
All Imperial architectural dimensions under one foot shall be in inches. All metric dimensions shall be in millimeters. Dimensions under 1 foot need not show the leading 0’ (Example 6 1/2") however, dimensions over 1 foot without an inch suffix must show following 0" (Example 1’ - 0”). Metric dimensions shall be indicated by the decimal characters without metric suffix (Example 100). When required, dimension in meters shall be indicated by a suffix identifier (Example 100 m).

5.2 Location of Dimensions
Dimensions shall be shown in one location of the drawings and referred to from other drawings if necessary for clarity. Particular care shall be taken to avoid use of unnecessary dimensions. Preferences should be made to placing dimensions above or to the left of the object being dimensioned.
5.3 Units of Measurement
All project drawings shall employ imperial (example: 4'-6 1/2") or metric system (example 800 mm) as determined appropriate by the SEPTA Project Manager and shall employ the same measurement convention throughout the drawings except Civil, Track and Survey information such as elevations, gradients and points on horizontal and vertical alignments. Refer to Chart 3 - “SEPTA Standard CADD Scale Factor Chart”

5.4 Spacing
All numerals and decimal points shall be properly spaced.

5.5 Scale
The basic scale used on each drawing shall be noted in the title block. On a drawing where various scales are used, the scale box of the title block shall read “AS NOTED,” and the scale of each view shall be shown directly below the title of the view, and shall be vertical capital letters 3/32" or 3 mm high. Scale bar graphs shall be included on all drawings for all scales used on the sheet. The bar graphics shall be located at the bottom right hand corner of each sheet above the title block.

5.6 Scale and Drawing Reductions
The scale for a drawing or a drawing view shall be selected to assure print clarity when it has been reduced to half-size or 11X17 versions of the original drawing, and to allow for reasonable space between views.

5.7 ‘Not-To-Scale’ Views
When an elevation, section or detail is shown schematically and it is not intended to specify the scale, the view shall be noted NTS under its title.

5.8 Rebar Size Designation
Center to center reinforcement spacing shall be specified with the inch abbreviation, (Example #4 at 18" or 2X6 @24"O.C.) or in metric designation if applicable.

5.9 Dimension Symbols
Arrow head shall be used at the ends of leader lines on contract drawings. Dots shall be used in conjunction with dimensioning of center lines. Ticks are commonly used on Architectural drawings.

\[\rightarrow\text{ Arrows}\]
\[\downarrow\text{ Dots}\]
\[\leftarrow\text{Ticks}\]

5.10 Dimension Size As Plotted
Size for dimensions symbols shall be:
(a) Arrow Head Width – 1/8"
(b) Dots - 3/32"
(c) Tick Height – 1/8"
(d) Dimension text height - 3/32"
(e) Extension line offset - 1/16"

In all metric applications, dimension graphic elements shall be 3 mm. Refer to Chart 3 - “SEPTA Standard Dimension Styles” clarification and options.

Section 6.0 – Layer Designations
The layer is the basic CADD tool for managing visual information. Layers allow for separation of graphic elements according to the design discipline they represent. Layers reduce drawing time and improve project coordination. The American Institute of Architects has established a prototype CADD layering model for use in the AEC environment. Adherence to this recognized and accepted format is an integral part of the EM&C CADD Standards.

6.1 AIA-derived formats
The Infrastructure CAD Standards are based on the AIA ‘Simplified’ Layer structure format modified as follows -

<table>
<thead>
<tr>
<th>Discipline Code</th>
<th>Discipline</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Architectural</td>
</tr>
<tr>
<td>M</td>
<td>Mechanical</td>
</tr>
<tr>
<td>C</td>
<td>Civil</td>
</tr>
<tr>
<td>S</td>
<td>Structural</td>
</tr>
<tr>
<td>E</td>
<td>Electrical</td>
</tr>
<tr>
<td>F</td>
<td>Fire Protection</td>
</tr>
<tr>
<td>P</td>
<td>Plumbing</td>
</tr>
<tr>
<td>L</td>
<td>Landscaping</td>
</tr>
<tr>
<td>G</td>
<td>General</td>
</tr>
<tr>
<td>N</td>
<td>New</td>
</tr>
<tr>
<td>E</td>
<td>Existing</td>
</tr>
<tr>
<td>P</td>
<td>Proposed</td>
</tr>
<tr>
<td>D</td>
<td>Demolition</td>
</tr>
<tr>
<td>Minor Group</td>
<td></td>
</tr>
<tr>
<td>- See Appendix</td>
<td></td>
</tr>
</tbody>
</table>

Additions to this list must be structured in a similar manner and be described in the written submittal provided with the drawing set. Any substantial deviation from the above format must be approved by the Infrastructure Drafting Administrator prior to submission of contract documents for review.

6.2 External Reference (XREF) Binding
All XREF drawings must be ‘bound’ to the parent drawing before submittal. Layer names from bound XREF drawings will be appended with the filename to the layer list. Submitted CADD drawings with dependent XREFs will be rejected.
Section 7.0 – Revisions and As-Built Drawings

7.1 Applicability
Any changes made prior to the printing of contract drawings will not be considered revisions. Contract drawings must include all of the information provided in the addenda issued during the bid process. Prepare additional contract drawings is necessary to include all graphical changes made during bid activity. Any changes made after the award of construction contracts will be considered as revisions unless specifically approved by the Project Manager or Drafting Administrator.

7.2 Title Block Revisions Section
In the revision section of the title block, the revision designation, the date of the revision and the initials of the approver shall be shown. The approver should be the individual whose seal appears on the drawings; in any event, he shall be a registered engineer or architect in the State of Pennsylvania. The approver shall be the project director of the design or his agent. The description of the revision shall be as complete as the space allows. The first revision shall be made on the lower line of the left revision box, followed by the second revision above it. Lettering criteria for miscellaneous descriptive notes shall apply for revisions.

7.3 Limits and Identification
A 3/8” triangle in which the revision designation is shown shall be placed on the drawing at the bottom of circle or enclose irregular area indicating extents of the revision. When another revision to the same sheet is required, the existing enclosed area shall be removed and a new area with triangle and numerical revision designation shall be added. The first triangle(s) shall remain to provide a continuous record. See figure shown below:

7.4 Issued-For-Bid Identification
A designation of 0 may be placed in the revision block along with the ‘Issued for Bid’ designation and date. All drawings in the bid set must be coordinated with this designation and date when Rev 0 is used.

7.5 After Award
When a Revision 0 designation is used, the second revision shall be revision 1 and subsequent revisions shall be identified by numerals in sequential order. Otherwise the first revision is always Revision 1. These revision marks or notations shall remain on the drawings showing where changes where made relating to the numbered revision.

7.6 Maintaining As-Built Drawings
When a change to contract drawings is made by change notice (Change order, bulletin, clarification, etc.) the revision shall be made to the contract drawings nonetheless at the same time to maintain an up-to-date status of the drawings. When the drawing is reissued at some later date, all revisions not previously identified shall be described with that issue is reissued at some later date, all revisions not previously identified shall be described with that issue.

7.7 Electronic Drawing Library
Physical ‘as-built’ drawings are considered representative of conditions and therefore must be treated as archival records. Archival records in the form of engineering drawing are scanned, information extracted and entered into the EM&C Digital Plans Room Electronic Library System. All ‘as-built’ drawings must be presented to the EM&C Drafting Administrator upon receipt by the Project Manager.
# Chart 1 - Scale Factor Standards

<table>
<thead>
<tr>
<th>Scale</th>
<th>Factor</th>
<th>3/32&quot;</th>
<th>1/8&quot;</th>
<th>3/16&quot;</th>
<th>X Scale</th>
<th>Insert Factor (1:1)</th>
<th>Setting</th>
<th>X Direction</th>
<th>Y Direction</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/32&quot; = 1'-0&quot;</td>
<td>348</td>
<td>144</td>
<td>36&quot;</td>
<td>48&quot;</td>
<td>72&quot;</td>
<td>1 = 304</td>
<td>348</td>
<td>0.0062041</td>
<td>348</td>
<td>1134'</td>
</tr>
<tr>
<td>1/16&quot; = 1'-0&quot;</td>
<td>192</td>
<td>72</td>
<td>18&quot;</td>
<td>24&quot;</td>
<td>36&quot;</td>
<td>1 = 192</td>
<td>192</td>
<td>0.0052083</td>
<td>192</td>
<td>567'</td>
</tr>
<tr>
<td>3/32&quot; = 1'-0&quot;</td>
<td>128</td>
<td>48</td>
<td>12&quot;</td>
<td>16&quot;</td>
<td>20&quot;</td>
<td>1 = 128</td>
<td>128</td>
<td>0.0078125</td>
<td>128</td>
<td>432'</td>
</tr>
<tr>
<td>1/8&quot; = 1'-0&quot;</td>
<td>96</td>
<td>36</td>
<td>9&quot;</td>
<td>12&quot;</td>
<td>15&quot;</td>
<td>1 = 96</td>
<td>96</td>
<td>0.0104166</td>
<td>96</td>
<td>288'</td>
</tr>
<tr>
<td>3/16&quot; = 1'-0&quot;</td>
<td>64</td>
<td>24</td>
<td>6&quot;</td>
<td>8&quot;</td>
<td>10&quot;</td>
<td>1 = 64</td>
<td>64</td>
<td>0.015625</td>
<td>64</td>
<td>216'</td>
</tr>
<tr>
<td>1/4&quot; = 1'-0&quot;</td>
<td>48</td>
<td>18</td>
<td>4.5&quot;</td>
<td>6&quot;</td>
<td>7.25&quot;</td>
<td>1 = 48</td>
<td>48</td>
<td>0.0208333</td>
<td>48</td>
<td>144'</td>
</tr>
<tr>
<td>3/8&quot; = 1'-0&quot;</td>
<td>32</td>
<td>12</td>
<td>3&quot;</td>
<td>4&quot;</td>
<td>5&quot;</td>
<td>1 = 32</td>
<td>32</td>
<td>0.03125</td>
<td>32</td>
<td>96'</td>
</tr>
<tr>
<td>1/2&quot; = 1'-0&quot;</td>
<td>24</td>
<td>9</td>
<td>2.125&quot;</td>
<td>3&quot;</td>
<td>3.75&quot;</td>
<td>1 = 24</td>
<td>24</td>
<td>0.0416666</td>
<td>24</td>
<td>72'</td>
</tr>
<tr>
<td>3/4&quot; = 1'-0&quot;</td>
<td>16</td>
<td>6</td>
<td>1-1/2&quot;</td>
<td>2&quot;</td>
<td>2.5&quot;</td>
<td>1 = 16</td>
<td>16</td>
<td>0.0625</td>
<td>16</td>
<td>48'</td>
</tr>
<tr>
<td>1&quot; = 1'-0&quot;</td>
<td>12</td>
<td>4.5</td>
<td>1-1/8&quot;</td>
<td>1.125&quot;</td>
<td>1.75&quot;</td>
<td>1 = 12</td>
<td>12</td>
<td>0.0833333</td>
<td>12</td>
<td>36'</td>
</tr>
<tr>
<td>1 1/2&quot; = 1'-0&quot;</td>
<td>8</td>
<td>3</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
<td>1.125&quot;</td>
<td>1 = 8</td>
<td>8</td>
<td>0.125</td>
<td>8</td>
<td>24'</td>
</tr>
<tr>
<td>3&quot; = 1'-0&quot;</td>
<td>4</td>
<td>1.5</td>
<td>3/8&quot;</td>
<td>1/2&quot;</td>
<td>5/8&quot;</td>
<td>1 = 4</td>
<td>4</td>
<td>0.25</td>
<td>4</td>
<td>12'</td>
</tr>
<tr>
<td>1&quot; = 1&quot;</td>
<td>1</td>
<td>0.375</td>
<td>3/32&quot;</td>
<td>1/8&quot;</td>
<td>3/16&quot;</td>
<td>1 = 1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>36&quot;</td>
</tr>
</tbody>
</table>

## Civil inch = foot

<table>
<thead>
<tr>
<th>Scale</th>
<th>Factor</th>
<th>3/32&quot;</th>
<th>1/8&quot;</th>
<th>3/16&quot;</th>
<th>X Scale</th>
<th>Insert Factor (1:1)</th>
<th>Setting</th>
<th>X Direction</th>
<th>Y Direction</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&quot; = 5'</td>
<td>60</td>
<td>22.5</td>
<td>5-3/4&quot;</td>
<td>7.5</td>
<td>9-3/8&quot;</td>
<td>1 = 60</td>
<td>60</td>
<td>0.0166666</td>
<td>60</td>
<td>180'</td>
</tr>
<tr>
<td>1&quot; = 10'</td>
<td>120</td>
<td>45</td>
<td>11-1/4&quot;</td>
<td>15&quot;</td>
<td>18-3/4&quot;</td>
<td>1 = 120</td>
<td>120</td>
<td>0.0083333</td>
<td>120</td>
<td>360'</td>
</tr>
<tr>
<td>1&quot; = 20'</td>
<td>240</td>
<td>90</td>
<td>22-1/2&quot;</td>
<td>30&quot;</td>
<td>37-1/2&quot;</td>
<td>1 = 240</td>
<td>240</td>
<td>0.0041666</td>
<td>240</td>
<td>720'</td>
</tr>
<tr>
<td>1&quot; = 25'</td>
<td>300</td>
<td>125</td>
<td>28-1/2&quot;</td>
<td>37.5&quot;</td>
<td>51-1/2&quot;</td>
<td>1 = 300</td>
<td>300</td>
<td>0.0033333</td>
<td>300</td>
<td>900'</td>
</tr>
<tr>
<td>1&quot; = 30'</td>
<td>360</td>
<td>135</td>
<td>33-3/4&quot;</td>
<td>45&quot;</td>
<td>56-1/4&quot;</td>
<td>1 = 360</td>
<td>360</td>
<td>0.0027778</td>
<td>360</td>
<td>1080'</td>
</tr>
<tr>
<td>1&quot; = 40'</td>
<td>480</td>
<td>180</td>
<td>45&quot;</td>
<td>60&quot;</td>
<td>75&quot;</td>
<td>1 = 480</td>
<td>480</td>
<td>0.0020833</td>
<td>480</td>
<td>1440'</td>
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<tr>
<td>1&quot; = 50'</td>
<td>600</td>
<td>225</td>
<td>56-1/4&quot;</td>
<td>75&quot;</td>
<td>93-3/4&quot;</td>
<td>1 = 600</td>
<td>600</td>
<td>0.0016666</td>
<td>600</td>
<td>1800'</td>
</tr>
<tr>
<td>1&quot; = 60'</td>
<td>720</td>
<td>270</td>
<td>67-1/2&quot;</td>
<td>90&quot;</td>
<td>112-1/2&quot;</td>
<td>1 = 720</td>
<td>720</td>
<td>0.0013888</td>
<td>720</td>
<td>2160'</td>
</tr>
<tr>
<td>1&quot; = 80'</td>
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<td>360</td>
<td>90&quot;</td>
<td>120&quot;</td>
<td>150&quot;</td>
<td>1 = 960</td>
<td>960</td>
<td>0.0010416</td>
<td>960</td>
<td>2880'</td>
</tr>
<tr>
<td>1&quot; = 100'</td>
<td>1200</td>
<td>450</td>
<td>112-1/2&quot;</td>
<td>150&quot;</td>
<td>187 1/2&quot;</td>
<td>1 = 1200</td>
<td>1200</td>
<td>0.0008333</td>
<td>1200</td>
<td>3600'</td>
</tr>
<tr>
<td>1&quot; = 1000'</td>
<td>12000</td>
<td>4500</td>
<td>112-1/2&quot;</td>
<td>150&quot;</td>
<td>187 1/2&quot;</td>
<td>1 = 12000</td>
<td>12000</td>
<td>0.0000833</td>
<td>12000</td>
<td>36000'</td>
</tr>
<tr>
<td>Dimension Style</td>
<td>ArrowDot</td>
<td>DotArrow</td>
<td>DotDot</td>
<td>Leader</td>
<td>SEPTA</td>
<td>Standard</td>
<td>Supp1</td>
<td>Supp2</td>
<td>SuppB</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>----------</td>
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</tr>
<tr>
<td><strong>Scaling</strong></td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Feature Scaling</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td><strong>Use Paper Space Scaling</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td><strong>Dimension Line</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Force Interior Dimensions</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><strong>Basic Dimension</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td><strong>Baseline Increment</strong></td>
<td>5/16&quot;</td>
<td>5/16&quot;</td>
<td>5/16&quot;</td>
<td>5/16&quot;</td>
<td>5/16&quot;</td>
<td>5/16&quot;</td>
<td>5/16&quot;</td>
<td>5/16&quot;</td>
<td>5/16&quot;</td>
<td></td>
</tr>
<tr>
<td><strong>Arrows</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>User</td>
<td>User</td>
<td>User</td>
<td>Dot</td>
<td>Arrow</td>
<td>Arrow</td>
<td>Arrow</td>
<td>Arrow</td>
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</tr>
<tr>
<td><strong>User Arrow</strong></td>
<td>Default</td>
<td>Default</td>
<td>Dot</td>
<td>Default</td>
<td>Default</td>
<td>Default</td>
<td>Default</td>
<td>Default</td>
<td>Default</td>
<td></td>
</tr>
<tr>
<td><strong>Separate Arrows</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<td>Dot</td>
<td>Default</td>
<td>Default</td>
<td>Default</td>
<td>Default</td>
<td>Default</td>
<td>Default</td>
<td></td>
</tr>
<tr>
<td><strong>Second Arrow</strong></td>
<td>Dot</td>
<td>Default</td>
<td>Dot</td>
<td>Default</td>
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<td>Default</td>
<td>Default</td>
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</tr>
<tr>
<td><strong>Tick Extension</strong></td>
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<td>0&quot;</td>
<td>0&quot;</td>
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<td>0&quot;</td>
<td>0&quot;</td>
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<td>REPORT OF TRACK MOVEMENT DUE TO SURFACING AND LINING</td>
</tr>
<tr>
<td>Report “D”:</td>
<td>THERMAL LOG FOR RAIL EXPANSION</td>
</tr>
<tr>
<td>Report “E”:</td>
<td>REPORT OF RAIL DEFECT/ FAILURE</td>
</tr>
<tr>
<td>Report “F”:</td>
<td>SPECIAL TRACK INSPECTION REPORT</td>
</tr>
</tbody>
</table>
§118.0 Continuous Welded Rail (CWR PLAN)

§118.1 Use

(a) CWR fabricated by an approved process may be laid without restriction in fully ballasted tracks.

(b) CWR may be laid across open deck bridges up to 100 feet in length where bridge ties are spaced with timber blocks between ties, provided that the following conditions are satisfied:

1. All ties and blocks are tightly jacked and fastened together with spacing bars secured by lag screws in at least every third tie.

2. Bridge ties are securely fastened to steel structure by means of hook bolts, tie anchors or other approved holding devices.

3. The bridge structure is properly anchored to abutments and piers to prevent any movement other than normal expansion.

4. CWR is anchored to the bridge ties in both directions in accordance with SMW-100 Part 2, §125.1 (f) , (g).

5. Approved resilient fastening systems shall be used on the running rails of all new bridge timber installations.

(c) After application, approved holding devices must be checked and re-tightened weekly, until ties have fully seated on top flanges of built up members.

(d) CWR may be installed through grade crossings. When CWR is installed through a grade crossing, no bolted joints will be permitted within the grade crossing.

§118.2 Connecting CWR

(a) CWR strings may be field butt welded by an approved method in all classes of track. When it is necessary to temporarily connect CWR strings, the rail should be at least 14' long.

(b) If it becomes necessary to apply joint bars temporarily, the end bolt hole in each rail must not be drilled to permit subsequent field welding.

(c) In the case of a bolted joint installed during CWR installation either of the following action shall be taken, within 60 days –

1. Weld the joint;

2. Install a joint with six bolts; or

3. Anchor every tie 200 feet in both directions from the point;
(d) In the case of a bolted joint in CWR experiencing service failure or a failed bar with a rail gap present, the track owner shall, within 60 days, perform one of the following actions –

(1) Weld the joint;

(2) Replace the broken bar(s), replace the broken bolts, adjust the anchors and, within 30 days, weld the joint;

(3) Replace the broken bar(s), replace the broken bolts, install one additional bolt per rail end, and adjust anchors;

(4) Replace the broken bar(s), replace the broken bolts, and anchor every tie 200 feet in both directions from the CWR joint; or

(5) Replace the broken bar(s), replace the broken bolts and reapply the anchors, add rail with provisions for later adjustment. Under no circumstances should rail be added when the rail temperature is below the temperature designated in section 118.4, without provision for later adjustment. If rail is added and not adjusted follow instructions under Part III – Record of Disturbance in CWR Territory.

CWR Joint Guide

A CWR Joint considered to be in "Good Condition"

Description:

- All bolts are tight.
- No bent bolts, loose, broken, missing or wrong type of bolt applied.
- No surface or crossties anomalies.
- No Excessive rail end batter
- No Excessive rail gap
- No Bent or broken bars

(e) When it is not intended to field weld, CWR strings are to be fastened to each other or to other rails with fully bolted rail joints.

(f) Field thermite welding shall not be performed within the limits of a highway grade crossing or open deck bridge.
(g) Only a power saw may be used to cut rails for field welding.

§118.3 Rail Anchoring
Each CWR string is to be anchored in accordance with Appendix “K” §125.1

§118.4 Rail Temperature
(a) A standard rail thermometer shall be used to measure the rail temperature of all CWR before it is laid in track. The thermometer should be laid on the base of the rail, close to the web shielded from direct rays of sun and left there long enough to determine the temperature accurately. All thermometers must be checked for accuracy.

(b) The desired rail laying temperature for rail outside of tunnels is 110° Fahrenheit. CWR outside of tunnels must be adjusted and anchored or fastened at rail temperatures between 95° and 120°F. Inside tunnels, CWR must be adjusted and anchored or fastened to a temperature approved by the Manager of Track Engineering.

(c) When the rail temperature is lower than 95° F, an approved rail expanding method must be used for adjusting the CWR.

(d) Where CWR has been anchored at a rail temperature below 95° Fahrenheit, but not adjusted for temperature, it should be adjusted as soon as conditions permit the rail to be properly anchored.

(e) The Supervisor installing CWR shall be responsible for recording the rail temperature at which each CWR string is anchored for all CWR laid or adjusted on CWR Report “D”.- Thermal Log for Rail Expansion as attached in appendices to this manual. They shall forward this information to the Director of Track Maintenance and retain a copy for his record for 1 year.

§118.5 Adjustment of CWR
(a) To adjust existing CWR when anchoring temperature was below 95° its length must be decreased in accordance with Paragraph “d” and then properly adjusted by expanding. To adjust CWR when the anchoring temperature was above 120°, it must be re-adjusted to 110° according to the requirements of this part. The closure of any gap must be made by installing a buffer rail in accordance with §118.2.

(b) If during the anchoring process of a string, the rail temperature rises above 120°, but is less than 125°, anchoring can be completed on the string and the temperature documented on the thermal adjustment
form. No additional strings may be anchored until the rail temperature falls within the required range.

(c) If during the anchoring process of a string, the rail temperature rises above 125°F, it must be re-adjusted according to the requirements of this part.

(d) The number of inches by which a segment of CWR should be adjusted may be calculated by taking the difference between the actual rail temperature at time of adjustment and desired rail temperature, multiplying that difference in degrees Fahrenheit by the length of the CWR in feet, and multiplying the product by 0.000078. For example, to adjust a 1600’ length of CWR, anchored at a rail temperature of 70°F to correspond to the length of this rail at 110°F, subtract 70°F from 110°F to obtain a difference of 40°F and then multiply as follows:

\[
(T_d - T_a) \times L \times E_s = A
\]

Where:

- \(T_d\) = Desired rail temperature in degrees Fahrenheit (110°F outside of tunnels)
- \(T_a\) = Actual rail temperature in degrees Fahrenheit
- \(L\) = Length of rail in feet
- \(E\) = 0.000078 coefficient of expansion for rail steel
- \(A\) = Adjustment in inches

Example:

\[
T_d = 110°F \\
T_a = 70°F \\
L = 1600’
\]

\[
(110°F - 70°F) \times 1600’ \times 0.000078 = A
\]

\[
40°F \times 1600’ \times 0.000078 = +5\text{ inches}
\]

A table of calculated Adjustment values is provided on the next page
<table>
<thead>
<tr>
<th>Temperature Differential in °F from PRLT</th>
<th>400'</th>
<th>600'</th>
<th>800'</th>
<th>1000'</th>
<th>1200'</th>
<th>1400'</th>
<th>1600'</th>
<th>1800'</th>
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<tbody>
<tr>
<td>70</td>
<td>2 - 3/16</td>
<td>3 - 1/4</td>
<td>4 - 3/8</td>
<td>5 - 1/2</td>
<td>6 - 9/16</td>
<td>7 - 11/16</td>
<td>8 - 1/4</td>
<td>9 - 13/16</td>
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<tr>
<td>65</td>
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<td>3 - 1/16</td>
<td>4 - 1/16</td>
<td>5 - 1/16</td>
<td>6 - 1/8</td>
<td>7 - 1/8</td>
<td>8 - 1/8</td>
<td>9 - 1/8</td>
</tr>
<tr>
<td>60</td>
<td>1 - 7/8</td>
<td>2 - 13/16</td>
<td>3 - 3/4</td>
<td>4 - 11/16</td>
<td>5 - 9/16</td>
<td>6 - 9/16</td>
<td>7 - 1/2</td>
<td>8 - 7/16</td>
</tr>
<tr>
<td>55</td>
<td>1 - 11/16</td>
<td>2 - 9/16</td>
<td>3 - 3/8</td>
<td>4 - 5/16</td>
<td>5 - 3/16</td>
<td>6</td>
<td>6 - 7/8</td>
<td>7 - 3/4</td>
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<tr>
<td>50</td>
<td>1 - 9/16</td>
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<td>6 - 3/8</td>
</tr>
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<td>3 - 3/4</td>
<td>4 - 3/8</td>
<td>5</td>
<td>5 - 5/8</td>
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<td>1 - 1/4</td>
<td>1 - 9/16</td>
<td>1 - 7/8</td>
<td>2 - 3/16</td>
<td>2 - 1/2</td>
<td>2 - 13/16</td>
</tr>
<tr>
<td>15</td>
<td>7/16</td>
<td>11/16</td>
<td>15/16</td>
<td>1 - 1/8</td>
<td>1 - 7/16</td>
<td>1 - 11/16</td>
<td>1 - 7/8</td>
<td>2 - 1/8</td>
</tr>
<tr>
<td>10</td>
<td>5/16</td>
<td>1/2</td>
<td>5/8</td>
<td>13/16</td>
<td>15/16</td>
<td>1 - 1/8</td>
<td>1 - 1/4</td>
<td>1 - 7/16</td>
</tr>
</tbody>
</table>

Based on Young's Modulus – Coefficient of Steel Expansion = 0.00078

Continuous Welded Rail Adjustment Table
§118.6 Adjustment by Heating, Natural Temperature Changes or Mechanical Expansion

(a) Rail may be expanded in the tie plates before or after spiking, but must be adjusted before it is anchored. All rail anchors, clips, and insulators must be removed from strings of CWR requiring adjustment to permit the desired expansion or contraction.

(b) The number of inches each CWR string should be adjusted during the rail laying or adjusting operation may be determined by calculation according to §118.5(d).

(c) Prior to removing anchors or clips, a space equal to the amount of expansion needed for each string of CWR should be provided between the end of that string and the near end of the next adjacent string. A minimum of 200’ should be box anchored or clipped on the near end of the adjacent string to hold it in place and avoid closing the expansion gap of the string being heated. Two fully clipped ties will be considered the same as a box anchored tie.

(d) Tie plates, on wood crosstie track, should be tapped with hammer or approved mechanical device used to free the rail.

(e) On concrete crosstie track, lightly tap with an approved brass hammer the head of the field side of the rail or use an approved mechanical device to free the rail.

(f) Uniformity of expansion is to be controlled by marking each quarter of the string and introducing expansion as follows:

- 1/4 point - 1/4 of total required expansion
- 1/2 point - 1/2 of total required expansion
- 3/4 point - 3/4 of total required expansion

(1) Quarter points should be marked with a continuous line from the base of rail to the tie plate, or shoulder of concrete tie so the amount of expansion can be accurately determined. The reference point must be one that will not move as rail expands.

(g) CWR should be heated so that expansion is introduced from one end of each string to the other. Heat should be steadily applied while moving forward until the required expansion has been obtained at the end of the string. In the event any quarter point does not have the required expansion, the heater will back over that portion (without applying heat), and then reheat the rail until the necessary expansion is obtained.
(h) As adjusting is progressed, a minimum of 4 ties should be boxed or fully clipped per 39’ of rail to prevent the rail from losing adjustment.

(i) At the end of the completely expanded string, a minimum of 20 ties should be box anchored or fully clipped immediately after the gap is closed, to hold the expansion.

(j) The maximum length of CWR to be adjusted will be in accordance with Engineering Practices.

(k) CWR is to be anchored in accordance with SMW-100 Part 2 §125.1.

§118.7 Maintaining CWR

(a) The following kinds of maintenance operations do not constitute disturbing the track structure:

(1) Cleaning ballast in the ballast shoulders or in the inter-track spaces, using Speno or comparable types of ballast cleaning equipment, provided that a full ballast section is restored in accordance with AREMA Fig. 2-1, with a minimum ballast shoulder width of 12 inches, immediately behind the ballast cleaning operation.

(2) Spot tie renewals (4 or less per 39’ of track) where there are 4 adjacent ties on each side of the tie to be replaced that are properly spiked, fastened and tamped, with rail anchors in prescribed positions, and the tie cribs and shoulders properly filled with ballast. The new ties must be promptly tamped, and the ballast properly dressed.

(3) Smoothing (spot surfacing) and lining where not more than 5 consecutive ties are lifted from their tie beds, and not more than 5 ties are lifted in any 39’ length of track.

(b) Work which disturbs the track structure can only be performed as follows and in accordance with Track Buckling Countermeasures Policy:

(1) Out Of Face Tie Renewal

(i) When renewing ties out of face not more than 3 successive ties nor more than 8 ties per 39-foot length of track are to be renewed in any one pass. If more ties than the above need to be renewed, additional passes must be made.

(ii) Before track is returned to maximum authorized speed, ties installed should have all fastener and components applied, tamped, and a standard ballast section restored.
(2) Out Of Face Lining/Surfacing

(i) When raising CWR track, the extent of raise should be kept to the minimum necessary to obtain a good surface, but should not exceed a general raise of 1-1/2 inches. If a higher raise is needed to meet a required profile, additional passes should be made.

(ii) Both rails should be raised simultaneously in CWR track, and the cross level maintained at all times. Raising track without fully tamping all ties should be avoided.

(3) Any other operation that disturbs the ballast section.

(c) Adjustment of disturbed track should be made in accordance with Sections 118.5 and 118.6 of this manual.

§118.8 CWR Track Buckling Countermeasures
PART I - INTRODUCTION

(a) SEPTA, by nature of its passenger operation cannot tolerate the risk of buckled track. Buckled track is the result of some deficiency in the track structure or track maintenance procedure such as misalignment, substandard ballast section, loss of neutral temperature, rail anchor deficiency, etc. A properly constructed and maintained section of track will not buckle from thermal loading during normal seasonal variations of temperature.

(b) The operations of the Track Department in its construction and maintenance activities have complete control over the first five critical items and substantial influence over the sixth. If track buckling is to be prevented, all six items must be controlled and maintained within standards. Effective protective action must be taken when conditions are present which take any of these critical items out of standards.

Track Curvature
Curved track is more prone to buckling than tangent track. As curvature is increased the temperature at which a track will buckle is decreased.

Alignment Deviation
Any alignment deviation significantly reduces the temperature at which a track will buckle. As an example, a deviation increase from 1” to 1 1/2” may reduce the buckling temperature by as much as 40ºF.
Rail Neutral Temperature

(a) Shifts in rail neutral temperature are hard to detect and measure. Shifts of 30ºF to 40ºF from the established neutral temperature for a track can be critical and lead directly to buckling. Factors influencing rail neutral temperatures shifts are:

(1) Improper rail installation.
(2) Inadequate rail anchors/clips.
(3) Lateral movements in curves through lining operations.
(4) Skeletonized track.
(5) Inadequate ballast section.

Lateral and Longitudinal Restraint

Insufficient ballast section and/or compaction may result in a reduction in lateral restraint. Insufficient ballast section and/or compaction; insufficient number, defective, and/or misapplied anchors; and missing, defective, and/or misapplied pandrol clips may result in a reduction in longitudinal restraint. The above items, if allowed to exist in deficient conditions, may produce a potential for buckled track.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Temperature Condition</th>
<th>Potential Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undercutting Cribbing</td>
<td>Above Neutral Temperature</td>
<td>Potential buckling immediately or shortly after completion.</td>
</tr>
<tr>
<td>Surfacing</td>
<td>Below Neutral Temperature</td>
<td>Contributes by allowing track movement in curve territory, lowering neutral temperature with potential for buckling next hot season.</td>
</tr>
</tbody>
</table>

Dynamic Train Loading

(a) Studies indicate that buckling occurs under the train. Therefore train loading of the track structure plays a role in the buckling of track. There are a number of ways in which the dynamic train loads influence track buckling. These items must be recognized when planning and executing track work.
(1) Train induced uplift of the track structure can cause a large reduction in buckling temperature.

(2) High L/V ratios accelerate the growth of alignment deviations.

(3) Braking and traction forces result in additional compressive forces in the track.

(b) The track buckling countermeasures establish procedures and controls to minimize the possibility of Maintenance of Way track operations adversely affecting the track structure to produce a potential for buckling.

(c) The following is a brief description of the relationship of various Maintenance of Way activities to the critical items influencing track buckling, with the potential result if executed out of standards.

**PART II - TRACK WORK METHOD AND CRITERIA**

To establish and maintain a neutral temperature in CWR territory that will prevent buckled track, the following work methods and restrictions will be adhered to.

**Installing CWR**

All CWR must be installed in accordance with the guidelines presented in this manual. To install CWR at a final temperature other than that specified (110ºF), written approval must be obtained from the Manager of Track Engineering. This approval will specify track number, milepost, location, and protective action.

**Installing Rail Plugs in CWR Territory**

When it is necessary to install rail plugs in CWR territory, the Supervisor must assure the amount of rail installed, including the welds, is equal to or less than the length of rail removed. If the requirements of this section "cannot" be met, the Supervisor in charge must accurately complete the information required by, Report (A) Part 2-"Rail Cut in CWR Track", as attached in Appendix "A" to this manual, and report to the Assistant Director of Track Maintenance. In addition, the Supervisor must place a 30 MPH speed restriction on the affected portion of track until corrected.

**Field Welding Without Rail Plug Installation**

Field Welds must be made in accordance with the established procedures. When field welding CWR which has been temperature adjusted and whose present rail temperature is less than the neutral temperature, the necessary gaps for each weld will not be developed by allowing the rails to contract. It is critical that no additional rail is added.
Undercutting, Out of Face Surfacing and Lining, Out of Face Tie Renewal

The above operations will be performed at rail temperatures greater than 30ºF. To perform work at less than 30ºF rail temperatures, approval must be obtained from the Manager of Track Engineering or designee. This approval will address track number, milepost, location, and protective action.

Panel Turnout or Panel Track Installation in CWR Territory

(a) The installation of panel turnout track in CWR territory must be done in accordance with the guidelines presented in this manual. It is essential that there is no net addition of rail to the track upon completion of the panel installation. The expansion must be to the CWR string being connected to meet the rail of the last panel installed.

(b) If the requirement of this section “cannot” be met, the Supervisor in charge must accurately complete the information required in Report (A) Part 2 of the procedure under “Rail Cut in CWR Track” and report to the Assistant Director of Track Maintenance section. In addition, the Supervisor must place a 30 MPH speed restriction on the affected portion of track until corrected.

Cut and Throw Track

When CWR track is cut and thrown at less than 95ºF or more than 125ºF rail temperature, it will be considered to have lost its temperature adjustment and will have to be readjusted in accordance with with the guidelines presented in this manual.

Curve Realignment (Out-of-Face)

(a) Supervisor in charge of surfacing and lining through curved tracks must follow all procedures and accurately complete the information required in Report B of the appendices to this manual.

(b) Curves will be considered to have lost their temperature adjustment and will have to be adjusted in accordance with this manual when they are realigned out-of-face (shifting a curve consistently in one direction at all throw points) in the following amounts:

<table>
<thead>
<tr>
<th>Curves</th>
<th>More than 6” to the Outside</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 2º</td>
<td>More than 3” to the Inside</td>
</tr>
<tr>
<td>Curves 2º and Over</td>
<td>More than 3” to the Outside</td>
</tr>
<tr>
<td></td>
<td>More than 3” to the Inside</td>
</tr>
</tbody>
</table>
(c) The normal balancing of throws done during out-of-face surfacing operations does not constitute out-of-face realignment.

PART III - RECORD OF DISTURBANCE IN CWR TERRITORY

Purpose
To maintain a record of any disturbance of track in CWR territory which can cause a downward shift in the desired rail installation temperature range of continuous welded rail. This downward shift of desired rail installation temperature range can occur when any of the following operations are conducted below the established desired rail installation temperature range:

(a) Undercutting
(b) Out-of-face tie replacement
(c) Out-of-face surfacing
(d) Field Welding
(e) Rail replacement
(f) Anchor removal or clip removal (more than 8 ties per 39’ section of rail)
(g) Cribbing operations (in excess of 8 cribs per 39’ section of rail)
(h) Panel track installation
(i) Panel turnout installation
(j) Cutting and throwing of track

Report of Track Disturbance - (Report ‘A’)

(a) The “Track Disturbance Report” (Report A) with instructions is found in Appendix “A” to this manual. When this report is completed one copy will be forwarded to the Director of Track Maintenance, and one copy shall be retained by the Supervisor in charge of the operation for his records.

(b) Part 1 of Report ‘A’ must be completed by the supervisor in charge when any of the above operations are not conducted in accordance with Part II of this policy.

(c) Part 2 of Report ‘A’ will be completed whenever CWR track is cut or broken for any reason and the requirements of Part II are not met.

Report of Track Movement Due to Surfacing and Lining-(Report ‘B’)

For track receiving out-of-face surfacing and lining, a Report ‘B’- “Track Movement Due to Surfacing Report”, will be made for each curve worked. This report will be
completed by the Supervisor in charge of the operation, with one copy forwarded to the Assistant Director of Track Maintenance and one copy retained by the Supervisor in charge of the operation for his records. The “Track Movement Due to Surfacing Report” with instructions is found Appendix “A” of this manual.

PART IV – SPECIAL INSPECTIONS

Special Inspection in Hot Weather-“Heat Patrol” (Report “F”)

(a) Every calendar year heat patrols will be conducted for the first five (5) days that the air temperatures exceed 90°F. If no heat disturbances are identified during the first five (5) days when the air temperature exceeds 90°F, further heat patrols will not be required until the air temperature reaches or exceeds 95°F. If heat disturbances are identified, the heat patrols will be required over the affected area when air temperatures exceed 90°F until five (5) days of 90+°F are experienced without further disturbance. The Track Inspector will make out a Special Track Inspection Report “F” for this inspection and submit it to the Assistant Director of Track Maintenance. During this inspection, the Track Inspector must be particularly alert for wavy track, longitudinal rail movement, kinked joints in compression and evidence of lateral track movement. The Track Inspector must also be aware that the following conditions increase the possibility of buckling:

1. Recently worked track (within 7 days)
2. Mud spots
3. Existing deviations in line and surface
4. Fixed facilities (i.e., turnouts, road crossings, bridges, etc.)
5. Substandard ballast section
6. Substandard anchor pattern
7. Missing pandrol clips

(b) If any track is identified as having any conditions, which indicate the possibility of buckling, immediate protective action must be taken in the form of a speed restriction or removal from service, depending on severity. A special track inspection, Report “F” must be submitted for each line inspected. Additionally, if during a special track inspection an adverse track disturbance is identified, the track inspector will also submit a Track Disturbance, Report “A” for tracking adherence to SEPTA Track Buckling Countermeasures.
Special Inspection in Cold Weather-(Report ‘F’)

SEPTA’s mainline tracks all incorporate signal circuits that utilize the continuity of the rail to determine the presence of trains. When the continuity of the rail is broken, such as when a rail breaks or a joint fails, the signal system displays its most restrictive indication. In cold weather, this is typically how broken rails and pull aparts are detected. However, this system is not “fool proof.” If metal to metal contact is maintained across the break or pull apart, which may result if the break occurs over a tie plate or if the joint bars remain in contact, the defect will not be detected.

(a) Every calendar year, special inspections will be conducted when cold weather is expected to drop below 15° F. Areas that are identified on Track Buckling Countermeasures Report “A” or Report “B” shall be considered Pull Apart Prone Areas, and subject to Special Inspections.

(b) The Track Inspector will fill out a Special Track Inspection Report “F” for this inspection and submit it to the Assistant Director of Track Maintenance. During this inspection, the Track Inspector must be particularly alert for rail pull-aparts, gapped joints and evidence of any longitudinal track movement associated with track in tension.

(c) Special Inspections for cold weather shall be conducted every 72 hours over the Pull Apart Prone Area until the minimum temperature exceeds 15 degrees F.

(d) All inspections shall be conducted by persons fully qualified under SMW-100 - Part 1, Section 213.7 to inspect track and prescribe remedial actions to correct or safely compensate for any deviations detected.

PART V –PROTECTIVE AND CORRECTIVE ACTION

Procedures for Making Repairs to Sun Kinks

(a) If the rail temperature is between 95 and 120 degrees Fahrenheit, the adjusting of the rail can be completed by means of natural thermal expansion according to the following procedure.

(1) Cut both rails with a torch at the location of maximum displacement, after lining the track sufficiently to insure that all pressure has been removed, in order to prevent the possibility of the track reacting rapidly when it is cut. If the displaced area is near a joint, then the joint bars should be removed.
(2) Line track back to proper location allowing the cut ends to bypass each other.

(3) Particular attention must be paid to insure that the rail does not bind on tie plates, spikes or other obstructions. Unclip rails, remove any rail anchors and tap tie plates with sledge hammers, as necessary, to obtain free rail movement 200’ in each direction from the location where the rails are cut.

(4) In order to insure that the expansion is made uniformly throughout the rail being adjusted, mark the rail every 50’ for 200’ in each direction of the location where the rails have been bypassed, in order to properly adjust the rail.

(5) After determining that proper expansion has been attained throughout the 400’ of rail, the clips and/or anchors can be reapplied. Start applying the clips and/or anchors at the point 200’ from the location where the rails are bypassed and work towards that area. At each of the points marked on the rail, be certain that the expansion is being made uniformly throughout the rail. All anchors must be reapplied properly and installed tightly against the ties.

(6) Cut off excess rail at free ends and reconnect rails.

(7) Supervisor in charge shall fill out Report ‘C’

(b) If the rail temperature is **less than 95 degrees** the rail must be heated to obtain the proper adjustment. The procedures to be followed for preparing the rail for adjustment are the same as outlined above for adjusting rail at temperature between 95 and 120 degrees with the addition of the following procedures.

(1) The rail must be heated from the point 200’ from the location where the rails are bypassed and the anchors reapplied to hold the expansion as the heater moves toward the rail bypass point.

(2) Care must be exercised to insure that the rail is heated to a minimum of 95 degrees before the anchors are reapplied.

(3) If the rail temperature is less than 95 degrees and it is not possible to adjust it immediately to that temperature by heating, the following protective actions shall be taken after correcting the tracks according to the procedures outlined in paragraph (a) of this section:

   (i) The area adjusted will be protected by a maximum 10 M.P.H. speed restriction until
the rail is adjusted to the correct temperature range with or without heating.

(c) Supervisor in charge shall complete and submit Report ‘A’ Part 2 as required by §118.1 Part III of this manual upon the completion of the work

Out-Of-Face Surfacing or Lining - For existing wood tie track

(a) Track must be inspected by supervisor of the operation prior to returning track for service.

(b) First train will operate at 10MPH over work area.

(c) After the first train the supervisor of the operation will patrol the affected area to assure no deficiencies, such as misalignments, exist which would adversely affect the safe passage of trains.

(d) After requirements of paragraphs (a), (b), and (c) above have been met, track will be restricted as follows:

1. **30-MPH speed restriction** for a 24-hour period and passage of 12 trains for track *not* worked with a Crib and Shoulder Compactor.

2. **60-MPH speed restriction** for a 24-hour period and the passage of 12 trains for track worked with a Crib and Shoulder Compactor.

(e) After all above requirements in paragraphs (a) thru (d) have been fulfilled and the work area has been re-inspected by a designated qualified employee, the track may be returned to normal speed.

(f) Once track has been returned to normal speed and the requirements of the above paragraphs (a) thru (e) have been fulfilled, the disturbed track must be patrolled for the next 5 days that the air temperature exceeds 90 degrees Fahrenheit:

1. If the air temperature exceeds 90 degrees Fahrenheit within 7 calendar days of the disturbance the track inspection must be done on foot. If no disturbances are found these days may be counted towards the (5) occurrences required to move to the 95 degree trigger requiring heat patrol.

2. In any event after 7 calendar days have elapsed, the heat patrols may be conducted from the front end of revenue equipment.

Spot surfacing or lining operations will be protected as follows - For existing wood tie track

(a) Up to ten feet - no protection required.
(b) When the air temperature is not expected to exceed 80ºF for a 24 hour period after work, the following spot surfacing or lining operations may be conducted with the protection prescribed below:

(1) Eleven to forty feet - No protection required.

(2) Forty-one to two hundred feet - 60 MPH speed restriction for 12 trains and 24 hours.

(c) When the air temperature exceeds 80ºF in a 24 hour period after the work, the following spot surfacing or lining operations may be conducted with protection prescribed below:

(1) Eleven to two hundred feet - 30 MPH speed restriction for 12 trains and 24 hours.

Example: If the air temperature exceeds 80ºF in the 24-hour period following the work and until 24 hours and 12 trains have passed, then a 30-MPH speed restriction must be immediately applied. A designated qualified employee will make a ground inspection of the work area prior to returning the track to scheduled speed to determine that no deficiencies exist in the track structure that will prevent the safe passage of trains at scheduled speed (i.e. full ballast section, proper anchoring, etc.).

Out-of-Face Surfacing and Lining within Interlocking Limits - Switch Tamper

(a) For existing wood tie track within the limits of an interlocking:

(1) Track must be inspected by the 213.7 qualified inspector prior to returning track for service.

(2) First train will operate at 10-MPH.

(3) After the first train the 213.7 qualified inspector will perform an inspection to assure no deficiencies (i.e. misalignments, ballast section, anchoring, etc.) exist which would adversely affect the safe passage of train.

(b) Following (1), (2), and (3) above, track will be restricted as follows:

(1) 30-MPH speed restriction for a 24-hour period and the passage of 12 trains if air temperature exceeds 80ºF within the 24-hour period.

(2) 60-MPH speed restriction for a 24-hour period and the passage of 12 trains if air temperature will not exceed 80ºF within the 24-hour period.

(c) After (b) above and work area has been re-inspected by designated qualified employee, the track may be returned to normal speed.
Protective Speed restriction After Undercutting and Out-of-face Tie Renewal

(a) A 30-MPH protective speed restriction will be applied after out-of-face undercutting or tie renewal for a period of 24 hours and a minimum of 12 trains over the affected track.

(b) The disturbed track must be patrolled for the next 5 days that the air temperature exceeds 90 Degrees Fahrenheit.

(c) If the temperatures exceed 90 degrees Fahrenheit within 7 calendar days of the disturbance the track inspection must be done on foot. If no disturbances are found these days may be counted towards the (5) occurrences required to move to the 95 degree trigger requiring heat patrol. In any event after 7 calendar days have elapsed the heat patrols may be conducted from the front end of revenue equipment.

PART VI - TRAIN VERIFICATION

The designated qualified employee involved with removal or upgrading of a speed restriction will verify by conversation with the train dispatcher that the required amount of trains has passed over the track.

PART VII - GENERAL SPEED RESTRICTIONS AND SUSPENSION OF WORK

(a) See, also System Special Instructions, F-S1- Unusual Operating Conditions - A. Excessive heat operations, for general speed restrictions during hot weather.

(b) The following work will be suspended when the air temperatures are expected to be 95ºF or above during a 24 hour period.

(1) Out-of-Face Surfacing or Lining

(2) Spot Surfacing or Lining (From 11:00AM to 8:00PM)

(3) Tie Renewal and Undercutting (Except under a continuous track outage)

PART VIII - WORKING UNDER A CONTINUOUS TRACK OUTAGE

When undercutting, renewing ties out-of-face, and other work which disturbs the ballast is in progress under a continuous track outage, and it is expected that the air temperature will be 95ºF or above at the time track is returned to service, the 30 MPH speed restriction will remain in effect until seven (7) days and seven (7) days of
traffic have operated over affected track or until the air temperature drops below 95ºF.

PART IX - PROTECTION OF WORK AREAS FOR LATENT EFFECT

Track which has been worked within seven (7) days prior to the onset of high heat (95ºF) will be reduced to the speed restriction required under Part V of this policy until seven (7) days and seven (7) days of traffic has been over the affected track or the air temperature drops below 95ºF. The protective speed restriction of 50 mph will only be in effect during the period of the day that the air temperature is 95ºF or above.

PART X – CWR JOINT INSPECTION

(a) All rail joints in CWR Track shall be inspected in accordance with the schedule prescribed in paragraph (d) of this section by qualified employees designated under 213.7.

(b) Each inspection shall be made on foot by a person making a visual observation of the rail connection, including: joint bars, bolts, ties, rail fastening, ties and ballast section.

(c) Inspection records shall indicate the limits of the tracks inspected, the location of any joints exhibiting pull apart conditions or defects. Records shall also indicate remedial or corrective actions taken.

(d) Each inspection of CWR rail joints shall be made in accordance with the schedule found on the following page:
<table>
<thead>
<tr>
<th>Class of Track</th>
<th>Freight trains operating over track with an annual tonnage of:</th>
<th>Passenger trains operating over track with an annual tonnage of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less than 40 mgt</td>
<td>40 to 60 mgt</td>
</tr>
<tr>
<td>5 &amp; above</td>
<td>2</td>
<td>3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
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<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<sup>a</sup> Where a track owner operates both freight and passenger trains over a given segment of track, and there are two different possible inspection interval requirements, the more frequent inspection interval applies.

<sup>b</sup> When extreme weather conditions prevent a track owner from conducting an inspection of a particular territory within the required interval, the track owner may extend the interval by up to 30 calendar days from the last day that the extreme weather condition prevented the required inspection.

Where:

4 = Four times per calendar year, with one inspection in each of the following periods: January to March, April to June, July to September, and October to December; and with consecutive inspections separated by at least 60 calendar days.

3 = Three times per calendar year, with one inspection in each of the following periods: January to April, May to August, and September to December; and with consecutive inspections separated by at least 90 calendar days.

2 = Twice per calendar year, with one inspection in each of the following periods: January to June and July to December; and with consecutive inspections separated by at least 120 calendar days.

1 = Once per calendar year, with consecutive inspections separated by at least 180 calendar days.
(e) Consistent with any limitations applied by the track owner, a passenger train conducting an unscheduled detour operation may proceed over track not normally used for passenger operations at a speed not to exceed the maximum authorized speed otherwise allowed, even though CWR joints have not been inspected in accordance with the frequency identified in paragraph (d) of this section, provided that:

(1) All CWR joints have been inspected consistent with requirements for freight service; and;

(2) The unscheduled detour operation lasts no more than 14 calendar days. In order to continue operations beyond the 14 day period, the track owner must inspect the CWR joints in accordance with the requirements of paragraph (d) of this section.

(f) Tourist, scenic, historic, or excursion operations, if limited to the maximum authorized speed for passenger trains over the next lower class of track, need not be considered in determining the frequency of inspections under paragraph (d) of this section.

(g) All CWR joints that are located in switches, turnouts, track crossings, lift rail assemblies or other transition devices on moveable bridges must be inspected on foot at least monthly, consistent with the requirements in SMW-100 - Part 1, §213.235; and all records of those inspections must be kept in accordance with the requirements in SMW-100 - Section 1, §213.241 that contributes to the instability of the joint.

(h) Evidence of excessive longitudinal rail movement in or near the joint, including but not limited to, wide rail gap, defective joint bolts, disturbed ballast, surface deviations, gap between the plates and rail, or displaced rail anchors.

(i) Corrective actions for conditions found shall be taken in accordance with the following requirements as found in SMW 100 Part 1:

(1) Joint bars - Section 213.121
(2) Bolts - Section 213.121
(3) Track Gage - Section 213.53
(4) Track Surface - Section 213.63
(5) Ballast - Section 213.103
(6) Crossties - Section 213.109

(j) The inspector shall report conditions for which no single criteria exceeds inspection criteria, but the combination of factors may be indicative of imminent
joint failure. Joints identified as such shall be re-inspected monthly until the conditions are corrected.
Adjusting / Destressing - The procedure by which a rail’s temperature is re-adjusted to the desired value. It typically consists of cutting the rail and removing rail anchoring devices, which provides for the necessary expansion and contraction, and then re-assembling the track.

Annual Retraining - Training every calendar year.

Braking Force - The longitudinal force induced into the rail as a result of brake application of a train.

Buckling incident - The formation of a lateral misalignment sufficient in magnitude to constitute a deviation from the Class 1 requirements specified in §213.55. These normally occur when rail temperatures are relatively high and are caused by high longitudinal compressive forces.

Buckling – Prone Condition - A condition when the actual rail temperature is above the actual rail neutral temperature. This varies given the geographical composition of the track.

Continuous welded rail (CWR) - Rail that has been welded together into lengths exceeding 400 feet. Rail installed as CWR remains CWR, regardless of whether a joint or plug is installed into the rail at a later time.

Corrective actions - Those actions which track owners specify in their CWR plans to address conditions of actual or potential joint failure, including, as applicable, repair, restrictions on operations, and additional on-foot inspections.

CWR Joint - Any joint directly connected to CWR.

Prescribed Rail Laying Temperature (PRLT) - The rail temperature range, within a specific geographical area, at which forces in CWR should not cause a buckling incident in extreme heat, or pull apart during extreme cold weather.

Disturbed track - The disturbance of the roadbed or ballast section, as a result of track maintenance or any other event, which reduces the lateral or longitudinal resistance of the track, or both.

Dynamic Train Loading - Forces which are imparted to the track structure during the passing of a train due to wheel action and vehicle response.

Established Neutral Temperature - The temperature at which rail is secured in a stress free condition.
L/V Ratio - The relationship of lateral force on the rail to the vertical force on the rail which is produced by the wheel of the train.

Lateral Resistance - The ability of the track structure to remain in position under the influence of forces which are generated in a plane perpendicular to the line of the rail. Lateral resistance is a product of interaction of the ballast with the sides, bottom, and end face of the tie.

Longitudinal Resistance - The ability of the track structure to remain in position under the influence of forces which are generated in a plane which is parallel to the line of the rail.

Longitudinal Resistance – A product of the interaction of the ballast, the tie body, rail anchor / grip or pandrol clip toe load.

Mechanical stabilization - A type of procedure used to restore track resistance to disturbed track following certain maintenance operations. This procedure may incorporate dynamic track stabilizers or ballast consolidators, which are units of work equipment that are used as a substitute for the stabilization action provided by the passage of tonnage trains.

Out of Face Tie Renewal - Tie replacement at a rate of more than four (4) ties per 39’ of rail.

Out of Face Surfacing or Lining - Surfacing and/or lining a continuous piece of track in excess of 200 feet.

Pull apart or stripped joint - A condition when no bolts are mounted through a joint on the rail end, rendering the joint bar ineffective due to excessive expansive or contractive forces.

Pull-apart prone condition - A condition when the actual rail temperature is below the rail neutral temperature at or near a joint where longitudinal tensile forces may affect the fastenings at the joint.

Rail anchors - Those devices which are attached to the rail and bear against the side of the crosstie to control longitudinal rail movement. Certain types of rail fasteners also act as rail anchors and control longitudinal rail movement by exerting a downward clamping force on the upper surface of the rail base.

Rail neutral temperature - The temperature at which the rail is neither in compression nor tension. Also known as Stress Free rail.

Rail temperature - The temperature of the rail, measured with a rail thermometer.
Remedial actions - Those actions which track owners are required to take as a result of requirements of this part to address a non-compliant condition.

Thermal Loading - The compressive forces generated in the rail due to its temperature being increased above its neutral temperature.

Tight / kinky rail - CWR which exhibits minute alignment irregularities which indicate that the rail is in a considerable amount of compression.

Tourist, scenic, historic, or excursion operations - Railroad operations that carry passengers with the conveyance of the passengers to a particular destination not being the principal purpose.

Track Breathing - The changing of the neutral temperature of CWR as a result of the natural cycle of seasonal temperature variations and the effect of the dynamic loading due to train operations.

Track Buckling - The sudden formations of large lateral misalignments caused by high compressive forces, usually in the presence of other influencing factors.

Traction Force - The longitudinal force induced into the rail as a result of the tractive effort of the locomotive and rolling of the wheels of all equipment.

Track longitudinal resistance - The resistance provided by the rail anchors / rail fasteners and the ballast section to the rail / crosstie structure against longitudinal displacement.

Train-induced forces - The vertical longitudinal, and lateral dynamic forces which are generated during train movement and which can contribute to the buckling potential of the rail.

Unscheduled detour operation - A short term, unscheduled operation where a track owner has no more than 14 calendar days’ notice that the operation is going to occur.
### REPORT “A”

<table>
<thead>
<tr>
<th>“INSTRUCTIONS” for the REPORT OF TRACK DISTURBANCE - REPORT A - Part 1 and Part 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>This report of disturbed track will be filled out as required by Part II of the Track Buckling Countermeasures Policy. The report will be completed by the Supervisor in charge of the work as follows:</td>
</tr>
</tbody>
</table>

#### Part 1

This part will be completed in its entirety any time track is worked on and there is a loss of track support or restraint and not in compliance as outlined in the policy. This may include; tie removal, washout or spot surfacing activities.

#### Part 2

This part will be completed in its entirety any time main track CWR is cut or broken for any reason.

When it is necessary to install rail plugs in CWR territory, the Supervisor must assure the amount of rail installed, including the welds, is equal to or less than the length of rail removed. If the requirements of this section “cannot” be met, the Supervisor in charge must accurately complete the information required in Part XII of this procedure, “Report (A) part 2 of Rail Cut in CWR Track”, and report to the Assistant Director of Track Maintenance. In addition, the Supervisor must place a 30 MPH speed restriction on the affected portion of track until corrected. The distance over which rail movement occurred will be measured as follows:

1. Prior to cutting the rail or removing bolts from a joint, make a match mark on the base of the rail and tie plate. These marks will be made every 50 feet (approximately every thirtieth tie) for 200 feet (approximately 100 ties) in each direction.

2. Also prior to cutting rail, mark the location of the saw cuts and measure the distance between these marks. This is the “x” dimension required in Report A.

3. After the rail is cut or the joint is broken, inspect the marks and identify whether the rail has moved.

4. In the event of a rail weld or joint service failure, temporary repairs are to be made in accordance with track buckling countermeasures.

5. Report A document to incorporate Log # to track report. Log #’s are to be assigned by Assistant Director of Track Maintenance.

6. Report to be maintained for 7 days after protective restrictions have been removed.
# REPORT “A”

## REPORT OF TRACK DISTURBANCE

### PART 1- (Loss of track support or restraint)

<table>
<thead>
<tr>
<th>Date:</th>
<th>Line:</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP Location:</td>
<td>to</td>
</tr>
<tr>
<td>Cause of Disturbance:</td>
<td></td>
</tr>
<tr>
<td>Rail Temp:</td>
<td>Time:</td>
</tr>
<tr>
<td>Issue (Circle all that apply)</td>
<td></td>
</tr>
<tr>
<td>Fasteners</td>
<td>Anchors</td>
</tr>
<tr>
<td>Other (write in):</td>
<td></td>
</tr>
<tr>
<td>Other Remarks:</td>
<td></td>
</tr>
<tr>
<td>Supervisor's Name (Print):</td>
<td>Signature:</td>
</tr>
</tbody>
</table>

### PART 2- (Rail cut-in or pull-apart)

<table>
<thead>
<tr>
<th>Date:</th>
<th>Line:</th>
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<tbody>
<tr>
<td>MP Location:</td>
<td>to</td>
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<tr>
<td>Cause of Disturbance:</td>
<td></td>
</tr>
<tr>
<td>Rail Temp:</td>
<td>Time:</td>
</tr>
<tr>
<td>Issue (Circle all that apply)</td>
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</tr>
<tr>
<td>Fasteners</td>
<td>Anchors</td>
</tr>
<tr>
<td>Other (write in):</td>
<td></td>
</tr>
<tr>
<td>Other Remarks:</td>
<td></td>
</tr>
</tbody>
</table>

*For Rail Cut In:*

- "x" dimension prior to saw cut: |
- "x" dimension after saw cut: |
| Other Remarks: |

| Supervisor's Name (Print): | Signature: |

Log #: |
Prior to the start of out-of-face surfacing and lining in a block, the supervisor in charge will set a minimum of three reference points in the full body of each curve. In no case may the points be more than 250 feet apart. These points will be set to the outside (high side) of the track, and out of the way of regulators or other equipment. A reference point on the adjacent track (if the track is not to be disturbed), a point on a cat pole foundation, or a stake may be used. The distance from the reference point to the field side of the high rail will be recorded.

Within 24 hours after completion of high speed surfacing, the supervisor will measure and record the distances from the reference point to the field side of high rail.

If uniform movement in excess of the following is detected, the supervisor will so indicate on the Summary Report of Track Disturbance under Remarks, and protect the track in question with a 30 MPH speed restriction until the curve is readjusted in accordance with the SMW 100.

Report to be maintained for 7 days after protective restrictions have been removed.

| Curves Under 2° | More than 6" to the outside  
More than 3" to the inside |
|-----------------|-----------------------------|
| Curves 2° and Over | More than 3" to the outside  
More than 3" to the inside |
# REPORT “B”

## REPORT OF TRACK MOVEMENT DUE TO SURFACING AND LINING

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<tr>
<th>Date:</th>
<th>Line:</th>
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<tbody>
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<table>
<thead>
<tr>
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<th>MP Location:</th>
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<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>Rail Temp:</th>
<th>Curve No:</th>
</tr>
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<tbody>
<tr>
<td></td>
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### DISTANCE FROM REFERENCE:

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<th>Point Number</th>
<th>Prior to Surfacing</th>
<th>Before 1st Train</th>
<th>After 24 Hours</th>
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<tbody>
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**Remarks:**

<table>
<thead>
<tr>
<th>Supervisor’s Name: (Print)</th>
<th>Signature:</th>
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<tbody>
<tr>
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**Log #**
**REPORT "D" - Thermal Log for Rail Expansion {RETAIN for 1 Year}**

<table>
<thead>
<tr>
<th>Date:</th>
<th>Branch:</th>
<th>Track #:</th>
<th>Foreman:</th>
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<tbody>
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<table>
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<tr>
<th>Weather:</th>
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<th>Rail Section:</th>
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<table>
<thead>
<tr>
<th>String #:</th>
<th>String Length:</th>
<th>From Cat / Bent:</th>
<th>to Cat / Bent:</th>
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<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Air Temp:</th>
<th>Rail Temp Prior to Heating:</th>
<th>Expansion Method: Natural - Heat - Mechanical</th>
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</thead>
<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Location</th>
<th>Temperature When Anchored</th>
<th>Calculated Expansion</th>
<th>Measured Expansion</th>
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<tbody>
<tr>
<td>1/4 Point</td>
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<td>Remarks</td>
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<tr>
<td>1/2 Point</td>
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<tr>
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<tr>
<td>End Point</td>
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</table>
# REPORT "E" - Report of Rail Defect / Failure Report

<table>
<thead>
<tr>
<th>Detected by</th>
<th>Date</th>
<th>Location</th>
<th>Date</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIVISION:</td>
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</tr>
<tr>
<td>LINE:</td>
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<tr>
<td></td>
<td>O L.RAIL</td>
<td>O S. HILL</td>
<td>O CHE</td>
<td>O MAINLINE</td>
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<tr>
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<td>O MSHL</td>
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<td>O W. TRENTON</td>
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<td>H OTHER</td>
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<td>O W. CHESTER</td>
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<tr>
<td>LOCATION</td>
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<td>CAT POLE OR BENT</td>
<td>MILE POST</td>
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<td>DEFECTIVE RAIL</td>
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<td>O SOUTH</td>
<td>O EAST</td>
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CONFINED SPACE ENTRY PROGRAM

DEFINITIONS

Attendant means an individual stationed outside one or more permit spaces who monitors the authorized entrants and who performs all attendant’s duties assigned in the employer’s permit space program.

Confined Space means a space that:

1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and

2) Has limited or restricted means for entry or exit (for example, manholes, tanks, vaults and pits are spaces that may have limited means of entry); and

3) Is not designed for continuous employee occupancy.

Entry means the action by which a person passes through an opening into a permit-required confined space. Entry includes ensuing work activities in that space and is considered to have occurred as soon as any part of the entrant’s body breaks the plane of an opening into the space.

Entry Permit (permit) means the written or printed document that is provided by the employer to allow and control entry into a permit space.

Entry Supervisor means the person responsible for determining if acceptable entry conditions are present at a permit space where entry is planned, for authorizing entry and overseeing entry operations, and for terminating entry as required.

Note 1: The Entry Supervisor is the person conducting the atmospheric tests and completing the entry permit (not necessarily an “A” payroll employee).

Note 2: An Entry Supervisor also may serve as an attendant or as an authorized entrant, as long as that person is trained and equipped for each role he or she fills. Also, the duties of entry supervisor may be passed from one individual to another during the course of an entry operation.

Hazardous Atmosphere means an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-resource (that is, escape unaided from a permit space), injury or acute illness from one or more of the following causes:

1) Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL):

2) Atmospheric oxygen concentration below 19.5 percent or above 23.0 percent.
**Hot Work Permit** means the employer’s written authorization to perform operations (for example, riveting, welding, cutting, burning and heating) capable of providing a source of ignition.

**Permit-Required Confined Space** (permit space) means a confined space that has one or more of the following characteristics:

1) Contains or has a potential to contain a hazardous atmosphere;

2) Contains a material that has the potential for engulfing an entrant;

3) Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or

4) Contains any other recognized serious safety or health hazard.

**Permit-Required Confined Space Program** (confined space safety program) means the overall program for controlling, and, where appropriate, for protecting employees from, permit space hazards and for regulating employee entry into permit spaces.

**Permit System** means the written procedure for preparing and issuing permits.

**Retrieval System** means the equipment (including a retrieval line, chest or full-body harness, wristlets, if appropriate, and a lifting device or anchor) used for non-entry rescue of persons from permit spaces.

**GENERAL GUIDELINES**

1. An individual shall be appointed within the respective operating departments to have overall responsibility for the Confined Space Safety Program in their area. This person shall assure that adequate personnel are trained and certified to perform the daily functions required by the program. The System Safety Department will provide initial training to these individuals.

2. All manholes and pumpwells will be considered confined spaces; therefore, the procedures developed herein must be strictly applied.

3. All confined spaces will require the completion of a permit prior to any personnel entry. Permits must be filed and maintained for at least one year.

**GENERAL GUIDELINES (continued)**
4. All employees, inclusive of supervisors, who are involved in any work which requires entry into a confined space shall be trained on these guidelines and procedures. Training records shall be maintained on file.

Note: Any personnel not receiving the minimum training as outlined in #4 above, are not permitted to perform confined space work (entry or top side attendant).

5. An attendant shall remain outside a confined space while employees are working inside. Verbal and/or visual communication with workers in the confined space shall be maintained.

Note 1: At no time is the attendant permitted to leave the general work area unless another attendant is available. If no replacement is available, all personnel must exit the confined space.

Note 2: The attendant shall never enter a confined space to attempt a rescue. Entry may jeopardize the attendant’s own safety as well as the chance for that person to initiate a successful rescue procedure by qualified personnel.

6. Attendants for workers in confined spaces shall have some form of communication capable of contacting emergency personnel (i.e., Philadelphia Fire Department via the Power Dispatcher).

7. If ventilation is used, it is preferred that air be blown in to the confined space, not exhausted. Air intake to the blower shall be located in fresh air, not next to vehicle exhaust pipes or other potential sources of contamination.

8. All atmosphere testing equipment shall be calibrated with a known concentration of gas at least once per week and maintained per manufacturer’s recommendations. Records of calibrations shall be maintained on file.

9. Any unusual or hazardous condition detected (i.e., instrument alarm sounds) in a confined space shall be reported to the immediate supervisor and the Department’s Confined Space Coordinator and System Safety. The space shall not be entered until it is ventilated for at least 15 minutes and retested for acceptable atmospheric conditions. The ventilation should be shut off for 5 minutes prior to the retest.
PROCEDURES

1. Check gas detection instrument prior to leaving office to ensure it is operational and all sensors are indicating normal conditions.

2. Secure area around manhole/confined space from vehicular and pedestrian traffic prior to removing manhole cover, (i.e., flags, cones signs, etc.).

3. Follow the department’s lock out/tag out procedures or other approved safety practices while working on or around energized cables.

4. Without entering the confined space, *slowly* lower the instrument’s sensor or extension hose into the space. The sensor shall traverse all levels of the manhole, top to bottom, to check for pockets of hazardous gases.

   **Note:** If instrument sounds alarm at any time, do not enter space.

5. The following readings are *acceptable for safe entry* into the space:
   
   Oxygen (O₂):               Greater than 19.5%, Less than 23.0%
                           The Normal Level is 20.9%

   Lower Flammable Limit (LFL): Less than 10% LFL for entry only.
                           Less than 5% LFL if hot work is to be done (lead splicing and any open flame inside of the confined space is considered hot work.
                           The Normal Level is 0% LFL

   Carbon Monoxide (CO):       Less than 25 ppm
                           The Normal Level is 0-5 ppm

   Hydrogen Sulfide (H₂S):     Less than 5ppm
                           The Normal Level is 0 ppm

   **Note:** Normal level refers to typical concentrations of outside air.
6. If any of the instrument readings do not meet the values in (5) above, place the ventilation tube into the space, supply air for 15 minutes, secure ventilation for 5 minutes, and then retest. If new values are acceptable, the space is safe to enter. If instrument sounds an alarm a second time then work shall cease and a supervisor notified of the situation.

7. If the manhole/confined space is safe for entry, enter the space with the instrument and conduct atmospheric tests throughout the space.

8. Complete the attached Confined Space Entry Permit prior to any personnel entering the space to perform scheduled work. This permit must be completed by personnel who have received the minimum training as outlined in #4 of the General Guidelines.

9. The duration of the permit shall not exceed the length of a specific job or a work shift (8-10 hours). If employees of a new shift are to occupy the same space, a new atmospheric test must be conducted and a new permit issued.

10. Position attendant outside of confined space and check means of verbal and/or visual communication.

Note: Attendants may be assigned to monitor more than one permit space provided that their duties described in this program can be effectively performed for each permit space that is monitored. Likewise, attendants may be stationed at any location outside the permit space to be monitored as long as communication with the entrants can be maintained.

11. If ventilation will be used to supply air to the space, ensure the air intake is located in fresh air.

12. The gas detection instrument should remain in the space to provide continuous monitoring only if hot work is to be performed.

13. If gas was detected during the initial test, continuous monitoring should also be performed.

14. If the job lasts an extended period of time, instrument readings shall be logged on the permit every two hours.

15. If the instrument sounds an alarm at any time during the work, all employees shall exit the space until the conditions are retested and determined to be safe. If the alarm is sounded two times during the same shift, the work shall cease immediately and a supervisor shall be notified. Supervisor shall also contact System Safety.
**PROCEDURES (continued)**

16. The atmospheric conditions of a confined space can change if the manhole cover is replaced during breaks or lunch. A new permit is not required to be issued, but a new test must be taken and documented on the existing permit.

17. All permits shall be returned to a central location for filing. The department’s coordinator should conduct periodic audits of the permits to ensure the program is being enforced. System Safety will conduct periodic evaluation of the program.

**CONTRACTOR OPERATIONS**

1. If SEPTA arranges to have a contractor perform work that involves confined space entry, then SEPTA shall:
   
   (i) Inform the contractor that the workplace contains confined spaces and that confined space entry is allowed only through compliance with a permit space program.
   
   (ii) Apprise the contractor of the elements, including the hazards identified and SEPTA’s experience with the space, that make the space in question a permit space;
   
   (iii) Apprise the contractor of any precautions or procedures that have been implemented for the protection of employees in or near permit spaces where contractor personnel will be working;
   
   (iv) Coordinate entry operations with the contractor, when both SEPTA personnel and contractor personnel will be working in or near permit spaces.

2. Each contractor who is retained to perform confined space entry operations shall:

   (i) Obtain any available information regarding permit space hazards and entry operations from SEPTA;

   (ii) Coordinate entry operations with SEPTA when both SEPTA personnel and contractor personnel will be working in or near permit spaces.

   (iii) Inform SEPTA of the permit space program that the contractor will follow and of any hazards confronted or created in permit spaces, either through a debriefing or during the entry operation.

3. It is not permissible for SEPTA employees to enter a confined space based on a contractor’s entry permits.

**CONTRACTOR OPERATIONS (continued)**

1003, Confined Space Entry, 2015
4. It is **not** permissible for contractor employees to enter a confined space based on SEPTA’s entry permit.

5. SEPTA employees observing contractor employees entering a SEPTA confined space without following appropriate testing and permit requirements should notify the contractor of the potential hazards. A SEPTA supervisor and System Safety shall also be notified with the name of the contractor and location of incident.

**DUTIES of AUTHORIZED ENTRANTS**

1. Know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure.

2. Properly use testing equipment.

3. Communicate with the attendant *as necessary* to enable the attendant to monitor entrant status and to enable the attendant to alert entrants of the need to evacuate the space.

4. Alert the attendant whenever:
   (i) The entrant recognizes any warning sign or symptom of exposure to a dangerous situation, or
   (ii) The entrant detects a prohibited condition; and

5. Exit from the permit space as quickly as possible whenever:
   (i) An order to evacuate is given by the attendant or the entry supervisor,
   (ii) The entrant recognizes any warning sign or symptom of exposure to a dangerous situation,
   (iii) The entrant detects a prohibited condition, or
   (iv) An evacuation alarm is activated.

**DUTIES of ATTENDANTS**

1. Know the hazards that may be faced during entry, including information on the mode, signs or symptoms and consequences of the exposure;

2. Be aware of possible behavioral effects of hazard exposure in authorized entrants;

3. Remain outside the permit space during entry operations until relieved by another attendant;

**DUTIES OF ATTENDANT (continued)**

4. Communicate with authorized entrants as necessary to monitor entrant status
and to alert entrants of the need to evacuate the space.

5. Monitor activities inside and outside the space to determine if it is safe for entrants to remain in the space and orders the authorized entrants to evacuate the permit space immediately under any of the following conditions:

(i) If the attendant detects a prohibited condition;
(ii) If the attendant detects the behavioral effects of hazard exposure in an authorized entrant;
(iii) If the attendant detects a situation outside the space that could endanger the authorized entrants.

6. Summon rescue and other emergency services as soon as the attendant determines that authorized entrants may need assistance to escape from permit space hazards.

7. Takes the following actions when unauthorized persons approach or enter a permit space while entry is underway;

(i) Warn the unauthorized persons that they must stay away from the permit space;
(ii) Advise the unauthorized persons that they must exit immediately if they have entered the permit space; and

8. Performs non-entry rescues as specified by the employer’s rescue procedure.

RESCUE and EMERGENCY SERVICE

1. To facilitate non-entry rescue, retrieval systems or methods shall be used whenever an authorized entrant enters a permit space, unless the retrieval equipment would increase the overall risk of entry or would not contribute to the rescue of the entrant. Retrieval systems shall meet the following requirements:

(i) Each authorized entrant shall use a chest or full body harness, with a retrieval line attached at the entrant’s back near shoulder level or above the entrant’s head. Wristlets may be used in lieu of the chest or full body harness if the use of a chest or full body harness is infeasible or creates a greater hazard and that the use of wristlets is in the safest and most effective alternative.

(ii) The other end of the retrieval line shall be attached to a mechanical device or fixed point outside the permit space in such a manner that rescue can begin as soon as the rescue team arrives on scene. Retrieval systems shall be available to retrieve personnel from vertical type permit spaces more than 5 feet (1.52m) deep.

RESCUE and EMERGENCY SERVICE (continued)

2. Notify 911 and/or the Control Center Dispatcher that a confined space rescue is needed.
3. The Control Center Dispatcher shall call 911 that a confined space rescue is necessary and to request that Rescue #1 be dispatched to the scene.

4. Personnel at the incident scene shall remain at the site to direct rescue personnel upon their arrival.
CONFINED SPACE ENTRY PERMIT

DATE: ____________________________ TIME: ____________________________ AM/PM

SITE LOCATION: _______________________________________________________________

DESCRIPTION OF WORK: _______________________________________________________

ENTRY SUPERVISOR: ______________________ ACCT #: __________

ATTENDANT: ______________ ACCT #: __________

ENTRANT #1: ______________________ ACCT #: __________

ENTRANT #2: ______________________ ACCT #: __________

ENTRANT #3: ______________________ ACCT #: __________

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ATTENDANT IS REQUIRED FOR ALL CONFINED SPACE WORK

IN THE EVENT OF AN EMERGENCY CALL THE POWER DISPATCHER (Railroad - x 8606, 8607, or 8608; City - x 8616) AND/OR 911

TIME GRANTED ENTRY FROM POWER DISPATCHER (IF NEEDED): ________AM/PM

PERMIT MUST REMAIN AT JOB SITE UNTIL COMPLETION OF WORK. RETURN TO CENTRAL FILE AT COMPLETION OF SHIFT. KEEP ALL PERMITS FOR 1 YEAR FROM DATE OF ISSUE.
PUBLIC & OPERATIONAL SAFETY DIVISION
SYSTEM SAFETY DEPARTMENT

MANAGEMENT PROGRAM
FOR
SOILS, CONSTRUCTION AND DEMOLITION DEBRIS
GENERATED FROM SEPTA PROPERTY

PREPARED BY – SYSTEM SAFETY
Document # 3005, May 2009
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ACRONYMS AND DEFINITIONS

Acronyms

C&D  Construction and Demolition Debris
DOT  Department of Transportation
EDR  Environmental Data Resources
ESA  Environmental Site Assessment
PADEP Pennsylvania Department of Environmental Protection
PCBs Polychlorinated Chlorinated Biphenyls
RCRA Resource Conservation and Recovery Act
SWMA Solid Waste Management Act
TSCA Toxic Substances Control Act

Definitions

Act 90 The Pennsylvania regulation that establishes requirements for the transportation of municipal and residual waste.

Clean Fill Uncontaminated, non-water-soluble, nondecomposable, inert, solid material that includes soil, rock, stone, dredged material, and used asphalt, brick, block or concrete from construction and demolition activities that is separate from other wastes. If tested, concentrations of regulated substances are below the limits in Tables FP-1a and b in the Management of Fill Policy.

Contaminated Material with concentrations of regulated substances above the Clean Fill limits in Tables FP-1a and b of the Management of Fill Policy.

C&D Solid waste resulting from the construction or demolition of buildings and other structures including wood, plaster, metals, asphalt, brick, block and unsegregated concrete.

Environmental Due Diligence Investigative techniques, including but not limited to, visual inspections, electronic data base searches, review of ownership and use history of the property, Sanborn maps, environmental questionnaires, transaction screens, analytical testing, environmental assessments or audits.

Hazardous Waste Waste exhibiting a RCRA hazardous waste characteristic, a listed hazardous waste, universal waste (batteries, mercury containing equipment, pesticides) and mixed waste.

Management of Fill Policy The Policy as amended (Document No. 258-2182-773) that provides the PADEP’s procedures for determining whether material is Clean Fill or
Regulated Fill. This Policy does not apply to mine land reclamation, including quarry restoration activities.

**Historic Fill**
Material used to bring an area to grade prior to 1988 that is a mixture of soil and residuals, including ashes from the burning of wood and coal, incinerator ash, coal ash, slag, dredged material and construction and demolition debris waste.

**Regulated Fill**
Soil, rock, stone, dredged material, historic fill and used asphalt, brick, block or concrete from construction and demolition activities that is separate from other wastes and has been affected by a spill or release of a regulated substance. If tested, concentrations of regulated substances are above the limits in Tables FP-1a and b but below the limits in Tables GP-1a and b in the Management of Fill Policy.

**Regulated Substance**
Hazardous substance and contaminants regulated under Pennsylvania regulations including the Hazardous Sites Cleanup Act and substances covered by the Clean Streams Law, the Air Pollution Control Act, the Solid Waste Management Act, the Infectious and Chemotherapeutic Waste Law and the Storage Tank and Spill Prevention Act.

**Residual Waste**
Garbage, refuse, discarded materials and other waste including solid, liquid and gaseous materials resulting from industrial, mining and agricultural operations. Residual waste is not hazardous. Residual waste must be managed in a Pennsylvania- permitted residual waste disposal facility.

**RCRA**
The Federal regulation enacted in 1976 that regulates the management of hazardous waste.

**Soils**
The naturally occurring, unconsolidated or loose covering on the Earth’s surface. Soil is comprised of particles of broken rock that have been altered by chemical and environmental processes including weathering and erosion.

**TSCA**
The Federal regulation enacted in 1976 that regulates the management of PCB waste.

**Uncontaminated**
Material with concentrations of regulated substances below the Clean Fill limits in Tables FP-1a and b of the Management of Fill Policy.
1.0 INTRODUCTION AND PURPOSE

The primary objective of this Soils and Construction and Demolition Debris Management Program (Program) is to present cost-effective options for the proper management of non-hazardous soils and construction and demolition debris (C&D) generated at SEPTA facilities, stations and other construction projects that are compliant with all applicable regulations and meet SEPTA's risk management requirements.

Non-hazardous soils and C&D materials addressed by this Program include clean fill, regulated fill and residual waste as defined by the Pennsylvania Department of Environmental Protection (PADEP). It does not include Resource Conservation Recovery Act (RCRA) hazardous wastes and Toxic Substances Control Act (TSCA) PCB wastes. These wastes shall be disposed of in properly permitted RCRA and TSCA disposal facilities, respectively. Fact sheets for clean fill, regulated fill, residual waste and C&D materials are presented in Attachment A.

Specifically, this Program establishes the requirements that will govern the excavation, transportation and offsite management of soils and C&D materials that may be generated by SEPTA including:

- Construction projects where excess materials will be generated due to the presence of unsuitable soils (i.e. not suitable for structural fill) as well as where cut and fill balances indicate the need for offsite removal of soils.
- Construction projects where C&D materials will be generated.
- Soils containing ash, slag and cinders and spill-impacted soils.
- Underground storage tank (UST) closure activities that result in the removal of incidental and petroleum-impacted soils (1).
- Other SEPTA projects/activities that will result in the excavation of soils and/or generation of C&D materials.

The Program establishes the sequence of steps for the proper management of soils that shall be addressed early in the life cycle of the project, starting as early as the 30% design. The Program shall apply to projects that are self-performed by SEPTA as well as those performed by third-party design consultants and contractors. The Program shall also apply to activities that will generate excess soils on properties both owned by SEPTA and in the process of being acquired by SEPTA.

This Program also addresses SEPTA construction projects where cut and fill balance deficiencies may exist and soils will need to be imported onsite. As discussed herein, SEPTA needs to ensure that soils brought onto SEPTA properties do not pose environmental liabilities to the Authority.

The SEPTA System Safety Department should be contacted for clarification of the contents of this Program.

(1) SEPTA System Safety and the TES Environmental Consultant shall oversee all UST removal projects to ensure compliance with Federal and state regulations.
2.0 GENERAL APPROACH

By the 30% design of a SEPTA project consideration should be given as to whether offsite management of soils and C&D materials will be required and if so, how they are going to be managed. These considerations include:

- Will excess soils be generated from the project?
- Has the design considered options for eliminating or reducing the amount of soils requiring offsite management (e.g., raising site elevations)?
- Do design activities address adequate characterization of site soils requiring offsite management to identify suitable reuse/disposal options?
- Is there historical information available on the quality of these soils (environmental reports, site knowledge)?
- Can these excess soils be reused at another SEPTA location?

Figure 1 presents a flow diagram that outlines the steps to be followed in evaluating whether offsite soil management on a project is required and if so, determining the most appropriate soil management option(s) based on project objectives, the quality and quantities of soils to be managed and other considerations. Potential soil management options include the reuse of soils at other offsite locations for soils meeting PADEP Clean Fill or Regulated Fill limits and the disposal of soils at local permitted facilities including the Clean Earth, Inc., Waste Management, Inc. and Republic Conestoga facilities located in the Philadelphia Pennsylvania area. Note that other soil management options can be considered but shall be reviewed and approved by SEPTA System Safety during the project design.

A Soils Management Checklist that shall be completed for every project requiring offsite management of soils and C&D materials is presented in Attachment A. A more detailed discussion of these steps is presented in the following sections.
3.0 **SOILS MANAGEMENT**

**Design Considerations**

Early in the design of the project, starting with the 30% design stage, the project design team shall evaluate whether excess soils will be generated and require offsite management. This may be based on the geotechnical investigations that may identify unsuitable soils as well as cut and fill calculations during design that indicate that an export of soils from the site will be required. If this is the case, the design team should conduct “value” engineering to evaluate design options that can eliminate or significantly reduce the need for offsite soils management such as raising final site elevations.

For projects requiring offsite soils management after value engineering is conducted, efforts shall be made to characterize excess soils to determine the most cost-effective option(s) for offsite management. This effort includes due diligence activities and sampling of soils between the 30 and 60% design stages in order to incorporate this information and the recommended soil management option in a submittal to System Safety for approval at the 60% design stage.

**Environmental Due Diligence**

Available information on the quality and quantity of soils to be managed shall be obtained and evaluated early in the project. To identify available information on soil quality, environmental due diligence should be conducted that shall include the review of available site historical information, prior Phase I Environmental Site Assessments (ESA) and Phase II investigations, interviews of personnel familiar with the site’s history, and computerized environmental database reports with historical aerial photographs that can be ordered through Environmental Data Resources (EDR) or equivalent. For the estimated soil quantities to be managed, design specifications and drawings, cut and fill balance calculations, geotechnical reports and other project information shall be reviewed, supported by discussions with SEPTA and/or third party Consultant engineers.

**Clean Fill/Regulated Fill Sampling**

1. In the Commonwealth of Pennsylvania, soils and selected C&D materials (segregated used asphalt, brick, block and concrete) can be classified as Clean Fill in accordance with PADEP’s Management of Fill Policy. Clean Fill is considered non-regulated fill, and not a waste, that can be reused without restrictions. If due diligence activities as described above do not indicate that site soils have been impacted and do not contain historic fill, then the Management of Fill Policy allows that the soils may be managed as Clean Fill without testing. However, on SEPTA projects where the soils to be managed offsite are located near railroad tracks and at maintenance facilities, testing shall be performed as described below. Note that Clean Fill can include rocks, stone, used asphalt, brick, block and concrete from C&D activities if segregated from other wastes. These materials are not typically tested; however, due diligence shall still be conducted to confirm that they are uncontaminated.

2. On SEPTA projects where the soils to be managed offsite are located near railroad tracks and at maintenance facilities, testing shall be performed. If site historical information reviewed as part of due diligence activities indicates that site soils to be managed have not been significantly impacted, then the soils shall be tested in accordance with PADEP’s Management of Fill Policy for the Clean Fill parameters listed in Tables FP-1a and FP-1b in Attachment B. If site soil concentrations do not exceed the Clean Fill limits presented on these tables, then the soils are
considered Clean Fill, are non-regulated and can be used as backfill at other SEPTA locations without restrictions and the need for permits. However, soils on SEPTA property classified as Clean Fill shall not be reused on residential properties without System Safety approval.

3. If soil concentrations exceed the Clean Fill limits but are below Regulated Fill limits in Tables GP-1a and GP-1b (Attachment C), then these soils may still be used onsite as backfill or at other offsite locations, including other SEPTA properties, under a PADEP General Permit (see Attachment C). However, as indicated on the General Permit form, the soils need to be used on a specific construction project that will be implemented within a specific timeframe. Regulated fill relocated within the same Right of Way or property does not require a General Permit.

4. If soils classified as either Clean Fill or Regulated Fill cannot be reused at other offsite locations, then the soils shall be disposed of at a permitted facility as discussed in the next section.

5. The following shall be considered when conducting soil sampling for Clean Fill:
   
a. If the soils to be sampled for Clean Fill have been excavated and are presently in stockpiles, then clean trowels and/or shovels shall be used to collect grab samples that are representative of the entire soil volume. If the soils have not yet been excavated, then soil borings can be drilled using drilling equipment such as a GeoProbe (direct-push technology) to collect representative soil samples within proposed excavation areas and depths.

b. If geotechnical testing is being conducted in support of project design activities, concurrent chemical testing of soils for Clean Fill may be considered.

c. Samples shall be biased, i.e., stained soils and/or soils exhibiting odors should be collected for chemical analysis.

d. Samples for Clean Fill testing shall be four-point composites. However, soil samples for volatile organics analysis shall be grab samples and not composited.

e. Samples shall be analyzed for the organic and inorganic chemical parameters presented in Tables FP-1A and FP-1B, respectively (Attachment B). Soil concentrations shall be compared to the Clean Fill limits presented in these same tables.

f. The grab samples used to generate the composite samples for Clean Fill analysis shall be retained and sent to the laboratory for additional analyses. For example, if a specific parameter(s) exceeds its Clean Fill limit, then the grab samples can be analyzed for the specific parameter(s) to determine if sample concentrations pass the 75/2X rule (75% of the sample concentrations are below the Clean Fill limit and no concentrations exceed twice the Clean Fill limit) for that parameter (see Appendix A of the Management of Fill Policy in Attachment B). If the concentrations meet the 75/2X rule, the soils would meet the Clean Fill for that parameter. The grab samples can also be analyzed to meet waste disposal testing requirements as discussed below if the soils are to be disposed at a permitted disposal facility.

g. Soils shall not be blended or mixed to become Clean Fill (i.e., no dilution).

h. Clean/Regulated Fill shall not contain free liquids including water. The soils can be drained to remove the free liquids.

i. Soils that meet the Clean Fill limits but have odors shall not be considered Clean Fill.
j. Historic fill (containing ash, slag and/or cinders) can not be considered Clean Fill even if testing of these materials indicates that concentrations are below the Clean Fill limits (PADEP telephone conversation, April 15, 2009).

k. Soils that exceed Regulated Fill limits shall be managed as residual waste and tested and managed at a permitted disposal facility as discussed in the next section.

Waste Disposal Testing/Clean Earth, Waste Management and Republic Conestoga Facilities

If due diligence indicates that the soils to be managed offsite have been significantly impacted by a spill or release and/or the soils contain ash, slag and cinders and potentially will not pass the Clean Fill and Regulated Fill limits, then the soils shall be tested instead for waste disposal acceptance. Similarly, if analytical testing indicates that soil concentrations exceed Regulated Fill limits or soils that meet Regulated Fill limits cannot be reused at another location, then these soils shall be properly disposed of at a permitted facility. Waste disposal testing will be specific to the disposal facility. The following discussion outlines the steps for testing soils to obtain acceptance at the Clean Earth, Waste Management and Republic Conestoga disposal facilities located in the Philadelphia, Pennsylvania area that have been approved by System Safety:

1. Disposal facilities should be conducted prior to testing to confirm testing requirements.

2. Soils confirmed to be Clean Fill by testing do not need to be further tested for disposal acceptance. This is because Clean Fill is not a waste. However, the final analytical data (signed by the laboratory) and other supporting information will need to be submitted to the facility. Waste Management has a formal Clean Fill package that is to be completed (see Attachment D).

3. Soils being considered for disposal at Clean Earth’s Philadelphia facility are to be tested in accordance with the requirements on Table 1 in Attachment E. The PADEP Form U and the Non Hazardous Profile Sheet shall be completed, signed and submitted with the final analytical data (also in Attachment E). Clean Earth can be contacted at 302-427-6633 for further information and testing requirements. Based on Clean Earth’s review of the analytical data, soils may either be disposed of at a facility located in Pennsylvania or outside the state. If the soils are to be disposed of outside Pennsylvania, then waste acceptance by Clean Earth can typically be obtained in a few calendar days. However, if the soils are to be disposed of at a Pennsylvania facility, then soil acceptance may take up to 15 calendar days due to the requirement for PADEP to review and approve the Form U.

4. Waste Management considers soils meeting regulated fill to be a Pennsylvania residual waste. To obtain acceptance at their Pennsylvania facilities (GROWS and Tullytown), soils shall be tested for the Table A parameters presented in Attachment F at a frequency of one sample per 500 cubic yards of soil. A PADEP Form U, Non-Hazardous Waste Certification, site history, sampling approach and other related information shall be submitted to Waste Management along with the final analytical data (see Attachment E). Up to 15 calendar days should be allowed for to obtain disposal acceptance since the Form U needs to be reviewed and approved by PADEP. Waste Management can be contacted at 267-580-2816.

5. Soil testing requirements for the Republic Conestoga facility located in Morgantown, Pennsylvania are similar to those of Waste Management. The main difference is that samples for disposal acceptance need to be collected at a frequency of one (1) sample per 250 cubic yards for
the Conestoga facility as opposed to one (1) sample per 500 cubic yards for Waste Management. The Republic Conestoga landfill can be contacted at 610-286-6844.

Disposal Facility Qualifications

It shall be specified in the design documents that the proposed disposal facility(ies) shall be permitted for the soils to be removed from the site for off-site disposal. It shall also be specified that for disposal facilities other than Clean Earth, Waste Management and Republic Conestoga, the Contractor shall submit copies of the current permit(s) for the facility, the name and telephone number of the primary contact at the state regulatory agency that issued the permit(s), a copy of the most recent inspection report from the disposer state, a history of any violations/orders/deficiencies and their resolution, financial assurance documents and a list of major customers with contact names and phone numbers.

Transportation of Soils

It shall be specified in the design documents that the soil transportation company shall be licensed and permitted in all states and Canadian provinces through which they will travel with decals/placards appropriate for the soils removed from the Project. This includes having a PADEP Waste Transporter Authorization issued under Act 90 if hauling soils that do not meet Clean Fill. The Contractor shall also submit documentation of Department of Transportation (DOT) training requirements, a list of vehicles and DOT approved containers that will be available for use on the project, DOT violation history and a list of other projects similar in magnitude with contact names and telephone numbers.

Soil Management Specification

An example Soil Management Specification that can be included in the design documents is provided in Attachment G. This Specification shall be tailored to the project.

Importing of Soils

There may be projects where cut and fill deficiencies occur and soils will need to be imported onto a SEPTA location. Only soils tested by SEPTA that meet Clean Fill shall be accepted. The source of the soil, sampling plan, analytical data and evaluation showing that Clean Fill limits have been met shall be submitted to System Safety for approval prior to implementation.

Documentation

The following documentation shall be submitted to System Safety for review and approval at the 60% design:

- Environmental Due Diligence information
- Material sampling plan
- Analytical results
- Comparison of analytical results to Clean Fill, Regulated Fill and/or disposal facility limits and classification of soils (Clean Fill, Regulated Fill or Residual waste).
- Recommended soil management option. Include disposal facility information (permits, NOV's, state regulatory agency contact, etc.) if proposed disposal facility is other than Clean Earth, Waste management or Republic.
- Completed beneficial reuse permit application if applicable.
- Completed disposal facility information package(s).
4.0 C&D MANAGEMENT

As presented in Section 1, Construction and Demolition (C&D) waste is the solid waste resulting from the construction and/or demolition of buildings and other structures. It includes wood, plaster, metals, asphalt, bricks, blocks, and unsegregated concrete. Typically, these materials have been disposed of in municipal and C&D landfills. However, brick, block, concrete and asphalt are not considered C&D and can be reused as Clean Fill if segregated from other waste and not impacted by a spill or release.

Similar to the previous discussion on soil management in Sections 2 and 3, the offsite management of construction and demolition waste material should be considered early in the life cycle of the project, starting as early as the 30% design. Items to be considered regarding the management of C&D material include:

- The potential for the presence of asbestos and lead-based paint.
- Can the C&D material be sent to a recycling facility (economic benefit) for reuse as opposed to a disposal facility?

Best management practices shall be followed prior to demolition activities including the removal of materials like lead-based paint surface, asbestos, and hazardous materials (mercury switches, PCB ballasts and fluorescent light bulbs) if the brick, block or concrete is to be used as Clean Fill.

C&D material not containing lead-based paint can be considered clean fill. However, if it is painted, PADEP may require testing to confirm that lead concentrations are below the Clean Fill limits. C&D material that can not be managed as Clean Fill shall be managed through a recycling facility or a permitted disposal facility.

In addition, source segregated recyclable materials including cardboard, wood, glass, metals, paper and plastic are not considered waste. A number of companies in the Philadelphia area specialize in recycling of C&D material (Attachment II).

Documentation

The following documentation shall be submitted to System Safety for review and approval if the C&D material is going to be used as Clean Fill:

- Asbestos/lead based paint survey reports, including analytical results, indicating that these materials are not present.
- If present, mitigation reports documenting that proper removal of asbestos and/or lead-based paint was performed.
ATTACHMENT A

FACT SHEETS/SOILS MANAGEMENT PROGRAM CHECKLIST
FACT SHEET
CLEAN FILL

- Definition- Uncontaminated, non-water soluble, non-decomposable, inert, solid material that includes soil, rock, stone, dredged material and used asphalt, brick, block or concrete from construction and demolition activities that is separate from other waste.

- Clean Fill is not a waste.

- If tested, concentrations are equal to or below the limits in Tables FP-1a (organics) and b (inorganics).

- If due diligence indicates that soils have not been impacted, then PADEP allows that the soils can be managed as Clean Fill without testing. However, SEPTA will require that soils located near railroad tracks and at maintenance facilities or containing ash, slag and/or cinders be tested.

- Since Clean Fill is not a waste, it is not regulated and unrestricted. However, soils identified as Clean Fill on SEPTA properties shall only be reused as backfill on residential properties with System Safety’s approval.

- Offsite transportation of Clean Fill does not require Pennsylvania Act 90 authorization.

- Clean Fill from SEPTA properties can be disposed of at Clean Earth’s Morrisville, PA facility, Waste Management’s GROWs/Tulleytown facilities, Republic’s Conestoga facility and other facilities approved by System Safety.

- On projects where Clean Fill is present and offsite management of soils is required, the design should maximize to the extent possible the export of Clean Fill as opposed to Regulated Fill and residual waste to minimize regulatory requirements and disposal costs.

- As indicated in the Soil Management Program Checklist, sampling data, location map, the proposed disposal facility and other supporting information shall be submitted to System Safety for review and approval at the 60% design stage.
FACT SHEET

REGULATED FILL

- Definition- Soil, rock, stone, dredged material, historic fill and used asphalt, brick, block or concrete from construction and demolition activities that is separate from other wastes that has been affected by a spill or release and/or if tested, concentrations are above the limits in Tables FP-1a and b but below or equal to the limits in Tables GP-1a and b.

- Soils and other materials that have been impacted by a spill or release will be tested for Clean Fill only if the materials are being considered for reuse at another location. Otherwise, they will be tested for acceptance at a disposal facility approved by System Safety.

- Offsite transportation of Regulated Fill requires Pennsylvania Act 90 authorization.

- The reuse of Regulated Fill within the same property or right of way does not require a permit.

- The reuse of Regulated Fill on another property (including another SEPTA property) requires a general beneficial use permit (see attached).

- Regulated fill from SEPTA properties can be disposed of at Clean Earth’s Philadelphia facility, Waste Management’s GROWs/Tulleytown facilities, Republic’s Conestoga facility and other facilities approved by System Safety.

- Disposal at the Waste Management and Conestoga facilities will require the completion of a PADEP Form U that will require up to 15 days for approval.

- As indicated in the Soil Management Program Checklist, sampling data, sample location map, the proposed disposal facility and other supporting information shall be submitted to System Safety for review and approval at the 60% design stage.
FACT SHEET
RESIDUAL WASTE

- Definition- Garbage, refuse, discarded materials and other waste including solid, liquid and gaseous materials resulting from industrial, mining and agricultural operations. Residual waste is not hazardous.
- If tested, concentrations are above the limits in Tables GP-1a and b.
- Offsite transportation of Residual Waste requires Pennsylvania Act 90 authorization.
- Residual Waste must be managed at a permitted disposal facility.
- Residual Waste from SEPTA properties can be disposed at Clean Earth’s New Castle facility, Waste Management’s GROWs/Tulleytown facilities, Republic’s Conestoga facility and other facilities approved by System Safety.
- As indicated in the Soil Management Program Checklist, sampling data, sampling location map, the proposed disposal facility and other supporting information shall be submitted to System Safety for review and approval at the 60% design stage.
FACT SHEET
CONSTRUCTION AND DEMOLITION DEBRIS (C&D)

- Definition- Material from building construction or demolition activities separate from other waste and not impacted by a spill or release. It includes rock, stone, brick, block, concrete and used asphalt where lead-based paint surfaces, asbestos and hazardous materials such as mercury switches, PCB ballasts and fluorescent light bulbs have been removed.

- C&D can be used as Clean Fill when best management practices are followed.

- If due diligence indicates that C&D have not been impacted, then PADEP allows that the C&D can be managed as Clean Fill without testing.

- Since Clean Fill is not a waste, it is not regulated and unrestricted. However, C&D identified as Clean Fill on SEPTA properties shall only be reused as backfill on residential properties with System Safety’s approval.

- Offsite transportation of C&D, if it is beneficially reused or meets Clean Fill requirements, does not require Pennsylvania Act 90 authorization.

- C&D from SEPTA properties can be sent to a recycling facility or disposed of at Clean Earth’s Morrisville, PA facility, Waste Management’s GROWs/Tulleytown facilities, Republic’s Conestoga facility and other facilities approved by System Safety.

- On projects where C&D is present and offsite management is required, the design should maximize to the extent possible the export of C&D, if it meets Clean Fill requirements, as opposed to Regulated Fill and residual waste to minimize regulatory requirements and disposal costs.

- As indicated in the Soil Management Program Checklist, sampling data, location map, the proposed recycling or disposal facility and other supporting information must be submitted to System Safety for review and approval at the 60% design stage.
SOILS MANAGEMENT PROGRAM
CHECKLIST

Note: This Checklist is to be completed for every proposed construction project on SEPTA property or property to be acquired by SEPTA that has the potential to generate soils.

1. Project name and location ________________________________.

2. What is the estimated volume of excavated material for the project?
______________________________

3. Will the project require off site management of soils?

☐ Yes  ☐ No
If yes, what is the estimated volume of material that will require off site management? ________________________________
Proceed to Step 4.
If no, then the SEPTA Soils Management Program does not apply to the project.

4. Has value engineering been performed to eliminate or minimize the volume of soil requiring off site soil management? Note that System Safety requires that value engineering is to be completed at the 30% design level to minimize and/or eliminate offsite soils management.

☐ Yes  ☐ No
If yes, proceed to Step 5.
If no, conduct value engineering to consider options that will eliminate or reduce the volume of soils requiring offsite management (e.g., raising site elevations). After completing value engineering, return to Step 3.

5. Conduct Environmental Due Diligence to determine if soils requiring offsite management have been impacted by a release or contain historic fill (i.e. cinders and/or ash).

6. Have the soils been impacted by a release or contain cinders and/or ash?

☐ No. Proceed to Step 7.
☐ Yes. Proceed to Step 9
☐ Do not know. Proceed to Step 7.
Source of Information ________________________________
______________________________
7. Analyze for PADEP Clean Fill parameters in accordance with the PADEP Management of Fill Policy and SEPTA's Soil Management Program. Indicate below the outcome of the analytical results. (Check one.)
   □ Material meets Clean Fill limits. Proceed to Step 8.
   □ Material meets Regulated Fill limits. Proceed to Step 8.
   □ Material is above the Regulated Fill limits (i.e., residual waste). Proceed to Step 9.

8. Based on the analytical results from Step 7 indicate how the material will be managed.
   □ Material will be used as backfill at another SEPTA facility.
     If material meets Clean Fill, proceed to Step 10.
     If material meets Regulated Fill limits, complete beneficial reuse permit application and proceed to Step 10.
   □ Material will be managed off site at an approved disposal facility.
     If material meets Clean Fill, proceed to Step 10.
     If material meets Regulated Fill limits, proceed to Step 9.

9. If soils have been impacted by a release, contain cinders and/or ash, or are classified as Regulated Fill or Residual Waste and are to be managed at an approved disposal facility, conduct waste disposal testing for one or more of the following approved disposal facility (ies):
   □ Waste Management
   □ Clean Earth
   □ Republic
   □ Name of other permitted disposal facility _________________________
     (Submit required disposal facility information requested in Step 10)
10. Submit all appropriate information to System Safety for review and approval including: Incomplete information may result in approval delay.

☐ Environmental Due Diligence information
☐ Material sampling plan
☐ Analytical results
☐ Comparison of analytical results to Clean Fill, Regulated Fill and/or disposal facility limits and classification of soils (Clean Fill, Regulated Fill or Residual Waste).
☐ Recommended soil management option. Include disposal facility information (permits, Notices of Violation (NOVs), state regulatory agency contact, etc.) if proposed disposal facility is other than Clean Earth, Waste management or Republic.
☐ Completed beneficial reuse permit application.
☐ Completed disposal facility information package(s).
ATTACHMENT B

PADEP MANAGEMENT OF FILL POLICY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF LAND RECYCLING AND WASTE MANAGEMENT

DOCUMENT NUMBER: 258-2182-773

ANTICIPATED EFFECTIVE DATE: April 24, 2004

TITLE: Management of Fill

AUTHORITY: This document is established in accordance with the Act of July 7, 1980, as amended, 35 P.S. §§ 6018.101 et seq., known as the Solid Waste Management Act (SWMA); the Act of June 22, 1937, as amended, 35 P.S. §§ 691.1 et seq., known as the Clean Streams Law; the Act of April 9, 1929, Section 1917-A of the Administrative Code, 71 P.S. § 510-17; the Act of July 18, 1995, 35 P.S. §§ 6026.101 et seq., known as the Land Recycling and Environmental Remediation Standards Act.

POLICY: This policy is designed to replace the Department's existing Clean Fill Policy dated February 29, 1996.

PURPOSE: This policy provides DEP's procedures for determining whether material is clean fill or regulated fill. Regulated fill may not be used unless a SWMA permit is secured by the individual or entity using the regulated fill.

APPLICABILITY: This policy shall be used to evaluate whether material qualifies as clean fill or regulated fill. This policy does not apply to mine land reclamation activities subject to a permit. Excavation, movement or reuse of fill material within a project area or right-of-way of a project is not an activity that requires a SWMA permit.

DISCLAIMER: The policies and procedures outlined in this guidance document are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements. The policies and procedures herein are not an adjudication or a regulation. There is no intent on the part of the DEP to give the rules in these policies that weight or deference. This document establishes the framework within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.

PAGE LENGTH: 4

LOCATION: Volume 6, Tab 40(b)

DEFINITIONS:

Clean fill—Uncontaminated, nonwater-soluble, nondecomposable inert solid material. The term includes soil, rock, stone, dredged material, used asphalt, and brick, block or concrete from construction and demolition activities that is separate from other waste and recognizable as such. (25 Pa. Code §§ 271.101 and 287.101) The term does not include materials placed in or on the waters of the Commonwealth unless otherwise authorized.

Environmental due diligence—Investigative techniques, including, but not limited to, visual property inspections, electronic data base searches, review of ownership and use history of property, Sanborn maps, environmental questionnaires, transaction screens, analytical testing, environmental assessments or audits.

Historic fill—Material (excluding landfills, waste piles and impoundments) used to bring an area to grade prior to 1988 that is a conglomeration of soil and residuals, such as ashes from the residential burning of wood and coal, incinerator ash, coal ash, slag, dredged material and construction and demolition waste. The term does not include iron or steel slag that is separate from residuals if it meets the coproduct definition and the requirements of 25 Pa. Code § 287.8. The term does not include coal ash that is separate from residuals if it is beneficially used in accordance with 25 Pa. Code § 287.661-287.666.

Regulated fill—Soil, rock, stone, dredged material, used asphalt, historic fill, and brick, block or concrete from construction and demolition activities that is separate from other waste and recognizable as such that has been affected by a spill or release of a regulated substance and the concentrations of regulated substances exceed the values in Table FP-1a and b.

Regulated substance—The term shall include hazardous substances and contaminants regulated under the Hazardous Sites Cleanup Act, and substances covered by the Clean Streams Law, the Air Pollution Control Act, the Solid Waste Management Act, the Infectious and Chemotherapeutic Waste Law, and the Storage Tank and Spill Prevention Act.

Release—Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping or disposing of a regulated substance into the environment in a manner not authorized by the Department of Environmental Protection. The term includes the abandonment or discarding of barrels, containers, vessels and other receptacles containing a regulated substance.

Uncontaminated material—Material unaffected by a spill or release of a regulated substance, or if affected by a spill or release, the concentrations of regulated substances are below the concentrations specified in Table FP-1a and b.

REFERENCES:

25 Pa. Code Chapters 287 to 299 (residual waste regulations)
25 Pa. Code Chapters 271 to 285 (municipal waste regulations)
Solid Waste Management Act, 35 P.S. §§ 6018.101 et seq.
Land Recycling and Environmental Remediation Standards Act, 35 P.S. §§ 6026.101 et seq.
TECHNICAL GUIDANCE:

FILL DETERMINATION
1) To determine whether fill is clean or regulated, a person must perform environmental due diligence.¹

   a) If due diligence shows no evidence of a release of a regulated substance, the material may be managed as clean fill under this policy.

   b) If due diligence shows evidence of a release, the material must be tested to determine if it qualifies as clean fill. Testing must be performed in accordance with Appendix A.

      i) If testing reveals that the material contains concentrations of regulated substances that are below the residential limits in Table FP-1a and b, the material must be managed as clean fill.

      ii) If testing reveals that the material contains concentrations of regulated substances that exceed the limits in Table FP-1a and b, the material must be managed as regulated fill.

2) A person may not blend or mix materials to become clean fill. Materials that contain regulated substances that are intentionally released may not be managed under this policy.

MANAGEMENT OF REGULATED FILL
1) Materials identified as regulated fill are waste and must be managed in accordance with the Department’s municipal or residual waste regulations, whichever is applicable, based on 25 Pa. Code §§ 287.2 or 271.2. Regulated fill may be beneficially used under General Permit WMGR096 (proposed) if the materials and the proposed activities for the fill meet the conditions of that permit. A person may apply for an industry-wide beneficial use general permit for the beneficial use of regulated fill in lieu of this general permit.

2) Regulated fill may not be placed on a greenfield property not planned for development, or on a property currently in residential use or planned for residential use unless otherwise authorized.

3) Fill containing concentrations of regulated substances that exceed the values in Table GP-1 a and b may not be managed under the provisions of this policy or General Permit WMGR096, but must be otherwise managed in accordance with the provisions of the Department’s municipal or residual waste regulations.

4) A general permit is not required for remediation activities undertaken entirely on an Act 2 site pursuant to the requirements of Section 902 of the Land Recycling and Environmental Remediation Standards Act. A general permit is also not required if regulated fill from an Act 2 site is used as construction material at a receiving site that is being remediated to attain an Act 2 standard as long as the procedural and substantive requirements of Act 2 are met. Regulated

¹ Analytical assessment, testing or sampling is only required if visual inspection or reviews of historic property use indicates evidence of a release of a regulated substance.
substances contained in the regulated fill must be incorporated into the notice of intent to remediate and the final report. Movement of regulated fill between Act 2 sites must be documented in both the sending and receiving sites' cleanup plans and final reports. Placement of the regulated fill may not cause the receiving site undergoing remediation to exceed the selected Act 2 standard.

**MANAGEMENT OF CLEAN FILL**
1) Use of material as clean fill does not require a permit under the Solid Waste Management Act and regulations, and it may be used in an unrestricted or unregulated manner under this Act and its regulations. The use of materials as clean fill is still regulated under other environmental laws and regulations. A person using materials as clean fill under the policy is still subject to and must comply with all applicable requirements governing the placement or use of material as clean fill, such as Chapter 102 (Erosion and Sediment Control) and Chapter 105 (Dam Safety and Waterway Management).

2) Any person placing clean fill which has been affected by a release of a regulated substance on a property must certify the origin of the fill material and results of analytical testing to qualify the material as clean fill on Form FP-001. Form FP-001 must be retained by the owner of the property receiving the fill.

3) Best management practices (BMP) must be followed prior to demolition activities to remove materials like lead-based paint surface, friable asbestos and hazardous materials such as mercury switches, PCB ballasts and fluorescent light bulbs from a building if the brick, block, or concrete is used as clean fill.

4) Clean fill may not contain any free liquids based on visual inspection, and shall not create public nuisances (for example objectionable odors) to users of the receiving property or adjacent properties.
Form FP-001
CERTIFICATION OF ORIGIN OF CLEAN FILL

I, the undersigned, certify that fill material that has been determined to be clean fill has been placed on the following property:

Property Name: ____________________________
Current Owner of Property: _________________
Property Address: __________________________
_________________________________________

This fill material will be used solely for property improvement or construction purposes. Copies of the laboratory analyses that confirm that this material is clean fill are attached to this form.

Date: ______________ Name: ____________________
Title: ______________ Address: ___________________
_________________________________________
_________________________________________
Phone: ______________

This form is to be maintained by the owner of the property receiving fill material. If a property received fill from multiple sources, a separate certification form is required for each source.
Appendix A

Sampling and Analyses foror of Regulated Material to be Used as Fill:

Sampling of regulated material proposed to be used as fill shall be done either by composite samples or by discrete samples. Sampling in either case shall be random and representative of the fill material being sampled. Sampling shall be in accordance with the most current version of the EPA RCRA Manual, SW-846 (Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Office of Solid Waste and Emergency Response).

(a) Sampling based on composite sampling procedures shall include the following:

   (i) For volumes of material equal to or less than 125 cubic yards, a total of eight samples shall be collected and analyzed as follows:

      (A) For analysis of all substances other than volatile organic compounds (VOCs), the samples shall be analyzed in two composites of four samples each, in accordance with the most current version of the USEPA Manual, SW-846 (Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Office of Solid Waste and Emergency Response).

      (B) Two samples shall be selected from the 8 samples for analysis of VOCs. The samples shall be based on field screening of the eight samples to select those samples that are most likely to contain the highest concentrations of VOCs.

   (C) Two grab samples shall be taken from the same areas in the material from which the two samples used for field screening of VOCs were taken, in accordance with Method 5035 from the most current version of the USEPA Manual, SW-846 (Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Office of Solid Waste and Emergency Response).

   (ii) For volumes of material greater than 125 cubic yards and less than or equal to 3,000 cubic yards, a total of 12 samples shall be collected and analyzed as follows:

      (A) For analysis of all substances other than VOCs, the samples shall be analyzed in three composites of four samples each.

      (B) Three samples shall be selected from the 12 samples for analysis of VOCs. The samples shall be based on field screening of the 12 samples to select those samples that are most likely to contain the highest concentrations of VOCs.

      (C) Three grab samples shall be taken from the same areas in the material from which the three samples used for field screening of VOCs were taken, in accordance with EPA, Method 5035, referenced in subparagraph (i)(C).
(iii) For each additional 3,000 cubic yards of material or part thereof over the initial 3,000 cubic yards, 12 additional samples shall be collected and analyzed as follows:

(A) For analysis of all substances other than VOCs, the samples shall be analyzed in three composites of four samples each.

(B) Three samples for analysis of VOCs shall be selected from the 12 samples for analysis of VOCs. The samples shall be based on field screening of the 12 samples to select those samples that are most likely to contain the highest concentrations of VOCs.

(C) Three grab samples shall be taken from the same areas in material from which the three samples used for field screening of VOCs were taken, in accordance with EPA Method 5035, referenced in subparagraph (i)(C).

(b) Sampling based on discrete sampling procedures shall include the following:

(i) For volumes of material equal to or less than 125 cubic yards, a minimum of eight samples shall be collected and analyzed. For volumes of material greater than 125 cubic yards and less than or equal to 3,000 cubic yards, a minimum of 12 samples shall be collected and analyzed. For each additional 3,000 cubic yards of material or part thereof over the initial 3,000 cubic yards, a minimum of 12 additional samples shall be collected and analyzed.

(ii) For VOCs analysis, grab sampling procedures shall be the procedures described in paragraph (a), for the equivalent volumes of material sampled.

(c) Analyses of results:

(1) For a composite sample taken in accordance with subsection (a), the measured numeric value for a parameter shall be less than or equal to the concentration limit listed in Table FP-1a or b for that parameter in order for the material to qualify as clean fill, or in Table GP-1a or b for that parameter in order for the fill material to qualify as regulated fill.

(2) For a grab sample, taken in accordance with subsection (a) and (b), the measured numeric value for a parameter shall be less than or equal to the concentration limit listed in Table FP-1a or b for that parameter in order for the material to qualify as clean fill, or in Table GP-1a or b for that parameter for the fill material to qualify as regulated fill.

(3) For discrete samples required in subsection(b), the measured numeric values for a substance in 75% of the discrete samples shall be equal to or less than the concentration limit listed in Table FP-1a or b, or in Table GP-1a or b for that parameter with no single sample exceeding more than twice the concentration limit for a parameter.
(d) In lieu of subsection (c), a person may use 95% Upper Confidence Limit (UCL) of the arithmetic mean to determine whether a fill material meets the appropriate concentration limits for use as clean or regulated fill. The calculated 95% UCL of the arithmetic mean must be below the appropriate concentration limit for clean or regulated fill. Sampling shall be random and representative of the material being sampled. The minimum number of samples shall be determined in accordance with EPA approved methods on statistical analysis of environmental data, as identified in 25 PA. Code, §250.707(e)(relating to statistical tests). The application of the 95% UCL of the arithmetic mean shall comply with the following performance standards:

(1) The null hypotheses (Ho) shall be that the true fill arithmetic average concentration is at or above the regulated fill appropriate concentration limit, and the alternative hypothesis (Ha) shall be that the true fill arithmetic average concentration is below the regulated fill appropriate concentration limit.

(2) The underlying assumptions of the statistical method shall be met, such as data distribution.

(3) Compositing cannot be used for volatile organic compounds.

(4) The censoring level for each nondetect shall be the assigned value randomly generated that is between zero and the limit related to the PQL.

(5) Tests shall account for spatial variability, unless otherwise approved by the Department.

(6) Statistical testing shall be done individually for each parameter present in the fill.

(7) Where a fill has distinct physical, chemical or biological characteristics, or originates from different areas, the statistical testing shall be done separately.

(8) The following information shall be documented:

(i) A description of the original areas of the fill, and physical, chemical and biological characteristics of the fill.

(ii) A description of the underlying assumptions of the statistical method.

(iii) Documentation showing that the sample data set meets the underlying assumptions of the statistical method.

(iv) Documentation of input and output data for the statistical test, presented in tables or figured, or both, as appropriate.

(v) An interpretation and conclusion of the statistical test.
The Synthetic Precipitation Leaching Procedure (SPLP, per Technical Guidance Manual, 253-0300-100/ May 4, 2002 /Page II-26-27), is listed below:

The value for the SPLP is the concentration of a regulated substance in soil at the site that does not produce a leachate in which the concentration of the regulated substance exceeds the groundwater MSC. Since this test must be conducted on the actual site soil, no values for the SPLP could be published in the tables of MSCs in the regulations. The following procedure should be used to determine the alternative soil-to-groundwater value based upon the SPLP:

- During characterization, the remediator should obtain a minimum of ten samples from within the impacted soil area. The four samples with the highest total concentration of the regulated substance should be submitted for SPLP analysis. Samples obtained will be representative of the soil type and horizon impacted by the release of the regulated substance.
- Determine the lowest total concentration (TC) that generates a failing SPLP result. The alternative soil-to-groundwater standard will be the next lowest TC.
- If all samples result in a passing SPLP level, the alternative soil-to-groundwater standard will be the TC corresponding to the highest SPLP result. The remediator has the option of obtaining additional samples.
- If none of the samples generates a passing SPLP, the remediator can obtain additional samples and perform concurrent TC/SPLP analyses to satisfy the above requirements for establishing an alternative soil-to-groundwater standard.
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### Table FP-1b

Clean Fill Concentration Limits For Metals and Inorganics

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<td></td>
<td>Total Analysis</td>
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<td></td>
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<td>BARIUM AND COMPOUNDS</td>
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<td>ZINC</td>
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<sup>1</sup> The limit of 12 mg/kg applies to all releases of arsenic. A limit of 20 mg/kg applies to certain construction materials not subject to direct contact upon completion of construction. The limit of 20 mg/kg can only be used if a Department approved Best Management Practices Plan for Earthwork and General Construction is followed by all parties involved in supplying and using materials on the construction project.
ATTACHMENT C

PADEP GENERAL PERMIT FOR PROCESSING/
BENEFICIAL USE OF RESIDUAL WASTE
General Permit
For
Processing/Beneficial Use of Residual Waste

| Permit No.  | WMGR096 | Date Amended | Date Issued | April 13, 2004 | Date Expires | April 13, 2009 |

The Department of Environmental Protection, Bureau of Land Recycling and Waste Management, Division of Municipal and Residual Waste hereby approves the:

- [x] Beneficial Use
- [ ] Processing prior to Beneficial Use
- [ ] Other

of: regulated fill as defined in Guidance Document 258-2182-773 (Management of Fill)

for use as: construction material

This approval is granted to: Eligible persons or municipalities qualifying for the general permit.

subject to the attached conditions and may be revoked or suspended for any project which the Department of Environmental Protection determines to have a substantial risk to public health, the environment, or cannot be adequately regulated under the provisions of this permit.

The processing of wastes not specifically identified in the documentation submitted for this approval, or the beneficial use of wastes not approved in this permit, is prohibited without the written permission of the Department.


This approval is granted: By: __________________________

- [x] Statewide
- [ ] Regional

Title: Environmental Program Manager

THIS PERMIT IS NON-TRANSFERABLE
Page 1 of 7
1. **Permitted Activities.** The approval herein granted is limited to the beneficial use of regulated fill when moved offsite or received onsite. Regulated fill may only be moved to a property that is approved for construction and that is zoned and used exclusively for commercial and industrial uses or that is unzoned but is exclusively used for commercial and industrial uses (excluding parks, playgrounds, nursing homes, child care facilities, schools or other residential-style facilities or recreation areas). This permit does not authorize blending or processing of material to meet concentration limits in Table GP-1.

2. **Definitions.** The following terms, when used in this permit, have the following meanings:

   "Regulated fill" is soil, rock, stone, dredged material, used asphalt, historic fill, and brick, block or concrete from construction and demolition activities that is separate from other waste and recognizable as such that has been affected by a spill or release of a regulated substance and the concentrations of regulated substances exceed the values in Table FP-1 of the Department’s fill policy.

   "Historic fill" is material (excluding landfills, waste piles and impoundments) used to bring an area to grade prior to 1988 that is a conglomeration of soil and residuals, such as ashes from the residential burning of wood and coal, incinerator ash, coal ash, slag, dredged material and construction and demolition waste. The term does not include iron or steel slag that is separate from residuals if it meets the coproduct definition and the requirements of 25 Pa. Code § 287.8. The term does not include coal ash that is separate from residuals if it is beneficially used in accordance with 25 Pa. Code § 287.661-287.666.

3. **Concentration limits.** Regulated fill may not exceed the values in Table GP-1.

4. **Hazardous waste prohibited.** Material that is hazardous waste under Chapter 261a (relating to identification and listing of hazardous waste) may not be used under this permit.

5. **Proper management of fill.** Regulated fill may not be placed on a greenfield property not planned for development, or on a property currently used for or planned for residential use. Material containing concentrations of regulated substances that exceed the values in Table GP-1 may not be moved under the provisions of this general permit, but must be managed in accordance with the provisions of the Department’s municipal or residual waste regulations.

6. **Proper management of dredged materials.** In addition to meeting the values in Table GP-1, regulated fill consisting of dredged material from tidal streams shall meet 250 mg/l for chlorides based on an SPLP analysis.

7. **Proper management of fill materials containing metals.** Regulated fill containing metals may be moved to a site if those metals concentrations meet either the concentration limits for metals in Table GP-1 or the background concentration, whichever is higher. Fill that exceeds the concentration limits must be placed as part of an approved construction project in such a manner that all direct contact exposure pathways are eliminated. The background concentration is defined as the concentration of a substance that is present at the site before beneficial use activities occur under this permit. Background concentrations may be determined by taking a representative number of samples, based on the size of the site, from each of the receiving site and the fill proposed for beneficial use. The average concentration in the receiving site samples becomes the background concentration.
8. **Notice to municipalities.** A person that registers for coverage under this general permit shall submit a copy of the registration to each municipality in which the beneficial use activities will be located a minimum of 30 days prior to initiating operations.

9. **Sampling and analysis.** Prior to the beneficial use, the permittee shall perform chemical analysis on representative samples of regulated fill for the appropriate parameters in accordance with the protocol in Appendix A to the Fill Policy. The chemical analyses required in this condition shall be performed by a laboratory accredited or registered for accreditation under the Pennsylvania Environmental Laboratory Accreditation Act of 2002.

10. **Deed Acknowledgment for beneficial use of regulated fill.** The permittee shall provide to the Department proof of a recorded deed notice that includes the exact location of the fill placed on the property, including latitude and longitude descriptions, and a description of the types of fill identified by sampling and analysis. The location and description shall be made a part of the deed for all future conveyances or transfers of the subject property.

11. **Siting limitations.** Regulated fill shall not be beneficially used under this permit unless authorized in writing by the Department:
   
   a. in the 100-year floodplain;
   
   b. within 100 feet of a sinkhole or area draining into a sinkhole;
   
   c. within 50 feet of a dwelling unless the owner has provided a written waiver consenting to the beneficial use being closer than 50 feet;
   
   d. within 100 feet of a perennial stream;
   
   e. within 300 feet of a water source unless the owner has provided a written waiver consenting to the beneficial use being closer than 300 feet;
   
   f. within 300 feet of an exceptional value wetland, an exceptional value water or a high quality water.
   
   g. The siting limitations in paragraph 11(a) are not applicable to the placement of regulated fill at a brownfield site provided the placement is in accordance with all other applicable requirements.

12. **Water quality.** Regulated fill shall not be placed in the waters of the Commonwealth.

13. **Nuisances.** Regulated fill shall not contain any free liquids based on visual inspection, and shall not create public nuisances (for example objectionable odors).

14. **Construction material.** The construction activity associated with placement of regulated fill under this permit shall be conducted promptly. At a minimum, construction activity should begin within one year from the date the regulated fill is placed for beneficial use. Upon completion of areas where regulated fill is beneficially used, the areas shall be promptly vegetated or otherwise stabilized to minimize and control erosion if the construction activity is not undertaken within 30 days of fill placement.

Page 3 of 7
15. *Mixing prohibited.* The regulated fill may not be mixed with other types of solid waste unless otherwise approved by the Department.

16. *Storage and transportation.* The storage and transportation of regulated fill shall be in a manner that does not create a nuisance or be harmful to the public health, safety or the environment. Storage and transportation shall comply with the requirements of 25 Pa. Code Chapters 285 or 299 (relating to storage, collection and transportation of municipal waste and residual waste), whichever is applicable to the waste type being stored or transported.

17. Discharge of waste prohibited. This permit does not authorize and shall not be construed as an approval to discharge any other waste, wastewater or runoff from the site where regulated fill originated or the site where regulated fill is beneficially used, to the land or waters of the Commonwealth.


19. *Erosion and sedimentation control.* An erosion and sedimentation control plan shall be implemented that is consistent with the applicable requirements of Chapter 102 (relating to erosion and sedimentation control).

20. *Recordkeeping.* Records of all analytical evaluations conducted on the regulated fill under this permit shall be kept by the permittee at the permittee’s place of business and shall be available to the Department for inspection. This waste analysis information shall be retained by the permittee for a minimum of 5 years.

21. Relationship to local law. Nothing in this permit shall be construed to supersede, amend, or authorize a violation of any of the provisions of any valid and applicable local law, ordinance, or regulation, providing that said local law, ordinance, or regulation is not preempted by the Solid Waste Management Act, 35 PS §6018.101 et seq.; and the Municipal Waste Planning, Recycling and Waste Reduction Act of 1988, 53 P.S. §4000.101 et seq.

22. Inspections. As a condition of this permit and of the permittee’s authority to conduct the activities authorized by this permit, the person receiving the fill hereby authorizes and consents to allow authorized employees or agents of the Department, without advance notice or search warrant, upon presentation of appropriate credentials and without delay, to have access to and to inspect all areas on which solid waste management activities are being, will be, or have been conducted. This authorization and consent shall include consent to collect samples of waste, soils, water, or gases; to take photographs; to perform measurements, surveys, and other tests; to inspect any monitoring equipment; to inspect the methods of operation; and to inspect and/or copy documents, books, and papers required by the Department to be maintained. This permit condition is referenced in accordance with Sections 608 and 610(7) of The Solid Waste Management Act, 35 P.S. § 6018.608 and 6018.610(7). This condition in no way limits any other powers granted under the Solid Waste Management Act.

23. Prevention of harm or threat of harm. The activities authorized by this permit shall not harm or present a threat of harm to the health, safety, or welfare of the people or environment of this Commonwealth. The Department may modify, suspend, revoke, or reissue the authorization granted in
GENERAL PERMIT
WMGR096

this permit if it deems necessary to prevent harm or the threat of harm to the public health, the environment, or if the activities cannot be adequately regulated under the conditions of this permit.

24. **Individual permits.** The permittee shall comply with the terms and conditions of this general permit and with the environmental protection acts to the same extent as if the activities were covered by an individual permit. The Department may require the permittee to apply for, and obtain, an individual permit or cease operation if the permittee is not in compliance with the conditions of this general permit or is conducting an activity that harms or presents a threat of harm to the health, safety or welfare of the people or the environment.

25. **Incorporation of application.** All activities conducted under the authorization granted in this permit shall be conducted in accordance with the permittee’s application. Except to the extent that the permit states otherwise, the permittee shall use the regulated fill as described in the approved application.

26. **Permit application requirements.** Persons or municipalities that propose to beneficially use regulated fill by operating under the terms and conditions of this general permit after the date of permit issuance shall register for each location of beneficial use. The request shall be sent to the Department’s appropriate regional office that has jurisdiction for waste-related activities in the county where the regulated fill will be beneficially used. At a minimum, the following registration information shall be submitted on application forms provided by the Department:

a. Name and street address of the applicant;

b. Names and locations of the regulated fill generating sites;

c. Name, location, area and ownership of the location of beneficial use;

d. Documentation that the regulated fill meets the conditions of this general permit;

e. Number and title of the general permit;

f. Proof that the beneficial use management activities are consistent with the general permit, including a description of the construction activity to be conducted within the use of the regulated fill.

g. If the size of the receiving site, where the beneficial use takes place, is greater than or equal to one acre, proof that a Pennsylvania Natural Diversity Inventory (PNDI) review at the site has been completed. This review should be in accordance with the Department’s policy #400-0200-001, “Policy for Pennsylvania Natural Diversity Inventory Coordination During Permit Review and Evaluation” (Jan. 18, 2003) and all known occurrences must be resolved with the jurisdictional agency. If a PNDI review has been completed at the receiving site under another Department program, the report of that review and approval may be submitted to the Department to satisfy this permit application requirement.

h. Signed and notarized statement by the person who seeks “Registration” to accept all conditions and operate under the terms and conditions of this general permit;

i. Proof that copies of the “Registration” have been submitted to each municipality, county, county planning agency and county health department where the beneficial use is located;
j. Proof that the applicant has legal right to enter the land where the beneficial use will occur and perform the activities approved in Condition 1 of this permit and an irrevocable written consent from the landowner giving the Department permission to enter upon land where the applicant will be conducting waste management activities;

k. Information that identifies the applicant (i.e. individual, corporation, partnership, government agency, association, etc.) and related parties, including the names and addresses of every officer who has a financial interest in or controls the facility operation;

l. Evidence must be provided by persons operating under this general permit of noncompliance with state and federal environmental laws and regulations

m. Independent contractors retained by the applicant to perform any activities authorized under this permit must comply with state and federal laws and regulations relating to environmental protection and transportation safety.

n. A $250.00 registration fee, as specified in the residual waste management regulations, payable to the "Commonwealth of Pennsylvania."

27. Commencement of activities. For persons or municipalities that propose to beneficially use regulated fill on nonresidential brownfields, the activities may commence after 15 working days from the date the Registration application is submitted to the Department, unless otherwise instructed by the Department. A "brownfield" is defined as real property where regulated substances have been released and remain present. For persons or municipalities that propose to beneficially use regulated fill for one of the following, the activities may commence after 60 working days from the date the Registration application is submitted to the Department, unless otherwise instructed by the Department:

   a. on nonresidential greenfields;

   b. on properties where the area subject to regulated fill placement is larger than 10 acres; or

   c. on properties where waiver or modification of a siting limitation in Condition 11 has been requested.

A "greenfield" is defined as real property that is not a brownfield.

28. New sources of fill. If new sources of regulated fill are to be included at the approved beneficial use location, the permittee shall notify the Department in writing by submitting information in accordance with subparts a - f of Condition 25 above. A permittee may commence with beneficial use of the new source after 10 working days from the date the information is submitted to the Department, unless otherwise instructed by the Department.

29. Notification of changes in operator. Any person who is operating under the provisions of this permit shall immediately notify, in writing, the waste program Operations Manager of the appropriate regional office of the Department (address in attached list) within 30 days via certified mail of any changes in: the company name, address, owners, operators, and/or responsible officials of the
company; the generator(s) of the regulated fill; the compliance status (e.g., violations) of any permit issued by the Department or federal government under the environmental protection acts.

30. **Determination that material is no longer waste.** Regulated fill that meets all the terms and conditions of this permit and that does not exceed concentration limits in Table GP-1 shall cease to be waste once the regulated fill is placed. If dewasted regulated fill is subsequently excavated or moved beyond the area permitted for fill placement, it will then be subject to applicable requirements for the use of regulated fill.

31. **Revocation or suspension.** Failure of the measures herein approved to be performed as intended, or as designed, or in compliance with the applicable laws, rules and regulations, and terms and conditions of this permit, for any reason, shall be grounds for the revocation or suspension of the permittee’s approval to operate under this permit.
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Regulated Fill Concentration Limits for Organics

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ATTACHMENT D

WASTE MANAGEMENT CLEAN FILL PACKAGE
CHECKLIST FOR Clean Fill DISPOSAL REQUEST SUBMISSIONS

Before submitting any information to Waste Management of Pennsylvania, Inc., be certain you are including the following material:

☐ Site History

☐ Generator’s Waste Profile Sheet

☐ Copy of Completed Analytical

☐ Sampling Schematic or Map:
  1. show how composite sample was generated

☐ Sampling Description:
  1. explain how composite sample was collected

☐ Clean Fill Certification (to be placed on company letterhead)
Clean Fill Certificate

I, the undersigned, being duly authorized by my company certify that the soil we are disposing at the G.R.O.W.S. Landfill and Tullytown Resource Recovery Facility is not contaminated. Furthermore, based on generator’s knowledge of the soil and analytical testing, the soil meets the analytical criteria as defined by Pennsylvania Clean Fill Standards for unrestricted use.

______________________________
Signature

______________________________
Printed Name

______________________________
Date

***** Please copy this onto your company letterhead.
**GENERATOR'S WASTE PROFILE SHEET**

*PLEASE PRINT IN INK OR TYPE*

<table>
<thead>
<tr>
<th>Service Agreement on File?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile Number: WMI</td>
<td></td>
<td></td>
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<tr>
<td>Renewal Date:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**A. Waste Generator Information**

1. **Generator Name:**
2. **SIC Code:**
3. **Facility Street Address:**
4. **Phone:**
5. **Facility City:**
6. **State/Province:**
7. **Zip/Postal Code:**
8. **Generator USEPA/Federal ID #:**
9. **County:**
10. **State/Province ID #:**
11. **Customer Name:**
12. **Customer Phone:**
13. **Customer Contact:**
14. **Customer Fax:**

**B. Waste Stream Information**

1. **Name of Waste:** Clean Fill 2. **State Waste Code:** NA
3. **Process Generating Waste:**
4. **Estimated Annual Volume:**
   - Tons
   - Yards
   - Other (specify)
5. **Personal Protective Equipment Requirements:**
6. **Transporter/Transfer Station:**
7. **Is this a US Department of Transportation (USDOT) Hazardous Material? (If no, skip 8, 9 & 10)** Yes No
8. **Reportable Quantity (lbs.; kgs.):**
9. **Hazardous Class/ID #:**
10. **USDOT Shipping Name:** Check if additional information is attached. Indicate the number of attached pages:

**C. Generator's Certification** (Please check appropriate responses, sign, and date below.)

1. Is the waste represented by this waste profile sheet a "Hazardous Waste," as defined by USEPA, Canadian, Mexican and/or state/province regulation, in the location where generated or ultimately managed? Yes No
2. Does the waste represented by this waste profile sheet contain regulated radioactive material or regulated concentrations of Polychlorinated Biphenyls (PCBs)? Yes No
3. Does this waste profile sheet and all attachments contain true and accurate descriptions of the waste material? Yes No
4. Has all relevant information within the possession of the Generator regarding known or suspected hazards pertaining to the waste been disclosed to the Contractor? Yes No
5. Is the analytical data attached hereeto derived from testing a representative sample in accordance with 40 CFR 261.20 (c) or equivalent rules? N/A Yes No
6. Will all changes that occur in the character of the waste be identified by the Generator and disclosed to the Contractor prior to providing the waste to the Contractor? Yes No

**Certification Signature & Date:** 
**Name (Type or Print):** 
**Title:** 
**Customer Name:**

**D. WMI Management's Decision**

1. **Management Method:** Landfill Solidify Bioremediation Other (specify) Yes No
2. **Proposed Ultimate Management Facility:**
3. **Hours of Acceptance:**
4. **Supplemental Information:** Meets PADEP Clean Fill Limits to be managed as unregulated fill.
5. **Precautions, Special Handling Procedures, or Limitations on Approval:** Unrestricted use.

**Special Waste Decision:**
- Approved
- Disapproved

**Salesperson's Signature:**
**Date:**

**Division Approval Signature (Optional):**
**Date:**

**Special Waste Approvals Person Signature:**
**Date:**
ATTACHMENT E

CLEAN EARTH TESTING AND DOCUMENT REQUIREMENTS
# Table 1

**Clean Earth**

**Sampling Frequency Protocol**

Philadelphia

<table>
<thead>
<tr>
<th>Parameters</th>
<th>TPH</th>
<th>BTEX</th>
<th>TOX</th>
<th>Total Volatile Organic</th>
<th>Total Metals (As, Pb)</th>
<th>Bioremediation</th>
<th>Reactivity</th>
<th>PCB</th>
<th>Total Sulfate (AOAC)</th>
<th>Total Volatile Organics</th>
<th>Total Petroleum (AOAC)</th>
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<td>1010A</td>
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*If TPH is > 10,000 ppm, a PADEP Form U must be submitted.

This is to be used as a guideline for sampling. Sampling frequencies and parameter requirements may be modified at the discretion of the CE Approval staff based items such as site history, levels of contamination and/or source of contamination, etc.
REQUEST TO PROCESS OR DISPOSE OF RESIDUAL WASTE

This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided. If additional space is necessary, identify each attached sheet as Form U, reference the item number and identify the date prepared. The date on attached sheets needs to match the date noted below.

Date Prepared/Revised

SECTION A. LANDFILL CLIENT (LANDFILL OR PROCESSING FACILITY OWNER) INFORMATION

DEP Client ID# 378
DEP Client Type / Code NPACO

Organization Name or Registered Fictitious Name
Clean Earth, Inc.

SECTION B. LANDFILL SITE (LANDFILL OR PROCESSING FACILITY) INFORMATION

DEP Site ID# Site Name Landfill Permit ID#
Clean Earth of Philadelphia, Inc. 301220

Site Contact Last Name First Name MI Suffix
Tanner Dane M

Site Contact Title Laboratory Director
Site Contact Email Address dtanner@cleanearthinc.com

SECTION C. GENERATOR CLIENT (GENERATOR OF THE WASTE) INFORMATION

Company Name

Company Contact Last Name First Name MI Suffix

Company Mailing Address Line 1 Company Mailing Address Line 2

Company Address Last Line – City State Zip+4 Country

Company Phone Ext Company Email Address

Company Contact Last Name First Name MI Suffix

Contact Phone Ext Contact Email Address

If a Subsidiary, Name of Parent Company

Is the waste generated at the Company Mailing Address (noted above)? Yes No
If ‘No’, describe location of waste generation and storage.

Township County State

SECTION D. WASTE DESCRIPTION

Residual Waste Code Residual Waste Code Description Amount Unit of Measure Time Frame

cu yd gal lb ton One Time

1. GENERAL PROPERTIES

a. pH Range to (based on analyses or knowledge)

b. Physical State

Liquid Waste (EPA Method 9095)
Solid (EPA Method 9095)
Gas (ambient temperature & pressure)

c. Physical Appearance

Color

Number of Solid or Liquid Phases of Separation
Describe each phase of separation
d. Attached is information from the generator certifying that a hazardous waste determination has been done and that the waste is not hazardous waste as defined in 40 CFR 261.1, as incorporated by reference at 25 Pa. Code 261a.1. Caution: If 'No', the application form is incomplete.

<table>
<thead>
<tr>
<th>d.</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

e. Is the waste treated hazardous waste?  
If 'Yes', list the hazardous waste code(s) that apply to the hazardous waste before treatment.

<table>
<thead>
<tr>
<th>e.</th>
<th>Yes</th>
<th>No</th>
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</table>

If 'Yes', what treatment option was selected?

<table>
<thead>
<tr>
<th>e.</th>
<th>Yes</th>
<th>No</th>
</tr>
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</table>

What limit was required to be met by the treatment option?

<table>
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<tr>
<th>e.</th>
<th>Yes</th>
<th>No</th>
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</table>

Provided a copy of the certification required under 40 CFR 268.7(a), as incorporated by reference at 25 Pa. Code 268a.1, that the waste meets all the land disposal restriction requirements, as specified in 40 CFR Part 268, Subpart D (Land Disposal Restrictions-Treatment Standards).

<table>
<thead>
<tr>
<th>e.</th>
<th>Yes</th>
<th>No</th>
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</table>

f. Has the waste been delisted as a hazardous waste by DEP or US EPA?  
If 'Yes', list the facility permit ID number(s).

<table>
<thead>
<tr>
<th>f.</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
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</table>

g. Has the waste been accepted for disposal/processing at another Pennsylvania facility?  
If 'Yes', list the facility permit ID number(s).

<table>
<thead>
<tr>
<th>g.</th>
<th>Yes</th>
<th>No</th>
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h. Has an application for disposal/processing of the waste at another Pennsylvania facility been submitted?  
If 'Yes', list the facility permit ID number(s).

<table>
<thead>
<tr>
<th>h.</th>
<th>Yes</th>
<th>No</th>
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### 2. CHEMICAL ANALYSIS ATTACHMENTS

<table>
<thead>
<tr>
<th>a.</th>
<th>Yes</th>
<th>No</th>
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</table>

Has a detailed physical and chemical characterization of the waste and its leachate been conducted?  
If 'No', provided detailed explanation supporting use of generator knowledge in lieu of actual chemical analysis.

<table>
<thead>
<tr>
<th>a.</th>
<th>Yes</th>
<th>No</th>
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</table>

If 'Yes', attached is a description of the waste sampling method, in accordance with the waste sampling plan as required in §271.611(a)(3) or §287.132(a)(3).

<table>
<thead>
<tr>
<th>a.</th>
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### 3. PROCESS DESCRIPTION & SCHEMATIC ATTACHMENTS

<table>
<thead>
<tr>
<th>a.</th>
<th>Yes</th>
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Attached is a detailed description of the manufacturing and/or pollution control processes producing the waste.  
If 'No', provide explanation.

<table>
<thead>
<tr>
<th>a.</th>
<th>Yes</th>
<th>No</th>
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b. Attached is a schematic of the manufacturing and/or pollution control processes producing the waste.  
If 'No', provide explanation.

<table>
<thead>
<tr>
<th>b.</th>
<th>Yes</th>
<th>No</th>
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c. Attached is the substantiation for a confidentiality claim (if portions of the information submitted are confidential).

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<tr>
<th>c.</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
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### 4. CHEMICAL ANALYSIS WAIVER

Categories of residual wastes that qualify for the waiving of chemical analysis by the Department are listed below. Check the appropriate box(es) that match the waste proposed to be accepted for disposal.

- [ ] burnt demolition debris  
- [ ] carpet scraps  
- [ ] cured rubber scrap  
- [ ] empty containers (uncontaminated)  
- [ ] fabric/cloth/textile/leather wastes (excluding treatment sludges)  
- [ ] fiberglass insulation scrap  
- [ ] food wastes (excluding treatment sludges)  
- [ ] hot drained used oil filters (non-terme plated)  
- [ ] metal scrap (excluding powdered grindings or if contaminated with fluids or oils)  
- [ ] sawdust (excluding treated wood)  
- [ ] shingle scrap  
- [ ] waste paper  
- [ ] waste plastic (excluding extrusion manufacturing & uncured resins)  
- [ ] wood wastes (excluding treated wood)  
- [ ] Other (explain)

All waste types not listed above must be approved in writing in the permit by the Department prior to processing or disposal facility acceptance.

### SECTION E. PROPOSED PROCESSING, STORAGE AND/OR DISPOSAL METHOD

Will any special handling procedures (besides direct disposal) described in the waste acceptance plan, be used when managing the waste?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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If 'Yes', describe.

<table>
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<th>Yes</th>
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Is this material re-used for construction or operation of the facility?

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<th>Yes</th>
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If 'Yes', describe.
SECTION F. SOURCE REDUCTION STRATEGY

Form 25R must be completed by the generator and attached to this application unless waived in the instructions to that form.

Form 25R attached. ☐ Yes ☐ No ☐ Waived

SECTION G. CERTIFICATION OF GENERATOR

I hereby certify that the statements of fact contained therein are true and correct to the best of my knowledge, information and belief. This statement and verification is made subject to the penalties of 18 Pa. C.S.A. Section 4904, relating to unsworn falsification to authorities.

Name of Responsible Official ____________________________ Title ____________________________

Signature ____________________________ Date ____________________________

SECTION G. CERTIFICATION OF PROCESSING OR DISPOSAL FACILITY

I hereby certify that the statements of fact contained therein are true and correct to the best of my knowledge, information and belief. This statement and verification is made subject to the penalties of 18 Pa. C.S.A. Section 4904, relating to unsworn falsification to authorities.

Name of Responsible Official ____________________________ Title ____________________________

Signature ____________________________ Date ____________________________
Check each site you would like to utilize for this waste approval:

- ☐ Clean Earth of Carteret
  24 Middlesex Avenue
  Carteret, NJ 07008
  Ph: 732-541-8599

- ☐ Clean Earth of Maryland
  1469 Oak Ridge Place
  Hagerstown, MD 21740
  Ph: 301-791-8200

- ☐ Clean Earth of New Castle
  94 Pyles Lane
  New Castle, DE 19720
  Ph: 302-427-6633

- ☐ Clean Earth of Southeast Pennsylvania
  7 Steel Road East
  Maysville, PA 19067
  Ph: 215-428-1700

- ☐ Clean Earth of West Virginia
  3615 South State Route 2
  Friendly, WV 26146
  Ph: 304-652-8580

- ☐ Clean Earth of North Jersey
  115 Jacobus Avenue
  South Kearny, NJ 07032
  Ph: 973-344-4004

- ☐ Other

<table>
<thead>
<tr>
<th>A. Waste Generator/Job Site Information</th>
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<tbody>
<tr>
<td>1. Generator Name:</td>
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<tr>
<td>2. Generator Address:</td>
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<tr>
<td>3. Generator City:</td>
</tr>
<tr>
<td>4. Generator State/Zip:</td>
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<td>5. Generator Phone:</td>
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<td>6. Generator Contact:</td>
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<td>7. Generator Email:</td>
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<td>8. Generator County:</td>
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<td>9. Job Site Name:</td>
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<td>10. Job Site Address:</td>
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<td>12. Job Site State/Zip:</td>
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<td>13. Job Site Phone:</td>
</tr>
<tr>
<td>14. Job Site Contact:</td>
</tr>
<tr>
<td>15. Job Site Email:</td>
</tr>
<tr>
<td>16. Job Site County:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Billing Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>17. Customer Name:</td>
</tr>
<tr>
<td>18. Customer Address:</td>
</tr>
<tr>
<td>19. Customer City:</td>
</tr>
<tr>
<td>20. Customer State/Zip:</td>
</tr>
<tr>
<td>21. Customer Phone:</td>
</tr>
<tr>
<td>22. Customer Contact:</td>
</tr>
<tr>
<td>23. Customer Email:</td>
</tr>
<tr>
<td>24. Customer County:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Waste Stream Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Name of Waste:</td>
</tr>
<tr>
<td>2. State Waste Code(s) (if applicable):</td>
</tr>
<tr>
<td>4. Estimated Quantity of Waste:</td>
</tr>
<tr>
<td>□ Tons □ Cubic Yards □ Gallons □ Tons</td>
</tr>
<tr>
<td>5. Term of Project: □ Recurring □ One Time</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. Waste Composition/Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Source of Contamination (i.e. UST, AST, leak, spill, urban fill, etc.):</td>
</tr>
<tr>
<td>2. Type of Contamination (i.e. diesel, gasoline, waste oil, heating oil, MOP, etc.):</td>
</tr>
<tr>
<td>3. Contaminants of Concern (i.e. Metals, TPH, PAH, etc.):</td>
</tr>
<tr>
<td>4. Provide a site history detailing past and present land uses, on site storage/process information and any activities related to contaminants of concern (attach a separate sheet if necessary):</td>
</tr>
<tr>
<td>5. Composition of Waste (clay, rock, sand, moisture, chemical, constituents, contaminants, etc.; should equal 100%):</td>
</tr>
<tr>
<td>% □ Yes □ No % □ Yes □ No % □ Yes □ No</td>
</tr>
<tr>
<td>6. Is this site a State or Federal Superfund Site?</td>
</tr>
<tr>
<td>□ Yes □ No</td>
</tr>
<tr>
<td>7. Is laboratory report being supplied with this profile?</td>
</tr>
<tr>
<td>□ Yes □ No</td>
</tr>
<tr>
<td>7a. If yes, you will need to attach a sampling plan description and diagram of sampling locations that ties to the data. Please refer to the &quot;Site Sampling Diagram&quot; form in your approval package for guidance.</td>
</tr>
<tr>
<td>8. Is the waste represented in this waste profile classified as a radioactive material under USEPA 40CFR 191.12 or other applicable regulatory provisions?</td>
</tr>
<tr>
<td>□ Yes □ No</td>
</tr>
<tr>
<td>9. Does the waste represented contain any levels of polychlorinated biphenyls (PCBs)?</td>
</tr>
<tr>
<td>□ Yes □ No</td>
</tr>
<tr>
<td>9a. If yes, list the level:</td>
</tr>
<tr>
<td>9b. If yes, is the waste material TSCA regulated or defined as a PCB remediation waste under TSCA?</td>
</tr>
<tr>
<td>□ Yes □ No □ N/A</td>
</tr>
<tr>
<td>10. Does the waste represented contain herbicides, pesticides, asbestos, insecticides or residues thereof at concentrations that would render it hazardous as defined by 40 CFR 261 or subject to additional state or federal regulations?</td>
</tr>
<tr>
<td>□ Yes □ No</td>
</tr>
</tbody>
</table>
### C. Waste Composition/Characteristics (continued)

11. The waste represented in this profile is generated as a result of the corrective response taken under the Federal Underground Storage Tank Regulation 40 CFR 280.  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

12. Is the waste a dioxin bearing waste?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

13. Is this waste a treatment residue from a previously listed or characteristic hazardous waste?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

14. Is there a nuisance level of odor associated with this waste?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

15. Are there any special handling instructions for management of this waste?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

16. If yes to any of the questions numbered 6-15, please explain (attach an additional sheet if necessary):


### D. Generator Certification

1. I certify that the waste represented by this profile is not a listed hazardous waste, nor does it contain a listed hazardous waste, nor does it exhibit any characteristics of a hazardous waste as defined by 40 CFR 261.  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

2. I certify that this waste profile and all attachments contain true and accurate descriptions of the waste material.  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

3. I certify that all relevant information in possession of the Generator pertaining to known or suspected hazards with regard to the waste has been disclosed to Clean Earth.  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

4. I certify that all changes that occur in the characteristics of the waste will be identified by the Generator and disclosed to Clean Earth prior to providing the waste to Clean Earth.  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

5. I certify that the analytical data attached hereto are derived from testing representative sample(s) as referenced in 40 CFR 261.20 or an equivalent state regulatory provision.  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
</table>

6. For sites that contain "clean fill," the undersigned certifies that a site investigation was conducted and that the soil was characterized according to the proposed Clean Earth facility(s) acceptance criteria for soil classification as "clean fill" and where applicable in accordance with the Pennsylvania Management of Fill Policy.  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
</table>

7. The undersigned has determined the non-hazardous status of the said waste in accordance with 40 CFR 261.11. Should, at any time after delivery, the material accepted by Clean Earth be found to be non-conforming to the information certified in this profile and represented by documentation attached hereto, it becomes the responsibility of the Generator/Agent to remove the waste from the designated Clean Earth facility within five (5) days of notification. Notification is to be verbal followed by written notification, overnight receipted. It is the Generator's/Agent's responsibility to abide by all Federal, State and Local regulations associated with the removal of their waste. If the waste is not removed within the specified time period, said disposal shall be arranged by a Clean Earth representative and billed to the Generator/Agent at cost plus basis. Furthermore, the Generator/Agent will be responsible for any and all cost for decontamination required by the Clean Earth facility that is related to the Generator's/Agent's material and all liability for such nonconforming waste shall revert to Generator/Agent.  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

*Certification*

Signature: ___________________________  
Date: ___________________________  
Company: ___________________________

*If someone other than the Generator is signing this profile or intends to sign any paperwork (which includes, but is not limited to, additional certifications, manifests, etc.) pertaining to this waste profile, authorization from the Generator, on the Generator's letterhead, must be supplied to Clean Earth prior to acceptance of waste material.*

### E. Clean Earth Waste Approval Decision

1. Treatment Option(s)

2. Proposed Treatment Facility(s)

3. Supplemental Information (special handling, hours of acceptance, etc.):

4. Approval Decision:  

<table>
<thead>
<tr>
<th>Approved</th>
<th>Denied</th>
</tr>
</thead>
</table>

Approved Tonnes:

4a. If denied, please indicate reason in the space provided:


5. Approval Signature: ___________________________  
Date: ___________________________

6. Facility Manager's Signature: ___________________________  
Date: ___________________________
ATTACHMENT F

WASTE MANAGEMENT TESTING AND DOCUMENTATION REQUIREMENTS
This form must be fully and accurately completed. All required information must be typed or legibly printed in the spaces provided. If additional space is necessary, identify each attached sheet as Form U, reference the item number and identify the date prepared. The date on attached sheets needs to match the date noted below.

Date Prepared/Revised

SECTION A. LANDFILL CLIENT (LANDFILL OR PROCESSING FACILITY OWNER) INFORMATION

<table>
<thead>
<tr>
<th>DEP Client ID#</th>
<th>DEP Client Type / Code</th>
</tr>
</thead>
</table>

Organization Name or Registered Fictitious Name
Waste Management Disposal Services of PA, Inc.

SECTION B. LANDFILL SITE (LANDFILL OR PROCESSING FACILITY) INFORMATION

<table>
<thead>
<tr>
<th>DEP Site ID#</th>
<th>Site Name</th>
<th>Landfill Permit ID#</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G.R.O.W.S. Landfill</td>
<td>100148</td>
</tr>
</tbody>
</table>

Site Contact Last Name | First Name | MI | Suffix
|-----------------------|-----------|----|------|

Site Contact Title | Site Contact Email Address

SECTION C. GENERATOR CLIENT (GENERATOR OF THE WASTE) INFORMATION

<table>
<thead>
<tr>
<th>Company Name</th>
<th>DEP Generator ID#</th>
</tr>
</thead>
</table>

Company Contact Last Name | First Name | MI | Suffix
|--------------------------|-----------|----|------|

Company Mailing Address Line 1 | Company Mailing Address Line 2

Company Address Line 1 – City | State | Zip+4 | Country
|-------------------------------|-------|-------|-------|

Company Phone | Ext | Company Email Address
|---------------------|-----|-------------------------|

Company Contact Last Name | First Name | MI | Suffix
|--------------------------|-----------|----|------|

Contact Phone | Ext | Contact Email Address
|---------------|-----|-------------------------|

If a Subsidiary, Name of Parent Company

Is the waste generated at the Company Mailing Address (noted above)?
☐ Yes  ☐ No
If ‘No’, describe location of waste generation and storage.

SECTION D. WASTE DESCRIPTION

<table>
<thead>
<tr>
<th>Residual Waste Code</th>
<th>Residual Waste Code Description</th>
<th>Amount</th>
<th>Unit of Measure</th>
<th>Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>cu yd</td>
<td>One Time</td>
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<td>ton</td>
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</tr>
</tbody>
</table>

1. GENERAL PROPERTIES

a. pH Range to (based on analyses or knowledge)
b. Physical State
   - Liquid Waste (EPA Method 9095)
   - Solid (EPA Method 9095)
   - Gas (ambient temperature & pressure)
c. Physical Appearance Color
   - Number of Solid or Liquid Phases of Separation
   - Odor
   - Describe each phase of separation.

Page 1 of 3
d. Attached is information from the generator certifying that a hazardous waste determination has been done and that the waste is not hazardous waste as defined in 40 CFR 261, as incorporated by reference at 25 Pa. Code 261a.1. Caution: If 'No', the application form is incomplete.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td>d.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

e. Is the waste treated hazardous waste?  
If 'Yes', list the hazardous waste code(s) that apply to the hazardous waste before treatment.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If 'Yes', what treatment option was selected?

What limit was required to be met by the treatment option?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

f. Has the waste been delisted as a hazardous waste by DEP or US EPA?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>f.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

g. Has the waste been accepted for disposal/processing at another Pennsylvania facility?
If 'Yes', list the facility permit ID number(s).

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>g.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

h. Has an application for disposal/processing of the waste at another Pennsylvania facility been submitted?  
If 'Yes', list the facility permit ID number(s).

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>h.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

2. CHEMICAL ANALYSIS ATTACHMENTS

a. Has a detailed physical and chemical characterization of the waste and its leachate been conducted?
If 'No', provide detailed explanation supporting use of generator knowledge in lieu of actual chemical analysis.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If 'Yes', attached is a description of the waste sampling method, in accordance with the waste sampling plan as required in §271.611(a)(3) or §287.132(a)(3).

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. Laboratory Accreditation Number

---

3. PROCESS DESCRIPTION & SCHEMATIC ATTACHMENTS

a. Attached is a detailed description of the manufacturing and/or pollution control processes producing the waste.
If 'No', provide explanation.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. Attached is a schematic of the manufacturing and/or pollution control processes producing the waste.
If 'No', provide explanation.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>b.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c. Attached is the substantiation for a confidentiality claim (if portions of the information submitted are confidential).

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>c.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

4. CHEMICAL ANALYSIS WAIVER

Categories of residual wastes that qualify for the waiving of chemical analysis by the Department are listed below. Check the appropriate box(es) that match the waste proposed to be accepted for disposal.

- burnt demolition debris
- cured rubber scrap
- fabric/cloth/textile/leather wastes (excluding treatment sludges)
- food wastes (excluding treatment sludges)
- metal scrap (excluding powdered grindings or if contaminated with fluids or oils)
- single scrap
- waste plastic (excluding extrusion manufacturing & uncured resins)
- Other (explain)
- carpet scraps
- empty containers (uncontaminated)
- fiberglass insulation scrap
- hot drained used oil filters (non-terne plated)
- sawdust (excluding treated wood)
- waste paper
- wood wastes (excluding treated wood)

All waste types not listed above must be approved in writing in the permit by the Department prior to processing or disposal facility acceptance.

---

SECTION E: PROPOSED PROCESSING, STORAGE AND/OR DISPOSAL METHOD

Will any special handling procedures (besides direct disposal) described in the waste acceptance plan, be used when managing the waste?
If 'Yes', describe.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Is this material re-used for construction or operation of the facility?
If 'Yes', describe.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Page 2 of 3
**SECTION F: SOURCE REDUCTION STRATEGY**

Form 25R must be completed by the generator and attached to this application unless waived in the instructions to that form.

Form 25R attached.  □ Yes  □ No  □ Waived

---

**SECTION G: CERTIFICATION OF PROCESSING OR DISPOSAL FACILITY**

I hereby certify that the statements of fact contained therein are true and correct to the best of my knowledge, information and belief. This statement and verification is made subject to the penalties of 18 Pa. C.S.A. Section 4904, relating to un-sworn falsification to authorities.

<table>
<thead>
<tr>
<th>Name of Responsible Official</th>
<th>Title</th>
</tr>
</thead>
</table>

Signature ___________________________  Date ___________________________
FORM U
REQUEST TO PROCESS OR DISPOSE OF RESIDUAL WASTE
INSTRUCTIONS

GENERAL INFORMATION

To Obtain DEP Application Packages. To expedite the processing of the applicant’s request, the Department of Environmental Protection (DEP) asks that you use the most up-to-date application package available. The most recent version of this package can be obtained by contacting the appropriate DEP office, or through our Web site noted below. This package, as well as other Department-wide and/or program-specific permit application form packages are available in Microsoft Word format at this same web location. Applicants can download the appropriate form to a personal computer, complete the form electronically, and print the document for submittal to the Department.

www.depweb.state.pa.us, Keyword: “Permits”

General Instructions. This package is designed to assist an existing client with DEP in completing the application form. Clients that do not currently exist with DEP should complete a Form R, Waste Analyses & Classification Plan. Please type or print clearly when completing the form. If information needed is more than space allows, attach additional sheets as necessary. If a question is not applicable to you or your application, write NA in the appropriate box.

A full application for this application package will consist of completion of this Form U application and submittal of all attachments noted in the application. Caution: Information from the generator certifying that a hazardous waste determination has been done and that the waste is not hazardous waste as defined in 40 CFR 261, as incorporated by reference at 25 Pa. Code 261a.1 must be attached to the submitted application for it to be considered complete.

Date Prepared/Revised. Provide the date the application was prepared and/or revised. When additional sheets are attached to include additional information, identify each attached sheet as Form U, reference the item number and identify the date prepared/revised.

DEFINITIONS

To provide the applicant with a better understanding of terminology, we are including the following definitions.

eFACTS (Environment, Facility, Application, Compliance Tracking System). The Department of Environmental Protection’s electronic application system to document and maintain client, site and facility data for purposes of authorizing regulated activities and tracking compliance.

eNotice. DEP has developed a comprehensive environmental compliance information reporting system to give the public access to permitting and compliance information on individual facilities by program and by geographic area. This system is available by logging on to the DEP Web site and selecting eNOTICE.

Client (Responsible Party). A client (also referred to as Applicant) is a person or organization that requests approval from DEP to perform a regulated activity. Client information is documented and assigned an internal DEP Client ID# for tracking purposes.

For this particular application, there are two associated clients. One is the landfill owner and another is the generator of the waste.
Site (Place). A site is a physical location of importance to DEP. A site may include locations where a regulated facility is physically located or where a regulated activity occurs that has the potential to impact the health and safety of the citizens and/or the natural resources of the Commonwealth. A site is not solely defined by geographical location (can span several municipalities and even counties in some cases) but rather by the client/applicant’s purpose of doing business. All DEP programs involvement at a physical location of importance to DEP is grouped under one ‘entity’ – site. This holistic view of site will promote an understanding of the interrelationships of facilities to support pollution prevention; multi-media inspections; a Department-wide view of compliance; and public understanding and access of information. Site information is documented and assigned an internal DEP Site ID# for tracking purposes.

For this particular application, the site is the landfill.

Site-to-Client Relationships. DEP will create internal records to relate (link) each site with all clients associated with the site and/or its facilities.

Authorization. Any DEP approval. For example: permits, plans, approvals, licenses, registrations, certifications, etc. Authorization information is documented and assigned an internal DEP Auth ID# for tracking purposes.

DEP Client ID#. A Department-wide unique identification number is assigned by DEP to the client after client information is entered into DEP’s computer system (eFACTS). This one number identifies the client regardless of the program with which the client is working. This identification number will be identified on future correspondence from DEP as well as on client information available on our DEP Web site. When interacting with DEP, inclusion of this number will make it easier to process your request in a timely manner. If you know your Client ID#, enter it. If you are a new client to DEP, skip to the next request for information.

DEP Client Type Code. Enter the code that represents the type of client acting as the responsible authority for the permitted activity. The list of Client Type Codes can be found on the ‘Codes Client Type’ document included with this package and are also available on the DEP Web site under Department-wide General Information/Codes, Contacts & Maps.

Organization Name or Registered Fictitious Name. Clients must provide the name under which they conduct the activity or business in which the permit or other authorization will be issued.

DEP Site ID#. A Department-wide unique identification number is assigned to the site after site information is entered into DEP’s computer system (eFACTS). This one number identifies the site regardless of the program with which the applicant is working. This identification number will be identified on future correspondence from DEP as well as on site information available on our DEP Web site. When interacting with DEP, inclusion of this number will make it easier to process your application in a timely manner. If you know your Site ID#, enter it. If you are identifying a new site to DEP, skip to the next request for information.

Site Name. The name of the site (i.e., landfill) at the specific physical location. Do not use abbreviations, acronyms, etc.

Landfill Permit ID#. Provide the Landfill Permit ID number.
**Site Contact Information.** Provide the name of the person having overall responsibility for environmental matters at the site. Include the individual's name, title and email address.

**SECTION C: GENERATOR/CLIENT (GENERATOR OF THE WASTE) INFORMATION**

**Company Name.** Identify the company name. The generator of the waste is a second client associated with this application (the first client being the landfill owner). Include the company's mailing address, phone number and email address. Provide the DEP Generator ID number.

**Company Contact.** Identify the company's contact and include the contact's phone number and email address.

**Subsidiary/Parent Company.** If the company identified is a subsidiary, identify the name of the parent company.

**Waste Generation & Storage Location.** If the waste generated is not at the company's mailing address, describe the location of the waste generation and storage; and provide the township, county, and state.

**SECTION D: WASTE DESCRIPTION**

**Residual Waste.** Enter the code that represents the type of residual waste. The list of Residual Waste Codes (RWC) can be found on the ‘Codes Residual Waste’ document included with this package. Also include the code's description, the amount of waste; the unit of measurement, and the timeframe for disposal/processing. If the timeframe is 'one time' check the box; if other than 'one time' provide the appropriate timeframe.

1. **GENERAL PROPERTIES**

   a. **pH Range.** Indicate the pH range based on analyses or knowledge.

   b. **Physical State.** Check appropriate box to indicate physical state.

   c. **Physical Appearance.** Describe the color and odor of the waste. Enter the number of solid and/or liquid phases of separation and describe each phase. For example, two phases: one yellow oily liquid and one gray granular solid.

   d. **Hazardous Waste Determination.** Check the appropriate box to indicate if information certifying that a hazardous waste determination has been done and the waste is not hazardous waste as defined in 40 CFR 261, as incorporated by reference at 25 Pa. Code 261a.1.

      **Caution:** Certification must be supplied with the submitted application in order for the application to be administratively and technically complete.

   e. **Treated Hazardous Waste.** Check the appropriate box to indicate if the waste is treated hazardous waste. If 'Yes', list the hazardous waste code(s) that apply to the hazardous waste before treatment. If 'Yes', provide the selected option; and include what limit was required to be met by the treatment option. Check the appropriate box to indicate if you are providing a copy of the certification required under 40 CFR 268.7(a), as incorporated by reference at 25 Pa. Code 268a.1, that the waste meets all the land disposal restriction requirements, as specified in 40 CFR Part 268, Subpart D.

   f. **Delisted Hazardous Waste.** Check the appropriate box to indicate if the waste has been de-listed as a hazardous waste by DEP or US EPA.
g. Waste Accepted at Another PA Facility. Check the appropriate box to indicate if the waste has been accepted for disposal/processing at another Pennsylvania facility. If 'Yes', list the Facility ID number(s).

h. Application Submitted for Waste at Another PA Facility. Check the appropriate box to indicate if an application for disposal/processing of the waste at another Pennsylvania facility has been submitted. If 'Yes', list the Facility ID number(s).

2. CHEMICAL ANALYSIS ATTACHMENTS

a. Physical & Chemical Characterization. Check the appropriate box to indicate if a detailed physical and chemical characterization of the waste and its leachate has been conducted. If 'No', provide a detailed explanation supporting the use of generator knowledge in lieu of actual chemical analysis. If 'Yes', check the appropriate box to indicate if a description of the waste sampling method, in accordance with the waste sampling plan as required in §271.611(a)(3) or §287.132(a)(3), is attached.

At this time, the Department is waiving the chemical analysis required in this section for individual residual waste streams generated at a rate of less than 2,200 lbs. per month per generating location and are not destined for disposal at Class III residual waste landfills. At its discretion, the Department may decide this waiver is not appropriate for 'specific' waste streams and will notify the generator and/or facility that the chemical analysis of the waste stream is required. This waiver in no way affects the responsibility of the generator under 40 CFR 262.11, as incorporated by reference at 25 Pa. Code 262a.1, to determine whether or not the waste is hazardous waste.

The analytical methodologies used shall be those set forth in the most recent edition of the EPA's Test Methods for Evaluating Solid Waste (SW-846), Methods for Chemical Analysis of Water and Wastes (EPA 600/4-79-020), Standard Methods for the Examination of Water and Wastewater (prepared jointly by the American Public Health Association, American Water Works Association, and Water Environment Federation), or a comparable method subsequently approved by EPA or the Department.

The person taking the samples and the laboratory performing the analysis shall employ the quality assurance/quality control procedures described in the EPA’s Test Methods for Evaluating Solid Waste (SW-846) or Handbook for Analytical Quality Control in Water and Wastewater Laboratories (EPA 600/4-79-019).

All analyses submitted must specify the method used and any special preparation, deviation from the method, or pertinent observations. Each analysis sheet must include: date of sampling, date of analysis, name of laboratory performing test, laboratory accreditation number, laboratory contact person and phone number. Analytical determinations should be run on the samples, as is, unless otherwise specified in the cited method. Report the analyses in mg/kg on a dry weight basis for solids or in mg/L for liquids, or as otherwise specified in cited method.

No single analytical method is applicable for all waste streams and some modifications may be necessary for unusual waste types. Any modifications, however, must be approved by the Department.

For contaminated soil, the top twelve inches of soil should be removed prior to sampling. Unless otherwise approved by the Department, a minimum of one sample shall be taken for every 250 cubic yards of contaminated soil. Field screening methods may be employed to reduce the number of samples required, provided by the screening method and if pre-approved by the Department. For samples used to determine volatile organics (VOCs), EPA Method 5035 shall be employed on grab samples. Composite sampling shall not be used to determine volatile organics. Attach a map of the spill or cleanup site including a diagram of the sample collection area.
If the sample is of unknown origin or characteristics, contact the appropriate Department regional office prior to analysis.

The analysis must include the following list of parameters as specified by facility type unless generator certifies in writing the absence of the parameter based on his or her knowledge of the manufacturing or pollution control processes:

- Parameters for all facilities:
  - pH
  - Ignitability
  - Reactive Sulfide
  - Reactive Cyanide
  - Toxicity Characteristic Leaching Procedure (TCLP) - include all parameters found in 40 CFR 261.24, as incorporated by reference at 25 Pa. Code 251a.1, as well as pH of extract. Report all results in mg/L or as otherwise specified in method.

- Additional parameters for Class I residual waste and municipal waste disposal facilities:
  - Additional TCLP parameters - copper, nickel, zinc
  - Free Liquids
  - PCBs
  - Water Leaching Procedure (ASTM) Method D3987) - COD, Total Solids, Oil and Grease or Petroleum Hydrocarbons, and Ammonia-Nitrogen. Report all results in mg/L or as otherwise specified in method.
  - Total Solids
  - Total Volatile Solids
  - Total Oil and Grease or Petroleum Hydrocarbons
  - For contaminated soil, TCLP results for other contaminants found in the soil. [Note: if an acidic extraction fluid is inappropriate for a particular parameter(s), a water leaching procedure (ASTM Method D3987) may be used.

- Additional parameters for Class II and Class III residual waste disposal facilities:
  - All additional parameters required for Class I facilities.
  - Additional TCLP parameters - iron, manganese.
  - Phenolics.
  - Additional Water Leaching Procedure parameters - chloride, cyanide, fluoride, nitrate, nitrite, sulfate, total organic halide.

- Other additional parameters for disposal facilities may be necessary due to the nature of the waste or conditions at the disposal facility. Constituents which could exceed the leachate limit for the class of facility, impact the liner, leachate treatment, air quality, compatibility to other wastes disposed at the facility, or induce harm to facility personnel should be identified and quantitated by generator. The facility operator or the Department may also require the determination of additional parameters for these reasons.

- The use of alternate leaching procedures for determining waste acceptability in monofills may be allowed by the Department.
Additional parameters for processing facilities may be necessary due to the nature of the waste processing and to comply with conditions of the facility permit. In addition, constituents which could impact the process, compatibility of process residuals from waste with treatment system, air quality, compatibility to other wastes processed at the facility, or induce harm to facility personnel should be identified and quantitated by generator. The facility operator or the Department may also require the determination of additional parameters for these reasons.

If the waste is known or suspected to have radioactivity above normal background levels for that material, the waste may need to be radiologically screened and modeled before disposal or processing. Contact the Regional Solid Waste Manager for additional guidance on analytical and other requirements.

b. Laboratory Accreditation Number. Also provide the Laboratory Accreditation Number.

a. Manufacturing and/or Pollution Control Processes. Check the appropriate box to indicate if a detailed description of the manufacturing and/or pollution control processes producing the waste is attached. If this documentation is not attached, provide an explanation as to why they are not attached.

Describe the manufacturing process that produced the waste and any pollution control methods involved. This must include the raw materials used in the process, any intermediate products formed, final products, and any substances added during treatment. For non-hazardous waste, provide sufficient detail to demonstrate the waste is not a listed hazardous waste. For example:

"Resin Resin Manufacture"

"These resins are formed by reacting phenol, or a substituted phenol with formaldehyde which contains an excess of formaldehyde. An alkali (sodium hydroxide) is used to catalyze the polymerization which takes place at a pH of between 8 and 11 and at a temperature of 60°C."

"When the desired degree of polymerization has occurred, the kettle is cooled to about 35°C to inhibit further reaction. The caustic may be neutralized in the kettle with sulfuric acid at this time. The water from this distillation forms a concentrated waste of unreacted materials and low molecular weight resin."

"The batch is dumped, and depending on the specific resin, the batch may be washed several times and a vacuum may be used during the dehydration cycle. It is important that molten resin be handled quickly to avoid its setting up to an insoluble, infusible mass which would become a waste."

For contaminated soil, describe the source of the contamination and type of facility where spill occurred. If manufacturing, indicate the products and raw materials produced, used, or stored in the vicinity of the spill, discharge, or release. If a waste management facility, indicate the wastes processed, treated, disposed, or stored in the vicinity of the spill or release. If the source of contamination was from spills or release of virgin petroleum fuel only, use Form FC-1 instead of this form.

b. Schematic of Manufacturing and/or Pollution Control Processes. Check the appropriate box to indicate if a schematic of the manufacturing and/or pollution control processes producing the waste is attached.

Provide, on 8½ x 11" size paper, flow schematics of the manufacturing and/or pollution control processes generating the waste stream starting with the raw materials and ending with the final products. (See example below.)
c. Confidentiality Claim. Check the appropriate box to indicate if the substantiation for a confidentiality claim (if portions of the information submitted are confidential) is attached.

Information submitted to the Department in this portion of the form may be claimed as confidential by the applicant. If no claim is made at the time of submission, the Department shall make the information available to the public without further notice.

Claim of confidentiality shall address the following:

- The portions of the information claimed to be confidential.
- The length of time the information is to remain confidential.
- The measures taken to guard undesired disclosure of the information to others.
- The extent to which the information has been disclosed to others and the precautions taken in connection with that disclosure.
- A copy of pertinent confidentiality determinations by EPA or any other federal agency.
- The nature of the substantial harm to the competitive position by disclosure of the information, the reasons it should be viewed as substantial, and the relationship between the disclosure and the harm.

### 4. CHEMICAL ANALYSIS WAIVER

**Waiving of Chemical Analysis.** Categories of residual wastes that qualify for the waiving of chemical analysis by the Department are listed on the form. Check the appropriate box(es) that match the waste proposed to be accepted for disposal. All waste types not listed on the form must be approved (in writing) in the permit by the Department prior to processing or disposal facility acceptance.

The Department may waive chemical analysis requirements for categories of residual wastes. **Wastes which have the potential to be hazardous or may adversely impact liner system or leachate treatability do not qualify for this waiver.**

Check the appropriate box(es) that matches the waste from the list provided. Typically, the qualifying residual wastes will include wood wastes, fabric/cloth/textile/leather wastes, waste paper, waste plastics, carpet wastes, etc.
In addition, other residual wastes may be considered and approved provided adequate documentation and justification are submitted to the Department by the processing or disposal facility operator and approved in the permit. A petition for such a waiver should include a demonstration to the Department's satisfaction, if additional analysis of a waste is not necessary, to determine that the waste can be received at the facility without adversely affecting the effectiveness of waste processing operations and established emission and wastewater discharge limits.

SECTION E: PROPOSED PROCESSING, STORAGE AND/OR DISPOSAL METHOD

Special Handling Procedures. Check the appropriate box to indicate if any special handling procedures (besides direct disposal) described in the waste acceptance plan will be used when managing the waste.

If 'Yes', briefly describe the method proposed to process this waste stream. For example, "Solvent removed from waste by solvent recovery apparatus to less than 1% solvent. Recovered solvent is sold to XYZ, Inc. for reclamation. Solids are polymerized and the remaining solvent is driven off by heat."

If 'Yes', briefly describe the method proposed to store this waste stream and its compatibility with the storage container, the waste pile liner, or the surface impoundment liner. For example, "Paint waste is placed into 55 gal. steel drums and is proposed to be stored at the XYZ Waste Disposal Company's storage building for 60 days prior to processing. The paint waste is compatible with its container and the other wastes stored in the immediate vicinity. The proposed location for the paint waste within the building is indicated on the attached drawing."

If 'Yes', briefly describe the method proposed to dispose of this waste stream. For example, "Polymerized solids are to be placed in a segregated cell of XYZ Waste Disposal Company with compatible wastes as indicated on the attached drawing. The cell is located at coordinates D-7. The cell design has been approved as part of the facility permit."

Material Re-Used. Check the appropriate box to indicate if this material is re-used for construction or operation of the facility. If 'Yes', briefly describe a viable alternative to your proposal.

SECTION F: SOURCE REDUCTION STRATEGY

Form 25R, Source Reduction Strategy. Form 25R must be completed by the generator and attached to this application unless waived in the instructions to that form. Check the appropriate box to indicate if a completed Form 25R is attached; or has been waived.

SECTION G: CERTIFICATION OF PROCESSING OR DISPOSAL FACILITY

The application must be certified in the following manner:

- **Corporation.** A corporate officer must sign the document and the corporate seal must be affixed.
- **Limited Partnerships.** A general partner must sign the document.
- **All Other Partnerships.** A partner must sign the document.
- **Sole Proprietorships.** The proprietor must sign the document.
- **Municipal, State, or Federal Authority or Agency.** An executive officer or ranking elected official responsible for compliance of the authority's or agency's waste activities and facilities with all applicable regulations must sign the document.
• The general manager or chief operator of the facility must sign the document.

APPLICANT'S CHECKLIST

To assure your application is complete, we are providing a convenient checklist of what may need to be attached to the application as well as who to contact for additional information. This checklist is optional and need not be returned with the completed application.

DEP OFFICES

Department-wide general information to assist the client with appropriate DEP contact information for regional, central, and district mining offices and the counties they serve can be found on the ‘Contacts & DEP Offices’ document included with this package. This information is also available on the DEP Web site under Department-wide General Information/Codes, Contacts & Maps.
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For samples used to determine volatile organics (VOCs), EPA method 5035 shall be employed on grab samples. Composite samples shall not be used to determine volatile organics.
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<th>Parameter</th>
<th>Maximum Allowable Levels (concentrations): mg/l</th>
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<td>Barium</td>
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<td>Cadmium</td>
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<td>Lead</td>
<td>&lt;5.0</td>
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<td>Silver</td>
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<td><strong>Additional TCLP Metals</strong></td>
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<tr>
<td>Nickel</td>
<td>&lt;5,000, (Case by Case Basis)</td>
</tr>
<tr>
<td>Zinc</td>
<td>&lt;5,000, (Case by Case Basis)</td>
</tr>
<tr>
<td><strong>TCLP Volatile Organics</strong></td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>&lt;100.0</td>
</tr>
<tr>
<td>Chloroform</td>
<td>&lt;6.0</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>1,1-Dichloroethylene</td>
<td>&lt;0.7</td>
</tr>
<tr>
<td>Methyl Ethyl Ketone</td>
<td>&lt;200.0</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>&lt;0.7</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td><strong>Additional TCLP Volatile Organics</strong></td>
<td></td>
</tr>
<tr>
<td>Ethyl benzene</td>
<td>&lt;1,000</td>
</tr>
<tr>
<td>Toluene</td>
<td>&lt;1,000</td>
</tr>
<tr>
<td>Xylene</td>
<td>&lt;1,500</td>
</tr>
<tr>
<td><strong>TCLP Semi-Volatiles (Base Neutrals)</strong></td>
<td></td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>&lt;7.5</td>
</tr>
<tr>
<td>Hexachlorobenzene</td>
<td>&lt;0.13</td>
</tr>
<tr>
<td>Hexachlorobutadiene</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Hexachloroethane</td>
<td>&lt;3.0</td>
</tr>
<tr>
<td>Nitrobenzene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Pyridine</td>
<td>&lt;5.0</td>
</tr>
<tr>
<td>2,4-Dinitrotoluene</td>
<td>&lt;0.13</td>
</tr>
<tr>
<td><strong>TCLP Semi-Volatiles (Acid Compounds)</strong></td>
<td></td>
</tr>
<tr>
<td>o-Cresol</td>
<td>&lt;200.0</td>
</tr>
<tr>
<td>m-Cresol</td>
<td>&lt;200.0</td>
</tr>
<tr>
<td>p-Cresol</td>
<td>&lt;200.0</td>
</tr>
<tr>
<td>Cresol, Total</td>
<td>&lt;200.0</td>
</tr>
<tr>
<td>Pentachlorophenol</td>
<td>&lt;100.0</td>
</tr>
<tr>
<td>2,4,5-Trichlorophenol</td>
<td>&lt;400.0</td>
</tr>
<tr>
<td>2,4,6-Trichlorophenol</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td><strong>TCLP Pesticides</strong></td>
<td></td>
</tr>
<tr>
<td>Chlordane</td>
<td>&lt;0.03</td>
</tr>
<tr>
<td>Endrin</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>Heptachlor (and its hydroxide)</td>
<td>&lt;0.008</td>
</tr>
<tr>
<td>Lindane</td>
<td>&lt;0.4</td>
</tr>
<tr>
<td>Methoxychlor</td>
<td>&lt;10.0</td>
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<tr>
<td>Toxaphene</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td><strong>TCLP Herbicides</strong></td>
<td></td>
</tr>
<tr>
<td>2,4-D</td>
<td>&lt;10.0</td>
</tr>
<tr>
<td>2,4,5-TP (silvex)</td>
<td>&lt;1.0</td>
</tr>
</tbody>
</table>

Revised: 8/26/02  

[Signature]
<table>
<thead>
<tr>
<th>Parameter:</th>
<th>Maximum Allowable Levels (concentrations):</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>2.0 &lt; x &lt; 12.5 s.u.</td>
</tr>
<tr>
<td>Ignitability</td>
<td>&gt; 140 Degrees, Fahrenheit</td>
</tr>
<tr>
<td>Reactive Sulfide</td>
<td>&lt; 500 mg/kg or ppm</td>
</tr>
<tr>
<td>Total Cyanide</td>
<td>≤ 200 mg/kg, if ≥ 200 mg/kg (Contact Dept. for additional testing)</td>
</tr>
<tr>
<td>*Reactive Cyanide</td>
<td>&lt; 250 mg/kg or ppm</td>
</tr>
<tr>
<td>Free Liquids</td>
<td>Must pass test for wastes not requiring solidification</td>
</tr>
<tr>
<td><strong>PCB's</strong></td>
<td>If ≥ 50 mg/kg, then must be &lt;0.1 mg/l on leach., if leaching test is feasible, PCB Megarule applicable</td>
</tr>
<tr>
<td>Total Volatile Solids</td>
<td>&lt; 90%, if &gt;5% for processed Medical Waste Incin. Ash additional information and testing may be necessary</td>
</tr>
<tr>
<td>***Total Oil &amp; Grease or TPH</td>
<td>If ≥ 10,000 mg/kg and if the source of contamination is ignitable than an F.P. test must be performed</td>
</tr>
<tr>
<td>Total Solids</td>
<td>No Limit, if less than 20%, must pass paint filter test or undergo solidification</td>
</tr>
</tbody>
</table>

Note:

(*) Reactive Cyanide may not need to be performed unless the method has been modified to produce more reliable results.

(**) Non-leaking small electrical capacitors that are bot TSCA regulated and exceed or equal the PCB concentration of 50 mg/kg will be of small quantity.

(***) Total Oil and Grease and TPH concentrations greater than 500,000 mg/kg will require the generator to certify that the material is not saturated and/or may also require more analytical testing and/or Material Safety Data Sheets.

**Excluded Hazardous Wastes** – The above stated MALs may be exceeded for an excluded hazardous waste based upon the criteria specified in the facility’s WACP permit conditions.
CHECKLIST FOR DISPOSAL REQUEST SUBMISSIONS

FORM U

Before submitting any information to Waste Management of Pennsylvania, Inc., be certain you are including the following material:

☐ Schematic or Flow Chart of Process Generating Waste

☐ Description of Process Generating Waste
  1. list of products generated (if applicable)
  2. brief history of facility

☐ Sampling Schematic or Map:
  1. show how composite sample was generated

☐ Sampling Description:
  1. explain how composite sample was collected

☐ Form U Application

☐ Generator’s Waste Profile Sheet

☐ Sample of waste material (3 liter composite sample- If WM handling sampling)

☐ Analytical Fee or Copy of Completed Analytical

☐ Form 25R - Source Reduction Strategy (if annual generation)

☐ Material Safety Data Sheets (if applicable)

☐ Certificate of Non-Hazardous Waste
### Residual Waste Code List

**GROWS, TRRF**

#### 000 Combustion Residues
- 3-3 A 001 Coal-Derived Bottom Ash
- 3-3 A 002 Coal-Derived Fly Ash
- 3-3 A 003 Flue Gas Desulfurization Residue (FGD)
- 3-3 A 004 Incinerator Bottom Ash
- 3-3 A 005 Incinerator Fly Ash
- 3-3 A 006 Incinerator Mixed Ash
- 3-3 A 007 Other Ash

#### 100 Metallurgical Process Residues
- 3-3 A 101 Foundry Sand
- 3-3 A 102 Slag
- 3-3 A 103 Refractory Material
- 3-3 A 104 Grindings, Shavings
- 3-3 A 105 Ferrous Baghouse Dust
- 3-3 A 106 Non-Ferrous Baghouse Dust
- 3-3 A 107 Ferrous Scrap, including Auto Recycle
- 3-3 A 108 Non-Ferrous Scrap

#### 200 Sludges, Scales
- 3-3 A 201 Water Treatment Sludge
- 3-3 A 203 Industrial Wastewater Treatment Sludge, including Acid Mine Drainage Sludge
- 3-3 A 204 Metallurgical Sludge
- 3-3 A 205 Food Processing Sludge
- 3-3 A 206 Paint, Coating Sludge and Scale
- 3-3 A 207 Tank Bottoms
- 3-3 A 208 Still Bottoms
- 3-3 A 209 Oily Sludge, Petroleum Derived
- 3-3 A 210 Emission Control Sludge
- 3-3 A 211 Other Industrial Sludge
- 3-3 A 212 Lime/Cement Kiln Scale, Residue
- 3-3 A 213 Lime - Stabilized Spent Pickle Liquor

#### 300 Chemical Wastes
- 3-3 B 301 Acidic Chemicals (pH < 6)
- 3-3 B 302 Basic Chemicals (pH > 8)
- 3-3 B 303 Combustible Chemicals
- 3-3 B 304 Chemical Salts
- 3-3 A 305 Carbon Residues (e.g., Decoloring, Filtering)
- 3-3 A 306 Surface Coatings (e.g., Solid, Semi-Solid Paints, Polishes, Adhesives, Inks)
- 3-3 A 307 Filter Aids (e.g., Diatomaceous Earth, etc.)
- 3-3 B 308 Filter Media
- 3-3 B 309 Spent Dyes
- 3-3 B 310 Detergents, Cleaning Agents
- 3-3 B 311 Off-Specifications Products, Intermediates
- 3-3 B 312 Pharmaceutical Wastes

#### 400 Generic Wastes
- 3-3 B 401 Leather Waste
- 3-3 B 402 Rubber, Elastomer Wastes
- 3-3 B 403 Wood Wastes (Including gypsum, particle board, sawdust, shavings)
- 3-3 B 404 Paper, Cardboard Wastes
- 3-3 B 405 Textile Wastes (Including yarn, fabric, fiber, elastic)
- 3-3 B 406 Glass Wastes (Excluding industrial refractory material)
- 3-3 B 407 Polyethylene, Polypropylene, Polyurethane and Other Non-Halogenated Plastics
- 3-3 B 408 Glass Reinforced Plastics
- 3-3 B 409 Halogenated Plastics (PVC, Teflon, CPE)
- 3-3 B 410 Electronic Component Wastes
- 3-3 B 411 Agricultural Wastes
- 3-3 B 412 Photographic Wastes - Film, Photographic Paper
- 3-3 B 413 Asphalt (Blistomious)
- 3-3 B 414 Ceramic Wastes
- 3-3 B 415 Linoleum Wastes
- 3-3 A 416 Thermal Insulation Wastes (cellulose, glass, wool)
- 3-3 A 417 Wiring, Conduit, Electrical Insulation

---

**Residual Waste Code List**

**GROWS, TRRF**

#### 500 Special Handling Residues
- 3-3 B 501 Asbestos-Containing Waste
- 3-3 B 502 PCB-Containing Waste
- 3-3 B 503 Oil Contaminated Waste (soils, spent absorbent, oily rags, booms)
- 3-3 A 505 Spent Catalysts
- 3-3 A 508 Virgin Petroleum Fuel (contaminated soil & debris)
- 3-3 A 509 Waste Oil Contaminated Waste (soils, spent absorbent, oily rags, booms)
- 3-3 A 510 Waste Tires
- 3-3 A 511 Municipal Sewage Sludge
- 3-3 A 512 Sterilized Infectious Waste, Chemotherapeutic Waste (including Incinerated)
- 3-3 A 513 Ash Residue from a Solid Waste Incineration Facility

#### 700 Industrial Equipment, Scrap
- 3-3 B 701 Pumping, Piping, Vessels, Instruments, Storage Tanks
- 3-3 B 702 Scrap Materials from Maintenance

#### 800 Non-Coal Mining Wastes
- 3-3 B 801 Drilling Residuals

---

**Analysis Table**

<table>
<thead>
<tr>
<th>Residual Waste Code List</th>
<th>Analysis Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-3 B 501 Asbestos-Containing Waste</td>
<td>3-3 B</td>
</tr>
<tr>
<td>3-3 B 502 PCB-Containing Waste</td>
<td>3-3 B</td>
</tr>
<tr>
<td>3-3 B 503 Oil Contaminated Waste (soils, spent absorbent, oily rags, booms)</td>
<td>3-3 A</td>
</tr>
<tr>
<td>3-3 A 505 Spent Catalysts</td>
<td>3-3 A</td>
</tr>
<tr>
<td>3-3 A 508 Virgin Petroleum Fuel (contaminated soil &amp; debris)</td>
<td>3-3 A</td>
</tr>
<tr>
<td>3-3 A 509 Waste Oil Contaminated Waste (soils, spent absorbent, oily rags, booms)</td>
<td>3-3 A</td>
</tr>
<tr>
<td>3-3 A 510 Waste Tires</td>
<td>3-3 A</td>
</tr>
<tr>
<td>3-3 A 511 Municipal Sewage Sludge</td>
<td>3-3 A</td>
</tr>
<tr>
<td>3-3 A 512 Sterilized Infectious Waste, Chemotherapeutic Waste (including Incinerated)</td>
<td>3-3 A</td>
</tr>
<tr>
<td>3-3 A 513 Ash Residue from a Solid Waste Incineration Facility</td>
<td>3-3 A</td>
</tr>
<tr>
<td>3-3 B 701 Pumping, Piping, Vessels, Instruments, Storage Tanks</td>
<td>3-3 B</td>
</tr>
<tr>
<td>3-3 B 702 Scrap Materials from Maintenance</td>
<td>3-3 B</td>
</tr>
<tr>
<td>3-3 B 801 Drilling Residuals</td>
<td>3-3 B</td>
</tr>
</tbody>
</table>

---

See FC-1 Permit Appendix V

Analysis on representative samples per 500 cubic yards of material based on project work plan and parameters of concern

See PADER Form 43 Analysis Appendix IX

See PADER Form 35 Analysis Appendix X

See PADER Form 36 Analysis Appendix XI
Generator's Nonhazardous Waste Profile Sheet

A. Waste Generator Facility Information (must reflect location of waste generation/origin)

1. Generator Name:
2. Site Address:
3. City/ZIP:
4. State:
5. County:
6. Contact Name/Title:
7. Email Address:
8. Phone:
9. FAX:
10. NAICS Code:
11. Generator USEPA ID #:
12. State ID# (if applicable):

B. Customer Information □ same as above

1. Customer Name:
2. Billing Address:
3. City, State and ZIP:
4. Contact Name:
5. Contact Email:
6. Phone: FAX:
7. Transporter Name:
8. Transporter ID # (if appl):
9. Transporter Address:
10. City, State and ZIP:

C. Waste Stream Information

1. DESCRIPTION
   a. Common Waste Name:
   b. Describe Process Generating Waste or Source of Contamination:
   c. Typical Color(s):
   d. Strong Odor? □ Yes □ No Describe:
   e. Physical State at 70°F: □ Solid □ Liquid □ Powder □ Semi-Solid or Sludge □ Other:
   f. Layers? □ Single layer □ Multi-layer □ NA
   g. Water Reactive? □ Yes □ No If Yes, Describe:
   h. Free Liquid Range (%): _______ to _______ □ NA(solid)
   i. pH Range: □ ≤2 □ 2.1-12.4 □ ≥12.5 □ NA(solid) □ Actual: _________
   j. Liquid Flash Point: □ < 140°F □ ≥ 140°F □ NA(solid) □ Actual: _________
   k. Flammable Solid: □ Yes □ No
   l. Physical Constituents: List all constituents of waste stream - (e.g. Soil 0-80%, Wood 0-20%): □ (See Attached)

<table>
<thead>
<tr>
<th>Constituents (Total Composition Must be = 100%)</th>
<th>Lower Range</th>
<th>Unit of Measure</th>
<th>Upper Range</th>
<th>Unit of Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
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<tr>
<td>3.</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. ESTIMATED QUANTITY OF WASTE AND SHIPPING INFORMATION
   a. □ One Time Event □ Base □ Repeat Event
   b. Estimated Annual Quantity: □ Tons □ Cubic Yards □ Drums □ Gallons □ Other (specify): _________
   c. Shipping Frequency: _______ Units per □ Month □ Quarter □ Year □ One Time □ Other
   d. Is this a U.S. Department of Transportation (USDOT) Hazardous Material? (If yes, answer e.) □ Yes □ No
   e. USDOT Shipping Description (if applicable):

3. SAFETY REQUIREMENTS (Handling, PPE, etc.):
**Generator's Nonhazardous Waste Profile Sheet**

### D. Regulatory Status (Please check appropriate responses)

1. Is this a USEPA (40 CFR Part 261)/State hazardous waste? If yes, contact your sales representative.  
   - Yes  
   - No

2. Is this waste included in one or more of categories below (Check all that apply)? If yes, attach supporting documentation.  
   - Delisted Hazardous Waste  
   - Excluded Wastes Under 40 CFR 261.4  
   - Treated Hazardous Waste Debris  
   - Treated Characteristic Hazardous Waste  
   - Yes  
   - No

3. Is the waste from a Federal (40 CFR 300, Appendix B) or state mandated clean-up? If yes, see instructions.  
   - Yes  
   - No

4. Does the waste represented by this waste profile sheet contain radioactive material?  
   - Yes  
   - No

   a. If yes, is disposal regulated by the Nuclear Regulatory Commission?  
      - Yes  
      - No

   b. If yes, is disposal regulated by a State Agency for radioactive waste/NORM?  
      - Yes  
      - No

5. Does the waste represented by this waste profile sheet contain concentrations of regulated Polychlorinated Biphenyls (PCBs)?  
   - Yes  
   - No

   a. If yes, is disposal regulated under TSCA?  
      - Yes  
      - No

6. Does the waste contain untreated, regulated, medical or infectious waste?  
   - Yes  
   - No

7. Does the waste contain asbestos?  
   - Yes  
   - No  
   - If Yes, is Friable  
     - Yes  
     - No  
     - Non Friable

8. Is this profile for remediation waste from a facility that is a major source of Hazardous Air Pollutants (Site Remediation NESHAP, 40 CFR 63 subpart GGGG)?  
   - Yes  
   - No

   If yes, does the waste contain <500 ppm volatile organic compounds (VOCs) at the point of determination?  
   - Yes  
   - No

### E. Generator Certification (Please read and certify by signature below)

By signing this Generator's Waste Profile Sheet, I hereby certify that all:

1. Information submitted in this profile and all attached documents contain true and accurate descriptions of the waste material;

2. Relevant information within the possession of the Generator regarding known or suspected hazards pertaining to this waste has been disclosed to WM/the Contractor;

3. Analytical data attached pertaining to the profiled waste was derived from testing a representative sample in accordance with 40 CFR 261.20(c) or equivalent rules; and

4. Changes that occur in the character of the waste (i.e. changes in the process or new analytical) will be identified by the Generator and disclosed to WM (and the Contractor if applicable) prior to providing the waste to WM (and the Contractor if applicable).

5. Check all that apply:
   - Attached analytical pertains to the waste. Identify laboratory & sample ID #s and parameters tested:

   ____________________________________________________________________________

   - Only the analyses identified on the attachment pertain to the waste (Identify by laboratory & sample ID #s and parameters tested).

   Attachment #: __________________________________________________________________

   - Additional information necessary to characterize the profiled waste has been attached (other than analytical).

   Indicate the number of attached pages: __________________

   - I am an agent signing on behalf of the Generator, and the delegation of authority to me from the Generator for this signature is available upon request.

   - By Generator process knowledge, the following waste is not a listed waste and is below all TCLP regulatory limits.

   Certification Signature: ________________________________  
   Title: ______________________________________________

   Company Name: ________________________________  
   Name (Print): ________________________________________

   Date: ________________________________

---

**FOR WM USE ONLY**

Management Method:  
- Landfill  
- Bioremediation

Management Facility Precautions, Special Handling Procedures or Limitation on approval: ________________________________

WM Authorization Name / Title: ________________________________  
Date: ________________________________

State Authorization (if required): ________________________________  
Date: ________________________________

Approval Decision:  
- Approved  
- Not Approved

Waste Approval Expiration Date: ________________________________

- Shall not contain free liquid
- Shipment must be scheduled into disposal facility
- Approval Number must accompany each shipment
- Waste Manifest must accompany load

©2008 Waste Management, Inc.
Certificate of Non-Hazardous Waste

I, the undersigned, being duly authorized by my company certify that the wastestream(s) we are disposing at the G.R.O.W.S. Landfill, G.R.O.W.S. North Landfill, Tullytown Resourse Recovery Facility, Mountain View Reclamation Landfill, Alliance Sanitary Landfill, Grand Central Sanitary Landfill and/or the Pine Grove Landfill is/are not a characteristic hazardous waste as defined in 40 CFR, Sections 261.20 to 261.24, and/or is not a listed hazardous waste as defined in 40 CFR, Sections 261.30 to 261.34. Furthermore, based on generator's knowledge of the company's process, TCLP and Total Characteristics not tested for are known not to be present in the concentrations equal to or greater than the value specified in the TC Rule 40 CFR Part 261.24.

Signature: ________________________________ Date: ________________________________

Printed Name: ________________________________
ATTACHMENT G

EXAMPLE SOIL MANAGEMENT SPECIFICATION
SECTION 02400
SOILS MANAGEMENT

PART 1 GENERAL

1.1 DESCRIPTION

The Work of this Section includes, but is not limited to the handling, storage, transportation, and disposal of excess soils associated with Specification Section 02222, Excavation.

1.2 RELATED WORK

All appropriate Sections of Division 1, and Division 2 of these Specifications.

1.3 JOB CONDITIONS

1.4 SUBMITTALS

A. The Contractor shall submit proof of qualifications for its proposed transportation contractor(s) for excess soils and liquids in accordance with Paragraph 3.2.D of this Specification and related Specification Sections.

B. The Contractor shall submit proof of qualifications for its proposed disposal facility(ies) for soils and liquids to be removed from the Site in accordance with Paragraphs 3.2.E and 3.2.F of this Specification and related Specification Sections.

C. The Contractor shall provide SEPTA with all records including completely executed manifests and certificates of disposal for all excess soils and liquids removed from the Site.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 GENERAL

A. The Contractor shall comply with the requirements of the Specifications. Should conditions arise that are not covered by these documents, the Contractor shall immediately notify SEPTA.
B. Limits of excavation shall be as directed by SEPTA.

3.2 EXCESS SOILS

A. The Contractor shall perform excavation of soils in accordance with Specification Section 02222.

B. On-Site Storage

To the maximum extent possible, the Contractor shall direct load all excess soils resulting from excavation activities. Only if necessary, and with the prior approval of SEPTA, will temporary staging of soils be allowed. The soil stockpiles shall be completely and securely covered for the duration of the storage period with an impermeable material of sufficient strength, thickness, anchoring or weighting to prevent tearing or uplifting of the cover, infiltration of precipitation, surface water run-on, and exposure to the atmosphere.

C. Loading

1. The Contractor shall furnish all equipment necessary for loading of excess soils in an effective and safe manner. Loading areas shall be designed to contain any spillage. The Contractor is responsible for removing any spillage or leakage outside of areas of excavation at no additional cost to SEPTA.

2. All vehicles used to haul excess soils shall be delivered to the Site in a completely clean manner, and shall be cleaned prior to first use. Records and documentation of cleaning/decontamination for each vehicle shall be kept on file by the Contractor for the duration of the project.

3. The Contractor shall implement measures to strictly control dust, odors, and spills during the transport of excavated materials. The Contractor shall use covers/tarps to prevent the release of dusts and odors from trucks or other equipment, as necessary.

4. All vehicles hauling excess soils shall be inspected by the Contractor following loading. No dripping or leaking of any quantity of material is allowed. Soils that contain excess moisture may be blended with drier materials to reduce their water content. Blending shall occur as part of loading activities at no additional cost to SEPTA. The hauling vehicles shall be sealed tightly in accordance with Federal, State, and local codes to prevent the release of materials during transport. Vehicles shall not be overloaded.
5. All vehicles shall be inspected by the Contractor to assure no excess soil adheres to its wheels or undercarriage to avoid tracking of soils. Exteriors of all vehicles must be cleaned prior to leaving the site.

D. Transportation

1. All excess soils must be transported off-site only to the facility(ies) pre-approved by SEPTA System Safety during the bidding process.

2. Transportation shall be provided in accordance with Department of Transportation (DOT) Hazardous Materials Regulations and State and local requirements.

3. The Contractor shall submit proof of qualifications that its proposed waste transportation contractor is licensed and permitted in all states and Canadian provinces through which they will travel with decals/placards appropriate for the excess soils and liquids removed from the Project. This includes having a PADEP Waste Transporter Authorization issued under Act 90. The Contractor shall also submit documentation of Department of Transportation (DOT) training requirements, a list of vehicles and DOT approved containers which will be available for use on the project, DOT violation history and a list of other projects similar in magnitude to this project with contact names and telephone numbers.

4. The Contractor shall minimize storage of excess soils on SEPTA property by transporting excavated soils directly to the approved disposal facility when schedule and conditions prove practicable.

5. The Contractor is responsible for obtaining fully executed manifests and certificates of disposal from the facility(ies) approved by SEPTA. This documentation must be maintained by the Contractor for the duration of the project, with copies supplied to SEPTA. The Contractor shall maintain the log of all manifests with corresponding truck numbers and waste weights onsite at all times for SEPTA inspection.

6. The Contractor is responsible for controlling any possible tracking or spilling of materials on public roadways and shall perform all cleanup if such occurs at no additional cost to SEPTA.

E. Disposal
1. Excess soils disposal will be at a SEPTA-approved facility(ies). This shall be the same facility(ies) proposed ten (10) days after bid opening and approved by SEPTA.

2. Disposal of excess soils shall occur in accordance with all local, State, and Federal laws and regulations.

3. The Contractor shall submit proof of qualifications that the Bidder’s proposed disposal facility(ies) is permitted for the soils to be removed from the project for off-site disposal. It is recommended that the Contractor use Clean Earth, Inc. (soils classified as historic fill) or Waste Management, Inc.’s GROWS facility (soils classified as residual waste) as the proposed disposal facility for soils removed from the project and requiring off-site disposal. The Contractor shall submit copies of the current permits for the facility. The Contractor shall also submit the name and telephone number of the primary contact at the state regulatory agency that issued the permit, a copy of the most recent inspection report from the disposer state, a history of any violations/orders/deficiencies and their resolution, financial assurance documents and a list of major customers with contact names and phone numbers. In addition, the Contractor may submit an alternative proposed waste disposal facility subject to the requirements of these Specifications. Disposal shall not occur until written approval is provided by SEPTA.

4. The Contractor shall maintain and provide SEPTA with all records (fully executed manifests and certificates of disposal) for all soils and liquids taken off-site.

F. Water/Liquids Management

1. The Contractor shall minimize the amount of water in the area of excavation by employing diversion berms or other approved applicable techniques. The excavation area should be limited to the boundaries shown in the Specifications or as directed by SEPTA. The Contractor must ensure that minimal disturbance is caused by diversions and proper controls are employed to minimize erosion and sediment transport. Surface runoff, seepage, or groundwater shall be managed according to the reviewed and approved Site Management Plan.

2. If any water appears at the bottom of the excavation, it may not be discharged into the storm sewer. When possible, all water should be left in place. If necessary, water may be removed along with the soil and placed into containers for future disposal.

3. If water in the excavation can no longer be managed by excavation equipment, the Contractor shall pump and collect it in 55-gallon drums or other suitable
watertight containers for further testing and disposal by the Contractor at a SEPTA-approved facility, at no additional cost to SEPTA.

4. All water used for cleaning of the Contractor’s equipment shall be collected into 55-gallon drums or other suitable watertight containers for further testing and disposal by the Contractor at a SEPTA-approved facility, and at no additional cost to SEPTA.

5. The Contractor shall submit proof of qualifications that its proposed facility(ies) is/are permitted for the treatment/disposal of water and liquids generated from the work activities. The Contractor shall submit copies of the current permits for the facility(ies). The Contractor shall submit the name and telephone number of the primary contact at the state regulatory agency that issued the permit, a copy of the most recent inspection report from the disposer state, a history of any violations/orders/deficiencies and their resolution, financial assurance documents and a list of major customers with contact names and phone numbers. Disposal shall not occur until written approval is provided by SEPTA.

END OF SECTION
ATTACHMENT H

C&D MATERIAL RECYCLING COMPANIES
CONSTRUCTION AND DEMOLITION MATERIAL RECYCLING COMPANIES

1. Construction Waste Management
   7333 Milnor Street
   Philadelphia, Pennsylvania 19136
   215-333-6505
   www.cwmanagement.net

2. Winzinger, Inc.
   2870 East Allegheny Avenue
   Philadelphia, Pennsylvania 19134
   609-267-8600

3. Richard S. Burns and Company
   4300 Rising Sun Avenue
   Philadelphia, Pennsylvania 19140
   215-324-6377