PORT AUTHORITY TRANS-HUDSON CORPORATION
TWO MONTGOMERY STREET - 1st FLOOR
JERSEY CITY, NJ 07302

July 3, 2019

ADDENDUM NO. 2

TO PROSPECTIVE BIDDERS ON CONTRACT PAT-784.166 – PATH – TRACKS G AND H
PERMANENT FLOOD PROTECTION

The following changes are hereby made in the Contract Documents for the subject Contract.

This communication should be physically annexed to back cover of the book and initialled by
each bidder before submitting his bid.

In case any bidder fails to conform to these instructions, his Bid will nevertheless be construed as
though this communication had been so physically annexed and initialled.

CHANGES IN THE CONTRACT BOOKLET

Page viii - Immediately following "341111 OPEN AREA TRACKWORK (PATH RAIL
TRANSIT)", insert new line "341130 CONCRETE CROSSTIES AND
FASTENERS".

Pages 257 - Delete these pages in their entireties and substitute therefor new pages 257
through 260A (5 pages) which are attached hereto and made a part hereof.

Page 306 - Delete this page in its entirety and substitute therefor new pages 306 and 306A
(2 pages) which are attached hereto and made a part hereof.

Page 330 - Make the following changes:

A. In the first line of 1.04 C.4., delete "have the ability to
provide standard" and substitute therefore "be able to
provide".

B. In the second line of 1.04 C.4, delete "separate future
agreements" and substitute therefor "a separate agreement".

Page 570 - Immediately following this page, insert new pages 570A through 570BBB (54
pages) which are attached hereto and made a part hereof.

CORRECTION TO ADDENDUM NO. 1

Page 2 - Delete the entire page and physically attach in its place new page 2 which is
attached hereto and made a part hereof.
PORT AUTHORITY TRANS-HUDSON CORPORATION

James Starace, P.E.
Chief Engineer/Director
The Port Authority of New York and New Jersey

INITIALLED BY THE BIDDER:
PORT AUTHORITY TRANS-HUDSON CORPORATION

James Starace, P.E.
Chief Engineer/Director
The Port Authority of New York and New Jersey

INITIALLED BY THE BIDDER:
SECTION 033010
PORTLAND CEMENT CONCRETE, LONG FORM
APPENDIX "A"
SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 01 - GENERAL PROVISIONS:

Shop Drawings
033010A01 Forms.
033010A02 Test pour details at least 15 calendar days before the test.
033010A03 Number, location and details of contraction, control, expansion and construction joints at least 15 days prior to concrete placement.

Catalog Cuts
033010B01 At least 35 calendar days prior to concrete placement, the following:
Name and address of concrete supplier, type of plant, documentation of State Certification for plant and ready mix trucks, AASHTO resource accreditation certification for the independent testing laboratory and certification for an on-site individual in a supervisory capacity with a valid ACI Concrete Construction Special Inspector Certification.
033010B02 At least 35 calendar days prior to concrete placement, the following:
Material certifications, source, brand name and test results (where required) of cement, fine and coarse aggregate, fly ash, slag, silica fume, metakaolin and concrete admixtures following guidelines of Appendix "B". In addition, arrange for an independent testing laboratory to verify that Very High Early Strength Cement meets compressive strength, absolute drying shrinkage and setting time requirements specified in 2.01 C at the testing frequency specified therein.
033010B03 At least 35 calendar days prior to concrete placement, the following:
Brand names and chemical compositions of form oil or release agents, evaporation retardant and liquid membrane curing compounds. For Architectural Concrete include this information also for forms, form liners and pigments.
033010B04 At least 35 calendar days prior to concrete placement, the following:
Certification of compatibility and five-year performance record for liquid membrane forming curing compound, when used under conditions specified in 3.04 B, and the requirements of 2.01 R.1.
033010B05 At least 35 calendar days prior to concrete placement, the following:
Test data and field use history for corrosion inhibitor admixtures (when shown on the Contract Drawings) in accordance with 2.01 P.4:
(1) Manufacturer's test method to determine the concentration of the active component of the inhibitor.
(2) Procedures for the production of concrete mixes containing a corrosion inhibitor for the range of concrete temperatures from 50 degrees Fahrenheit to 90 degrees Fahrenheit and a procedure for the placement of concrete when a retarder is being used.

033010B06 At least 35 calendar days prior to concrete placement, the following:
Certification that admixtures conform to the requirements of 2.01 N submitted with Appendix "B" "Concrete Materials and Mix Proportion Data". Include dosing and re-dosing charts, which shall demonstrate the effects of concrete temperatures from 50 degrees Fahrenheit and 90 degrees Fahrenheit.

033010B07 At least 35 calendar days prior to concrete placement, the following:
A chemical analysis report of the percent by weight of silica fume solids by an approved independent testing laboratory when a wet slurry type of silica fume is being used.

033010B08 At least 35 calendar days prior to concrete placement, the following:
Source of joint sealant for expansion and/or contraction joints.

033010B09 At least 35 calendar days prior to concrete placement, the following:
Type, number and method of application of concrete vibrators.

Samples
033010C01 Concrete ingredients for trial batches including cement, stone, sand, fly ash, slag, silica fume, metakaolin, admixtures, corrosion inhibitor, fibers, latex, pigment and anti-washout agent. Furnish these to the Engineer in whatever quantities he may require at least 35 days prior to concrete placement. This applies to all mixes, including changes to an approved mix.

033010C02 Cement, fly ash, slag, metakaolin and/or silica fume samples to check the Mill Certification at in accordance with 3.05 C.2.

033010C03 For Architectural Concrete, provide two sample panels (12 inches by 12 inches by 2 inches minimum size) for each mix for approval of color and texture. Provide catalog cuts for forms, form liners and form oil or release agents.

Product Data
033010D01 Mix Designs:
Appendix "B" "Concrete Materials and Mix Proportion Data" at least 35 calendar days prior to concrete placement in accordance with 2.02 A. To substantiate the mix proportions, submit all data and field results in accordance with 2.03 A.
Proposed changes to any constituents of the approved mix proportions.

Mix design submissions must include an intended use(s) (structure, pumping, etc.) for concrete for approval.

Certificates

At least 35 calendar days prior to concrete placement, the following:

b. Upon request material certifications, source, brand name and test results (where required) of cement, fine and coarse aggregate, fly ash, slag, silica fume, metakaolin and concrete admixtures following guidelines of Appendix "B". In addition, arrange for an independent testing laboratory to verify that Very High Early Strength Cement meets compressive strength, absolute drying shrinkage and setting time requirements specified in 2.02 B at the testing frequency specified therein.

At least 35 calendar days prior to concrete placement, the following:

Upon request certification of compatibility and five-year performance record for liquid membrane forming curing compound, when used under conditions specified in 3.04 C, and the requirements of 2.02 R.2.

At least 35 calendar days prior to concrete placement, the following:

Upon request certification that admixtures conform to the requirements of 2.02 M. submitted with Appendix "B" "Concrete Materials and Mix Proportion Data". Include dosing and re-dosing charts, which shall demonstrate the effects of concrete temperatures from 50 deg F and 90 deg F.

Manufacturer Test Reports

At least 35 calendar days prior to concrete placement, the following:

Test data and field use history for corrosion inhibitor admixtures (when specified on the Contract Drawings) as per 2.02 O.4.:

1. Manufacturer's test method to determine the concentration of the active component of the inhibitor.
2. Procedures for the production of concrete mixes containing a corrosion inhibitor for the range of concrete temperatures from 50°F to 90°F and a procedure for the placement of concrete when a retarder is being used.

At least 35 calendar days prior to concrete placement, the following:

Upon request a chemical analysis report of the percent by weight of silica fume solids by an approved independent testing laboratory when a wet slurry type of silica fume is being used.

Upon request type, number and method of application of concrete vibrators.

Construction and Installation Procedures

At least 35 calendar days prior to concrete placement, the following:

Contractor's Quality Control Plan in accordance with 1.04 B.
At least 35 calendar days prior to concrete placement, the following:
Precast concrete fabricator's planned schedule for all production and a Quality
Control Plan a minimum of 15 days prior to the commencement of production.

At least 35 calendar days prior to concrete placement, the following:
Cold and Hot Weather Concrete Construction Plans in accordance with 1.03 materials
and methods for protecting concrete from freezing.

At least 35 calendar days prior to concrete placement, the following:
Mass Concrete Thermal Control Plan(s) in accordance with 2.03 C. Utilize ACI 207
for guidance in development of documents.

At least 35 calendar days prior to concrete placement, the following:
Pumping Procedure Plan, including, at a minimum, the pumping scheme, pump
description, line diameter, line length and the number of turns and line offsets.

At least 35 calendar days prior to concrete placement, the following:
Written placement procedures that are in conformance with ACI 304R, Chapter 8 if
concrete is being placed underwater.

At least 35 calendar days prior to concrete placement, the following:
Methods of adding concrete admixtures, high range water reducers, non-chloride
accelerators, corrosion inhibitors, anti-washout agent, latex, fibers, pigment, slag, fly
ash and silica fume.

At least 35 calendar days prior to concrete placement, the following:
Mixing and placement procedures and methods, as well as catalog cuts of equipment
for installation. For hand mixes, submit the methods of proportioning, mixing
(including minimum time requirements), transferring and placing the concrete.

At least 35 calendar days prior to concrete placement, the following:
Method of concrete placement in pipe piles (including elephant trunk size, length and
material type).

At least 35 calendar days prior to concrete placement, the following:
Method of concrete placement and consolidation adjacent to joint assemblies and
embedded hardware.

At least 35 calendar days prior to concrete placement, the following:
Curing Procedure Plan in accordance with 3.04, including the method and materials
for curing.

At least 35 calendar days prior to concrete placement, the following:
Control Joint Location Plan.

At least 35 calendar days prior to concrete placement, the following:
Materials and procedures for filling cracks and patching honeycombs and/or spalls.
At least 35 calendar days prior to concrete placement, the following:
Proof of certification for all QC personnel as detailed in 1.04 A.2.

Calculations
If required by the Engineer or shown on the Contract Drawings, design computations
signed and sealed by the Professional Engineer licensed in the state where Work is
being performed.

Schedules
At least 35 calendar days prior to concrete placement, the following:
Precast concrete fabricator's planned schedule for all production and a Quality
Control Plan a minimum of 15 days prior to the commencement of production.

Quality Assurance-Quality Control
At least 35 calendar days prior to concrete placement, the following:
Upon request Contractor's Quality Control Plan in accordance with 1.04 B.

Record Documents
Daily copy of batch records in accordance with 1.04 A.1.a.

Information
Pre-concrete construction meeting agenda a minimum of 15 days prior to the
scheduled date of the meeting.

Minutes of the pre-concrete construction meeting within 5 days of the meeting.

END OF APPENDIX "A"
SECTION 079200

SEALANTS

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 01 - GENERAL PROVISIONS:

Samples
079200C01  1. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.
2. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch-wide joints formed between two 6-inch-long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

Product Data
079200D01  For each joint-sealant product, sealant backing, primer and accessory required, and instructions for joint preparation and sealant application.

Certificates
079200E01  From joint sealant manufacturer attesting that its sealant products comply with 2.03 A-F as applicable, and that their sealant products are suitable for the use shown on the Contract Drawings.

Manufacturer Test Reports
079200F01  1. Product Test Reports: For each kind of joint sealant, for tests performed by an independent testing agency acceptable to the Engineer.
2. Preconstruction Laboratory Test Reports: From sealant manufacturer, indicating the following:
a. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
b. Interpretation of test results and written recommendations for primers and substrate preparation are needed for adhesion.

Schedules
079200J01  1. Joint-Sealant Schedule: Include the following information:
a. Joint-sealant application, joint location, and designation.
b. Joint-sealant manufacturer and product name.
c. Joint-sealant formulation.
d. Joint-sealant color.
2. Preconstruction Laboratory Test Schedule: Include the following information for each joint sealant and substrate material to be tested:
   a. Joint-sealant location and designation.
   b. Manufacturer and product name.
   c. Type of substrate material.
   d. Test information.
   e. Number of samples required.

Qualifications
079200K01
1. Qualification Data: For qualified testing agency.
2. Evidence of installer's experience and capabilities. Include lists of completed projects with project names and addresses, names and addresses of architects and owners and other information specified.

Inspection Reports
079200O01
1. Preconstruction Field-Adhesion-Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on testing specified under "Preconstruction Tests".
2. Field-Adhesion-Test Reports: For each sealant application tested.

END OF APPENDIX "A"
DIVISION 34
SECTION 341111
OPEN AREA TRACKWORK (PATH RAIL TRANSIT)

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for furnishing and installing ballasted open area trackwork on the PATH rail transit system.

B. This Section includes the following trackwork:
   1. Open Area Tracks with concrete and timber crossties
   2. Installation of Contact Rail

1.02 REFERENCES

The following is a listing of the publications referred in this Section:

American National Standards Institute

ANSI B1.1 Unified Screw and Pipe Thread Package
ANSI B18.10 Track Bolts and Nuts
ANSI B18.2.1 Square and Hex Bolts
ANSI B18.2.2 Square and Hex Nuts
ANSI B18.21.1 Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)
ANSI B18.22.1 Flat Washers

American Railway Engineering and Maintenance of Way Association (AREMA)

Manual for Railway Engineering
Portfolio of Trackwork Plans, including Specifications for Special Trackwork

American Society for Testing and Materials International (ASTM)

ASTM A148 Standard Specification for Steel Castings, High Strength, for Structural Purposes
PART 2. PRODUCTS

2.01 STEEL TEE RAIL

A. General

Steel tee rails for use as running rail and restraining rail shall meet all requirements of the Specifications for Steel Rails of the AREMA Manual. Provide the name and the location of the Special Trackwork shop.

B. Type

All tee rails shall be standard control cooled rail in 115 RE section. Industrial quality rail is not acceptable.

C. Length

Rails shorter than 39 feet will not be permitted unless special length rails are required by the Contract Drawings.

D. Inspection

Complete records of all inspections and testing performed shall be made available to the Engineer when requested. The Contractor shall arrange to have available at the mill all instruments and gauges required to measure all thresholds as specified in this Specification.

E. Manufacturer

1. All rails shall be rolled by a single manufacturing entity.
2. Prior to procurement of rails, the name and the location of the rail rolling mill shall be submitted to the Engineer for approval.
2.02 BOLTS AND NUTS

A. Bolts and nuts shall be made from basic oxygen, open-hearth or electric furnace steel.

B. Bolts and nuts shall conform to one of six groups, as follows:

1. Group 1: Type “E” and “P” bolts; bolted insulated joints assembly bolts; frog, crossing, heel and shoulder bolts; anchor bolts; and brace bolts.

2. Group 2: Miscellaneous bolts for special trackwork.


4. Group 4: Type “A” and “G” bolts; tap bolts; threaded studs, type “U” bolts, countersunk ribbed bolts; type “J” bolts, sheathing bolts; and miscellaneous machine bolts.

5. Group 5: Joint bolts for contact rail.


C. The chemical composition of the steel for bolts shall conform to the following requirements:

1. Group 1: Heat treated carbon steel, A183 Grade 2 with:
   - Carbon, not less than - 0.30 percent
   - Phosphorus, not over - 0.05 percent
   - Sulfur, not over - 0.06 percent

2. Group 2: Low carbon steel, A183 Grade 1 with:
   - Carbon, not less than - 0.15 percent
   - Phosphorus, not over - 0.05 percent
   - Sulfur, not over - 0.06 percent

3. Group 3: Alloy steel, A325 Grade BD with:
   - Carbon, not less than - 0.30 percent
   - Phosphorus, not over - 0.03 percent
   - Sulfur, not over - 0.04 percent

4. Group 4: Carbon steel, A307 Grade A
   - Phosphorus, not over - 0.06 percent
   - Sulfur, not over - 0.15 percent

5. Group 5: Medium carbon steel per A449 with:
   - Carbon, not less than - 0.25 percent
   - Manganese, not less than - 0.57 percent

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Addendum No. 2
Phosphorus, not over - 0.04 percent
Sulfur, not over - 0.05 percent

6. **Group 6: Alloy steel, A490 150 ksi Minimum Tensile Strength, Type 1 with**
   Carbon, not less than - 0.30 percent
   Phosphorus, not over - 0.04 percent
   Sulfur, not over - 0.04 percent

D. **The chemical composition of the steel for nuts shall conform to the following requirements:**

1. **Group 1: Medium carbon steel, A183 Grade 2 with:**
   Carbon, not less than - 0.40 percent
   Phosphorus, not over - 0.05 percent
   Sulfur, not over - 0.06 percent

2. **Group 2: Low carbon steel, A183 Grade 1 with:**
   Carbon, not less than - 0.15 percent
   Phosphorus, not over - 0.12 percent
   Sulfur, not over - 0.06 percent

3. **Group 3 and 6: Alloy steel, A563 Grade DH with:**
   Carbon, not less than - 0.20 percent
   Manganese, not less than - 0.60 percent
   Phosphorus, not over - 0.04 percent
   Sulfur, not over - 0.05 percent

4. **Group 4: Carbon steel, A563 Grade A**
   Carbon, not over - 0.55 percent
   Phosphorus, not over - 0.12 percent
   Sulfur, not over - 0.15 percent

5. **Group 5: Carbon steel per A563 Grade C with:**
   Carbon, not over - 0.55 percent
   Phosphorus, not over - 0.12 percent
   Sulfur, not over - 0.15 percent
E. Ribbed Bolts
Ribbed bolts shall conform to the requirements of ASTM A 307.

F. Analyses
The Contractor shall arrange to have the manufacturer make an analysis of each heat of steel to determine the percentage of carbon, manganese, phosphorus and sulphur. These analyses shall be made from drillings taken at least 1/8-inch beneath the surface of a test ingot obtained during the pouring of the heat. Certified chemical composition thus determined shall be prepared.

G. Physical Requirements
1. Tensile properties: Bolts shall conform to the following minimum requirements as to tensile properties, except that the properties of Group 3 shall be after heat-treating but before carbo-nitride hardening:

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3, 6</th>
<th>Group 4</th>
<th>Group 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>110,000</td>
<td>75,000</td>
<td>150,000</td>
<td>60,000</td>
<td>120,000</td>
</tr>
<tr>
<td>Pounds per Square Inch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield Point</td>
<td>80,000</td>
<td>50,000</td>
<td>130,000</td>
<td>30,000</td>
<td>92,000</td>
</tr>
<tr>
<td>Pounds per Square Inch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elongation in Two Inches</td>
<td>12</td>
<td>20</td>
<td>14</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>Percent, max</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction of Area</td>
<td>25</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Percent, max</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Yield and Tensile Strength Tests
The yield point shall be determined by the drop of the beam of the testing machine and at a cross-head speed not to exceed 1/8-inch per minute. The tensile strength shall be determined at a speed not to exceed 1-1/2 inches per minute.

3. Head, Nut and Thread Strip Test
Nuts, "Elastic Stop Nuts," "Nylok Nuts" or an approved equal, shall develop the full strength of the bolt as determined by a strip test. The threads shall not strip when the bolt with nut fully mounted, is tested in tension to its yield point, the load being applied to the inside face or back of the nut.

4. Bend Test
Full size bolts shall bend cold as follows:
Group 1 bolts through 45 degrees around a pin the diameter of which is equal to the diameter of the bolt; Groups 2, 3 and 4 bolts through 180 degrees flat on themselves. All bend test specimens shall bend without cracking on the outside of the bent portion.

5. Test Specimens
Tension test specimens shall be taken from the finished bolts and shall conform to the dimensions of the ASTM A183 standard test specimen. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

6. Number of Tests
One tension, one bend, and one strip test shall be made from each lot of 50 kegs or fraction thereof, and certified test reports shall be prepared.

7. Defective Specimens
   If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

8. Retests
   If the results of any tension, bend or strip test of the test lot do not conform to the requirements, two additional tests of each shall be made from such lot. Failure of any of these to meet the requirements shall be cause for rejection of the lot represented.

H. Design and Tolerance
1. Bolts and nuts shall conform to the dimensions indicated on the Contract Drawings.
2. Unless otherwise indicated, Group 1 and 3 bolt and nut tolerances shall be in accordance with current ANSI B18.10.
3. Unless otherwise indicated, Group 2 bolt and nut tolerances shall be in accordance with the current AREMA Manual, Chapter 4, Rail, Part 2, Specifications for Heat-Treated Carbon Steel Track Bolts, and Carbons Steel Nuts.
4. Unless otherwise indicated, Group 4 and 6 bolt and nut tolerances shall be in accordance with the current ANSI Standard Specifications B18.2.1, Square and Hex Bolts; B18.2.2 Square and Hex Nuts, as appropriate.
5. Bolt and nut tolerances shall conform to the permissible variation difference between the limits of sized in accordance with the current ANSI B1.1.

I. Manufacture and Finish
1. Manufacture
   Bolts and nuts shall be neatly formed and free from injurious defects. The head of the bolt shall be concentric with and firmly joined to the shank, with the underside at right angles to the axis of the bolt. The threads shall be sharp and true to gauge and shall be rolled or cut as shown on the Contract Drawings. The nuts for ribbed bolts shall have a free fit per ANSI B1.1. The nuts for all other bolts shall have a free fit for at least two threads in starting on the bolt and when fully engaged and for the remainder of the screw length shall show a minimum of 5 pounds and a maximum of 55 pounds resistance to turning as expressed by pounds of pull applied to the end of a 24-inch wrench. Before packing, nuts shall be screwed on the bolts a sufficient number of turns to hold them in place until used.

2. Branding
   A letter or brand indicating the manufacturer shall be pressed on the head of the bolt when it is formed.

3. Finish
   Finished bolts and nuts shall be free from fins or nicking.

4. Galvanizing
   Where bolts are required to be galvanized, they shall be galvanized after threading.
J. Packing and Marking
When ungalvanized bolts and nuts are shipped they shall be oiled to prevent rusting. All containers shall be plainly marked as to type or class of material, size and number of bolts, weight, thread (UNC), and name of manufacturer.

2.03 WASHERS, SPRING AND PLAIN

A. Type
1. Spring washers shall include nutlocks and lock washers.
2. Plain washers shall include flat washers.

B. Material
1. Spring washers shall be made of 10 B 55, high alloy steel, manufactured by the basic oxygen electric furnace, open-hearth or crucible process and shall be treated by oil quenching and tempering to a hardness of Rockwell C-45-53.
2. Plain washers shall conform to the requirements of 2.03. In addition, plain washers shall be heat-treated by oil quenching and tempering to a hardness of Rockwell C-45-53.

C. Physical Requirements
1. Spring washers shall comply with the Specifications for Spring Washers of the AREMA Manual, Chapter 4, Part 3, except for E and C bolt spring washers shall have a reactive spring pressure as shown below.
2. Plain Washers shall comply with ANSI B18.22.1.

D. Chemical Analysis
The Contractor shall furnish to the Engineer two copies of the manufacturer's complete report of the ladle analysis, showing carbon, manganese, phosphorus and sulphur content of each heat of steel represented in the finished spring washers and plain washers.

E. Tolerances
1. Spring washers shall not deflect more than 0.10 inch for a concentrated load of 30,000 pounds.
2. The cross section and allowable tolerances of finished lock washers shall comply with ANSI B.18.21.1.
3. The allowable tolerances for finished plain washers shall comply with the ANSI B.18.21.1 paragraph 1.4, referencing appropriate table of tolerances for the size of plain washer required.

F. Design
The dimensions and form of the spring washers and plain washers shall conform to the Contract Drawings, where shown, or shall conform to AREMA recommendations. The inside diameter shall be such that a good fit is obtained around the bolt with which they are to be used.

G. Quality
All washers shall be clean, without burrs or rough edges, with uniform cross-section throughout and properly finished.
H. Method of Testing

1. Method of testing for spring washers shall be as prescribed in Sections 3, 5 and 6 of the AREMA Specification for Spring Washers, except that the applied load shall be 30,000 lbs.

2. Ductility for spring washers shall conform to Section 4b of the AREMA Specification for Spring Washers. Mechanical strength shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Nominal Bolt Diameter In Inches</th>
<th>Applied Load In Pounds</th>
<th>Release Distance In Inches</th>
<th>Reactive Spring Pressure In Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4</td>
<td>30,000</td>
<td>0.010</td>
<td>5,000</td>
</tr>
<tr>
<td>7/8</td>
<td>30,000</td>
<td>0.010</td>
<td>6,000</td>
</tr>
<tr>
<td>1</td>
<td>30,000</td>
<td>0.010</td>
<td>6,000</td>
</tr>
<tr>
<td>1-1/16</td>
<td>30,000</td>
<td>0.010</td>
<td>6,000</td>
</tr>
<tr>
<td>1-1/8</td>
<td>30,000</td>
<td>0.010</td>
<td>7,000</td>
</tr>
</tbody>
</table>

3. Method of testing for hardened plain washers shall comply with ANSI B.18.22.1, paragraph 1.4.2.

4. Submit certified test reports verifying conformance with this Specification.

I. Inspection

Before offering any lot of spring washers for inspection, each individual piece shall have been subjected as a part of the routine manufacturing process to shock or pressure sufficient to cause permanent set and any individual pieces having defects such as seams and quenching cracks shall be discarded.

J. Shipment

All packages shall be plainly marked as to material, size, quantity and the name of the manufacturer.

2.04 JOINT BARS AND COMPROMISE BARS

A. Material for track rail joint bars shall be rolled steel. Compromise joint bars shall be made of forged steel.

B. Rolled steel joint bars and forged steel compromise bars shall comply with the requirements of "Specifications for Quenched Carbon Steel Joint Bars and Forged Compromise Joint Bars" of the AREMA Manual, Chapter 4, Part 3.

C. Cast steel compromise joint bars shall comply with the requirements of ASTM A 148, Grade 105-85.

2.05 TIE PLATES

Where new timber transition ties are installed, remove and re-install the existing insulated ATC tie plate components.

2.06 SCREW SPIKES AND LAG SCREWS

Where new timber transition ties are installed, existing lag screws shall be reused.
2.07 INSULATED RAIL JOINTS

A. Field installed insulated rail joints for temporary track connections shall be the Toughcoat Insulated Rail Joint as manufactured by the Allegheny Rail Products Division of L.B. Foster or an approved equal meeting the requirements of AREMA Manual, Chapter 4, Part 3.

B. Technical Requirements

1. Insulated joints shall conform to the 115 RE rail section and to PATH's standard rail drilling pattern unless otherwise shown on the Contract Drawings.

C. Each complete field-installed joint set shall be individually packed into "kits" and marked for identification. A complete joint set shall have all components necessary to install an insulated joint complete, including bars, end posts, bolts, washers, nuts, and backing plates.

D. Permanent insulated joints shall be factory bonded plug rails meeting the requirements of AREMA Manual, Chapter 4, Part 3.

2.08 TIE PADS

Where new timber transition ties are installed, existing ATC-plate components shall be reused.

2.09 STEEL CONTACT RAILS

Existing contact rails shall be removed and reinstalled.

2.10 CONTACT RAIL INSULATORS

A. Existing contact rail insulators shall be removed and reinstalled.

2.11 CONTACT RAIL APPURTENANCES

A. Existing shims shall be removed and reinstalled.

2.12 STONE BALLAST

A. Material

1. Stone ballast shall be either traprock or granite and shall break into angular fragments. Stone shall be obtained from quarries that are approved by the Engineer as containing material of the desired quality in accordance with this Specification.

2. Gravel, limestone, dolomite, slag, cinders, or clinkers will not be acceptable for ballast.

3. The methods of determining the physical properties shall be in accordance with this specification and paragraph 2.4 of AREMA Manual, Chapter 1, Part 2 entitled "Property Requirements."

B. Physical Properties

Physical properties of acceptable ballast material shall conform to all requirements specified by AREMA Manual, Chapter 1, Part 2, Table No. 1, "Recommended Limiting Values of Testing for Ballast Material."
C. Gradation

Size graduation of ballast shall conform to AREMA Manual, "Recommended Ballast Gradations" for size No. 4 stone and for size No. 5 stone according to the size gradation of stone required by the Specifications and Contract Drawings.

D. Cleaning

Ballast shall be free from dirt, loam, dust, or rubbish. When the rock is of such a nature that when crushed and screened it is not free from dust, it shall be scrubbed in an approved scrubbing machine at the quarry.

E. Handling

1. Broken stone for ballast shall be delivered from the screens directly to the conveyances or to clean bins provided for storage of the output of the crusher.
2. Ballast shall be loaded into conveyances that are in good order and tight enough to prevent leakage and waste of material and are clean and free from sand, dirt, rubbish or any other substance which would foul or damage the ballast material.

F. Inspection

1. The Engineer may inspect ballast at its source or at delivery and test the material for conformance to the Specification.
2. Samples taken from material delivered to the construction site may be tested by the Engineer for conformance to this Specification.

2.13 TIMBER TIES - GENERAL

A. Material

Ties shall be produced from oak. Water oak is not acceptable. Hardwoods other than oak listed in the "Specification for Timber Switch Ties" and "Specifications for Timber Cross Ties" of the AREMA Manual, Chapter 30 are permissible when approved by the Engineer.

B. Quality

1. The timber from which the ties are produced shall be cut from straight sound trees. All ties shall be free from any defects that would impair their durability or strength as ties, such as decay; large shakes or large splits; large or numerous holes or knots; or grain with a slant greater than one in fifteen.
2. All ties shall be straight, and shall have all four sides well sawed and parallel. All switch ties shall be cut square at both ends and have all bark removed.
3. A tie will be considered straight when the center line of the tie along the top from the middle of one end to the middle of the other end is no more than two inches away from a straight line, and within one inch away from a straight along a side from the middle of one end to the other.

C. Defects

1. No splits more than five inches long or three-sixteenths inch wide is permitted.
2. Shake which is not greater than one-third of the width of the tie will be allowed; however, any shake that is not at least one inch from any edge is unacceptable.
3. A large hole is a cavity more than 1/2 inch in diameter and three inches deep within the rail bearing section of the switch tie, or more than one-quarter the width of the surface on which it appears and three inches deep outside the rail bearing section of the tie. Numerous holes are any number equaling a large hole in damaging effect.
4. A large knot is one in which the diameter exceeds one-quarter of the width of the surface on which it appears, but such a knot may be allowed if it occurs outside the rail bearing area of the switch tie. Numerous knots are any number equaling a large knot in damaging effect.

5. Ties with checks over one-half inch in width on any face and longer in aggregate than two-thirds of the tie length, will be rejected.

6. The meaning of the terms above shall be in accordance with the definitions in the Specifications for Timber Cross Ties and Switch ties of the AREMA Manual, Chapter 30.

D. Dimensions, Drilling and Pre-plating

1. The dimensions of transition and switch timbers for Special Trackwork shall be as shown on the Contract Drawings.

2. Except for switch movement timbers, for which a tighter tolerance is shown on the Contract Drawings, a tolerance of plus or minus one-quarter inch in width and thickness, and plus or minus one inch in length will be permitted.

3. Switch timbers for transition timbers and Special Trackwork shall be drilled and preplated with the required plates except when otherwise specified. Location and dimensions of drilled holes shall be as shown on the Contract Drawings and meet the requirements of this Specification. All plate holding spikes shall be screw spikes. Tie pads shall be used under plates applied to switch timbers.

4. When drilling timbers, pilot hole shall be drilled in timbers for spikes. The ties shall be accurately drilled from and normal to the top surface, which is the widest face farthest from the pith of the tree, whether or not the pith is present in the piece. The finished holes, in oak, shall be 9/16-inch in diameter and 5 1/2 inches deep. All unused holes in timbers shall be plugged with treated hardwood tie plugs.

E. Seasoning

Ties, prior to treatment, shall be air seasoned by "Boultonizing" or vapor drying in conformance with American Wood Preserver’s Association Book of Standards. After conditioning and immediately before preservative treatment, the ties shall be dressed on the top and bottom surfaces so that all warp is removed, the top and bottom surfaces are made parallel and the ties are finished to the specified thickness.

F. Preservative Treatment

Ties shall be treated in accordance with "Specifications for Treatment" of the AREMA Manual, Chapter 3, Part 9 using a creosote-coal tar solution as specified in "Creosote-Coal Tar Solutions" of the AREMA Manual, Chapter 3, Part 7. Incising shall be required regardless of the wood species used.

G. Anti-splitting Devices

Prior to treatment, anti-splitting devices shall be applied at each end of all ties. Framing of switch movement ties shall be done prior to treatment and as shown on the Contract drawings. Anti-splitting devices shall be of the multi-nail plate type and shall conform to AREMA specifications for material and installation requirements. The multi-nail plates shall measure five inches by seven inches.
H. Marking

Prior to preservative treatment, a brand showing the vendor's name, the place of manufacturer and the month and year of treatment, shall be stamped on the top and in the middle of each tie with letters and numerals not less than one-half inch high. Such brand shall be placed only on the top surface of each tie.

I. Inspection – Independent Inspector

1. Ensure that the timber manufacturer inspects each crosstie in accordance with the provisions of the "Standard Methods of Analysis" of the AWPA.

J. Inspection - Engineer

1. The Engineer may inspect ties at any time, before, during or after treatment for conformance to these Specifications. Each tie will be judged independently without regard for decisions on other ties in the same lot.

2. The Engineer will inspect materials and processes relative to preservative treatment of ties in accordance with the provisions of the "Standard Methods of Analysis" of the AWPA.

3. The Engineer may make any additional inspections of the ties after delivery in order to determine conformity to this Specification. However, the plant inspection shall be considered final with respect to the treatment materials and processes.

4. Each tie accepted by the Engineer will be end branded in three-quarter inch high letters with the following brand mark: PATH-XX. XX will be the year in which the branding occurs.

K. Manufacturers: Prior to milling of timber products, the name and the location of the timber products mill shall be submitted to the Engineer for approval.

2.14 TIMBER CROSS TIES

A. Ties shall conform to the requirements of 2.13 except as otherwise specified herein. Submit the name and the location of the timber products mill to the Engineer for approval.

B. Defects

1. No split more than 3/16-inch-wide or longer than the width of the face across which it occurs, is acceptable.

2. Shake which is not greater than one-half of the width of the tie will be allowed; however, any shake that is not at least one inch from any edge, is unacceptable.

3. Holes within the rail-bearing area larger than one-half inch in diameter or three inches from any edge, is unacceptable.

4. Sound, tight, medium knots are acceptable in the rail bearing area. A medium knot is defined as a knot greater than 3/4 inch in diameter but no more than 1-1/2 inches in diameter. Firm, fixed, large knots are acceptable in areas which do not bear rail. A large knot is defined as a knot greater than 1-1/2 inches in diameter but less than one-third of the width of the surface upon which it appears.

C. Dimensions; Drilling and Pre-Plating

1. The dimensions of cross ties shall be as specified in 3.02C.1.

2. The tolerances of dimensions required for switch timbers shall be used for cross tie dimensions.
3. Cross ties shall be drilled and preplated except when otherwise specified. Location and dimensions of drilled holes shall be as shown on the Contract Drawings or as indicated by the Engineer. Tie pads of the type specified in 2.08 shall be inserted between the plate and the tie. Submit a description of the construction and properties of the tie pad and a representative tie pad to the Manager, Materials Engineering Division for approval.

2.15 CONCRETE CROSS TIES

A. Concrete cross ties shall be per Section C341134.

PART 3. EXECUTION

3.01 TRACKWORK - GENERAL

A. Trackwork construction shall involve handling, distributing, cutting, fitting, drilling, grinding and altering materials required for their installation; straightening, curving and bending of rails, making all connections with adjacent tracks and Special Trackwork, top welding of rails, fitting and installing offset joint bars, installing fillers for planed guard rail flares, including milling and grinding of the flares; installing rail anchors as required, installing switch machine spacer templates, temporary insulated joints, shims for spacing rails at joints and painting all standard rail joints; also dapping the ties, punching extra holes and cutting plates, as required, saturating the cut surfaces of creosote-treated ties with hot creosote oil, and filling of unused spike holes in ties with treated tie plugs; all dewatering which may be necessary; spreading and tamping ballast within limits of the track or Special Trackwork portion being installed, and in areas adjacent to the track or Special Trackwork portion being installed, and all other work necessary for or incidental to the satisfactory installation of various types of track and Special Trackwork.

B. Procedure When Skeletonizing or Modifying Track

1. In all cases where the track has been disturbed and service disrupted, particular care shall be taken prior to the resumption of normal train operations. When track is skeletonized and track supports are installed, or running rails, contact rails, ties, ballast, or any other track appurtenances have been modified, the Contractor shall maintain a minimum crew of one foreman and four track workers at the work site until released by the Engineer. Prior to resumption of revenue train operations, revenue test train will be operated in accordance with the requirements of 3.01 E. The Engineer will observe the passing of at least one revenue test train and be satisfied that the trackways are safe and clear before releasing the Contractor's crew and placing the track back in service.

2. The Contractor shall submit details of track bracing, where ballast of tie cribs is removed down to base of tie for track lengths exceeding 50 feet.

C. Track Geometry

1. The Contractor shall exercise close control during construction and installation of track in order to ensure that any and all deviations from specified track geometry are held to a minimum, but in no case greater than the tolerances in the following table:

TRACT CONSTRUCTION TOLERANCES

Cross Level and Super-Elevation
Deviation of Cross Level and Super-Elevation ±1/8"

Track Gauge

570M

341111 - 13
Addendum No. 2
Deviations of Gauge

Flangeway Width

Deviation of Flangeway Width +0” to - 1/8”

Vertical Track Alignment

Variation in 31' Chords ±1/4”

Deviations in 31' Chords from Theoretical ±1/8”

Horizontal Track Alignment

Variation in 31' Chords ±1/4”

Deviations in 31' Chords from Theoretical ±1/8”

Contact Rail Gauge and Elevation

Deviation of Gauge and Elevation ±1/8”

2. The standard gauges for construction and installation of track, measured perpendicular to the track (radially on curves) between opposite points on the gauge surface of the rails, in a plane 5/8 inch below the head of rail shall be in accordance with the following table unless shown otherwise on the Contract Drawings or otherwise directed by the Engineer:

**GAUGE AND FLANGEWAY WIDTHS FOR TANGENT AND CURVED TRACK**

<table>
<thead>
<tr>
<th>Track Classification</th>
<th>Standard Gauge</th>
<th>Flangeway Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangents</td>
<td>4'-8-1/2&quot;</td>
<td>--</td>
</tr>
<tr>
<td>Curves over 750' Radius</td>
<td>4'-8-1/2&quot;</td>
<td>--</td>
</tr>
<tr>
<td>Curves 350' to 750' Radius</td>
<td>4'-8-3/4&quot;</td>
<td>2&quot;</td>
</tr>
<tr>
<td>Curves under 350' Radius</td>
<td>4'-9&quot;</td>
<td>2-1/4&quot;</td>
</tr>
</tbody>
</table>

3. Transition and spiral curves, including guard rail runoff portion of adjacent tangent track, shall be installed with the same gauge as the adjacent central curve. In special cases with the permission of the Engineer, the whole or parts of the transition curve can be used for the tapering of gauge.

4. Approaching or leaving curves or Special Trackwork, rate of taper of track gage shall be 1/4 inch in 40 feet. Where restrictive alignment conditions exist, the rate of taper may exceed the standard amount but in no case may it exceed 1/4 inch in 30 feet for design speeds of 31 mph or over nor 1/4 inch in 20 feet for speeds of 30 mph or less.

5. Gage shall be changed by suitable adjustments of the gage rail (rail opposite the line rail). In general, the gage rail is the low or inner rail on curves and the rail closest to the contact rail on tangents.

6. The high or outer rail on curves and the rail furthest from the contact rail on tangents shall be used as the line rail. The line rail shall be used whenever any work involving horizontal alignment is performed. All horizontal alignment measurements and sightings shall be referenced to the gage line of the line rail.

7. Vertical curves shall have zero cross-level on tangents and super-elevation on horizontal curves, as shown on the Contract Drawings.
8. When surfacing or raising track, one rail, which shall be the inner rail on curves and usually the line rail on tangents, shall be selected as the grade rail. This rail shall be first brought to proper profile. The opposite rail shall then brought to its proper elevation by use of a level board.

9. The Contractor shall make any necessary adjustments to the track to remove irregularities from the alignment and profile.

D. Quality of Final Track Alignment

Track alignment and profile, track geometry and contact rail elevation and gage shall be measured and verified by the Contractor subject to the satisfaction of the Engineer. Measurement of alignment and profile, track geometry and contact rail elevation and gage will also be subject to verification by the Engineer. Any deviations above the allowable shall be corrected by the Contractor.

E. Operation of Revenue Test Train

1. In all cases of new track, Special Trackwork, or contact rail construction, or where existing track, Special Trackwork, or contact rail has been modified or reconstructed with revised alignment or profile, the Engineer will require the operation of one or more revenue test trains prior to his placing the track into service. Test trains will operate both in the normal and the reverse directions of travel. When test trains operate over switches, the train will operate in both the normal and reverse directions for both the normal and the reversed positions of the switch points. Revenue test trains will consist of standard PATH revenue rolling stock and will be operated at PATH's expense. The Contractor shall make available his qualified representative to accompany the Engineer in observing the passing of the revenue test train over the trackwork.

2. The test train operation shall verify to the satisfaction of the Engineer that the trackwork has safe and good riding characteristics prior to placing the track into service.

3. The test train operation shall verify to the satisfaction of the Engineer that all car clearances of the test train on the trackwork are adequate, proper, and safe. Car clearances subject to checking shall include horizontal, vertical, and contact rail clearances, clearances to adjacent tracks, and lateral clearances and elevation of test train with relation to station, employee and material loading platforms. Horizontal and vertical clearances between the car door sill and the platform edge shall not exceed the tolerances shown on the Contract Drawings. The Engineer will check these clearances prior to placing the track into service.

4. Any deficiencies or hazardous or unsafe conditions in the track, Special Trackwork, and contact rail for train operations at the design speed shall be corrected by the Contractor. Where such deficiencies or hazardous or unsafe conditions are due to the Contractor's failure to follow this Specification, the Contractor shall make the corrections at no additional cost to the Authority.

5. Satisfying these requirements shall not release the Contractor from meeting the requirements of 3.01C.

F. Lines and Grades for Trackwork

1. During the progress of the Work, the Engineer will provide suitable points, marks or benches at such intervals as the Engineer deems necessary.
2. From the points, marks or benches given by the Engineer and from the data shown on the Contract Drawings showing the alignment and grades, the Contractor shall provide all field lines and grades necessary for the construction.

3. The Engineer will have the right at any time to determine the correctness or completeness of the field lines and grades given by the Contractor, and any imperfect or erroneous construction resulting from errors in the field lines or grades given by the Contractor shall be corrected or shall be replaced by construction which is strictly in accordance with the Contract Drawings.

4. The Engineer may draw the Contractor's attention to errors or omissions in construction lines or grades, but no omission on the part of the Engineer to point out such errors or omissions shall give the Contractor any right or claim against PATH or shall in any way relieve the Contractor of his obligations according to the terms of the Contract.

G. Removal and Collection of Track Materials
1. The Contractor shall remove and collect certain track materials not required for reinstallation from existing track.

2. The Contractor shall remove and dispose of away from PATH property in lawful manner track materials not required for reinstallation.

H. Alignment, Profile and Surface
All tracks shall be installed to the lines shown on the Contract Drawings and surfaced for good riding at maximum design speed and within the specified tolerances. An approved track level in conjunction with applicable surveying equipment shall be used for surfacing all tracks.

I. Gage and Flangeway
1. All tracks shall be laid to standard gage.

J. Track and Contact Rail Gauges
1. The Contractor shall utilize an AREMA standard track gauge with steel pipe center according to Plan 20-62 to set the gauge of the track.

2. The Contractor shall utilize a combination adjustable track gauge and level, Geismar Model RCAT-A1, or approved equal. Gauge shall be capable of verifying the track gauge, cross level, flangeway width and guard rail gauge.

3. The Contractor shall utilize a contact rail gauge capable of providing the correct contact rail elevation and gauge with respect to the running rails.

4. Approved gauges shall be used for the gauging of all tracks and the gauging and elevation of all contact rails. The gauges shall be plainly marked to show the gauge for which they are intended. Gauges will be inspected frequently by the Engineer in company with the Contractor's representative in order to make sure that the proper gauge is being used at all times.

5. Submit shop drawings or catalog cuts of all track and contact rail gauges to the Engineer for approval.

K. Super-elevation for Tracks
1. Super-elevate curves by the amount shown on the Contract Drawings and in accordance with the construction tolerances in 3.01 C.

2. In no case shall rail in turnouts or track crossings be super-elevated.
3. The super-elevation in open area tracks shall be obtained by raising the outer rail the total amount of the super-elevation.

4. The rate of super-elevation runoff and the limits of the runoff shall be as shown on the Contract Drawings.

L. Location of Joints

1. Rail joints shall be staggered. The joint in the running rail shall be as near as practicable opposite to the center of the running rail on the other side of the track. The stagger of the joint shall not vary by more than 30 inches in either direction from the midpoint of the opposite rail and preferably by not more than 18 inches in either direction. Short rails shall be used on the inside of curves to bring about these conditions. In the event that short rails are not available, the Contractor shall cut 39-foot rails. All joints in the running rail shall be suspended with the joint midway between two ties. Joints in the guard rail shall be placed between the joints in the running rail and shall be not less than 6 feet from such joints, except at special locations.

2. The Contractor shall prepare a shop drawing for rail layouts showing lengths of running rails and guard rails to be installed in track and the locations and types of rail joints indicated on the layouts. The locations of impedance bonds and automatic train stops shall also be shown. The joint locations and rail lengths shall be in accordance with these Specifications and the Contract Drawings. These shop drawings shall be submitted to the Engineer for approval.

M. Opening at Joints

1. The distance between rail ends at all joints shall be gauged according to the temperature at which the rails are laid.

2. The openings between the ends of 39-foot rails for different rail temperatures shall be as follows:

   For Open Area Tracks (Temperature Fahrenheit)

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>Opening</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 10 deg. below to 14 deg. above zero</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>From 14 deg. above to 38 deg. above zero</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>From 38 deg. above to 62 deg. above zero</td>
<td>1/8&quot;</td>
</tr>
<tr>
<td>From 62 deg. above to 86 deg. above zero</td>
<td>1/16&quot;</td>
</tr>
<tr>
<td>Above 86 deg</td>
<td>0</td>
</tr>
</tbody>
</table>

3. The space between the rails at insulated joints shall be 3/8 inch.

N. Joint Gap Gauges

Joint gap gauges, as shown on the Contract Drawings, shall be furnished by the Contractor and shall be used for the purpose of spacing rails at the joints. These gauges shall be removed as soon as the joint bar bolts are tightened and the rail securely anchored.

O. Joint Bars and Bolts

1. Where standard bolted joints are required, the rails shall be connected using toeless joint bars.

2. Joint bars shall have six bolt holes and shall be 36 inches long unless otherwise shown on the Contract Drawings.
3. Prior to installation, joint bars shall be bent to the curvature of the rail when the curve radius is 500 feet or less, and shall be bolted to the track rail so as to secure a snug fit.

4. Gauge-side joint bars at switch heels shall be kinked by the switch fabricator as shown on the Contract Drawings.

5. When installing joint bars in unguarded rail, the track bolts shall be inserted in such a manner that when viewing a gauge-side joint bar, the track bolts appear in succession as threaded end, head, threaded end, threaded end, head, threaded end. In running rail joints in guarded construction, or in guard rail joints, the track bolts shall always be inserted with the threaded ends located within the flangeway. Each bolted rail joint shall require the full complement of track bolts, nuts and spring washers.

6. The nuts shall be screwed up tight with an approved automatic nut tightener or track wrench. The heads of the bolts shall be tight against the joint bar before tightening the nuts.

7. As a protection against rust, all joint bars and the parts of all rails covered by joint bars shall be painted with "No-Oxid" Grade E, or an approved equal.

8. Joint bars and head of bolts shall be "tapped" frequently with a light sledge hammer to ensure that top and bottom fishing edges go all the way "home"; care being exercised so as not to strike the rail in the tapping procedure. At completion of Work prior to turning tracks over to PATH, all joints shall be given a final hand wrench tightening.

9. Upon initial application of joint bars, the bolt tension shall be in the range of 20,000 to 25,000 lbs. and, for subsequent retightening, 15,000 to 20,000 lbs. Bolts shall be tightened beginning with the center bolts and progressing to the end bolts.

10. The Contractor shall perform follow-up tightening of newly applied joint bars one month after track has been placed in service.

P. Insulated Track Rail Joints

1. Insulated joints, of the type specified, shall be installed where shown on the Contract Drawings at the locations designated by the Engineer prior to the installation of the tracks.

2. All parts shall be assembled in accordance with the manufacturer's installation instructions and care shall be taken not to damage any portion of the insulated joint.

3. An insulated joint shall not be applied to rails with battered or roughly cut edges. When a rail is cut and drilled in the field for an insulated joint, the rail shall be turned so that the mill-cut and drilled end is used in the insulated joint.

4. The Contractor shall remove from the rail ends all scale, dirt, burrs, lips and rough edges and clean the rail ends thoroughly by wire brushing with a power tool.

5. The rail ends and the immediate area around the insulated joint shall be cleared of all metallic shavings and debris by compressed air before applying "Glyptal" insulating paint. In the installation of insulated joints care shall be taken to provide at least one-inch clearance between metallic parts of the insulated joints and tie plates that may be installed under the insulated joints and tie plates or other joint bars installed on adjacent rails.

6. Where absolutely necessary to have a plate under the insulated joint, the plate shall be non-metallic and non-conductive material such as poly-plate or approved equal.

7. All metal and fiberglass parts of the insulated joint shall be carefully painted with a liberal coat of "Glyptal" insulating paint, or approved equal, to the satisfaction of the Engineer.
8. Nuts shall be tightened alternately, keeping the center bolts in the lead, bolt heads being tapped frequently while tightening.

9. Insulated joints will be inspected by the Engineer before the finished track will be accepted. Any insulated joint damaged as a result of the Contractor's rail construction operations shall be replaced by him at no expense to PATH.

10. Any insulated joints wholly or partly disassembled to replace a rail, shall not be reused until inspected and approved for reinstallation by the Engineer.

Q. Guard Rails

1. Guard rails shall be installed as shown in the Contract Drawings. In general, guard rails are to be placed adjacent to the gage side of inside rail of curves of less than 750 feet radius, including all transitions, and extend on the adjacent tangents 40 feet on the receiving and trailing end of transition curves, unless otherwise shown on the Contract Drawings. When installed on simple curves, guard rails shall extend on the adjacent tangents 50 feet on the receiving and trailing ends unless otherwise shown on the Contract Drawings. When installed on curves in yard track, guard rails shall extend on the adjacent tangents 15 feet on the receiving and trailing ends as shown on the Contract Drawings. Guard rails shall be placed opposite frogs, in approach to switches, and at other points in Special Trackwork, as shown on the Contract Drawings. Guard rails shall be flared at the ends and fitted with standard filler blocks unless otherwise shown on the Contract Drawings.

2. The guard rails shall be secured to the running rails as shown on the Contract Drawings.

R. Rail Braces

1. Unless otherwise shown on the Contract Drawings, on guarded curves and on transitions or run-offs thereof, Type C tie plate rail braces shall be applied to outside rails at every other tie on all curves from 140 feet to less than 750 feet radius, and every tie for curves less than 140 feet radius. Adjustable rail braces and separators shall be applied to guard rails at every third tie on curves from 350 feet to less than 750 feet radius; at every other tie on curves from 140 feet to less than 350 feet radius; and every tie for curves less than 140 feet.

2. In turnouts, Type C tie plate brace plates with adjustable rail braces and separators shall be applied as shown on the Contract Drawings.

3. Adjustable rail brace plates shall be fully spiked. The adjustable rail braces that are to be used in track and switches shall be the "RACOR" one-bolt security brace, or approved equal. The two-bolt system will not be acceptable.

S. Handling Rails

Rails shall be handled carefully to prevent bumping or bending of rail. In the process of laying, lifting or surfacing, particular care shall be taken to prevent the bending of the rails by the use of work trains or otherwise. The rails shall be skidded off the cars or other conveyances by a method approved by the Engineer and shall in no case be dropped. In skidding the rails, care shall be taken that they do not strike other rails.

T. Curving Rails

1. Running rails for use in curves of less than 750 feet radius shall be properly curved, using an approved rail-bending machine. Rails for use in curves of radius 750 feet and over may be spiked and sprung to the proper curve. Precautions shall be taken to obtain a uniform curve throughout the rail.
2. Guard rails for use on curves of radius less than 750 feet shall be properly curved using an approved rail-bending machine. Guard rails for use on curves of radius 750 feet and over may be spiked and sprung to the proper curve. Precautions shall be taken to obtain uniform curve throughout the rail.

3. When curving rails, the maximum amount of curvature in any one operation of the rail-bending machine shall not exceed a middle ordinate of 1-1/2 inches in 33 feet.

U. Special Length Rails

1. All short lengths of rail furnished by the Contractor shall be grouped into one part of the Work, except such short lengths as are absolutely necessary to fill in on the runoff or approach of curves or in any other location approved by the Engineer.

2. All special length rails necessary to complete the work shall be cut in the field by the Contractor. They shall be sawed square across the rail; a variation of more than 1/32 inch will not be accepted. All burrs shall be removed and ends made smooth. Use of special length rails will not be permitted unless specifically shown on the Contract Drawings. Any cut main or guard rails less than 25 feet long, left over upon the completion of the Work shall be collected on or near the site and disposed of away from PATH property. The work shall be laid out so as to involve a minimum amount of rail cutting.

3. Burning of rails will not be permitted for any reason.

V. Drilling Rails

Special lengths of rail cut in the field, as specified in 3.01 V.2, shall be drilled by the Contractor for joint bars when they are to be laid in bolted joint territory. All holes shall be spaced as shown on the Contract Drawing; conform accurately to the dimensions shown; be free from burrs and be cylindrical and not conical. All holes in rails shall be drilled and not punched or burned.

W. Tie Plates

1. Tie plates shall be used under all rails on all ties. Tie plates shall be placed with the shoulder tight against the outside base of rail so as to ensure a full bearing of all the assembled parts. Care shall be taken to place tie plates with canted rail seats in the proper orientation on the cross ties as shown on the Contract Drawings. Some of the plates may require additional holes punched in them in the field.

2. Tie plates, switch plates, gage plates, and frog plates in turnouts and crossings shall have flat rail seats for level running rails.

3. When required by this Specification or where shown on the Contract Drawings, plates for use with spring type fasteners shall be installed. When one side of the track has spring type fasteners, the other side shall also be equipped with spring type fasteners.

X. Tie Pads

Tie pads shall be used under all steel tie plates. Holes for spikes shall be drilled in the pads.

Y. Spiking

1. No spiking shall be done until after the ties have been properly spaced and squared across the center line of the track, on tangents, and placed in a radial position on curves.

2. Driving of spikes shall be controlled so as to avoid penetration of tie bottoms for shallow ties.
3. Spikes shall be installed in tie plates on wood ties as follows:
   a. On tangent track and track of 3,000 feet radius and over, one line spike on each side of each rail and one anchor spike on each end of the tie plate.
   b. On track of radius 750 feet or over and less than 3,000 feet, one line spike on the outside of each rail and two line spikes on the inside of each rail and one anchor spike on each end of the tie plate.
   c. On curves of radius less than 750 feet, one line spike on the outside of each running rail, one line spike between the inside running rail and the guard rail, one line spike on the side of guard rail toward the center line of track, two line spikes on the inside off the outside rail and one anchor spike on each end of the tie plate (D plate shall have two anchor spikes on each end of plate and C plate shall have additional anchor spike on end of plate outside of running rail).

Z. Spikes
   1. Cut spikes shall be installed normal to the top surface of the tie and straight, and care shall be used when spiking to avoid striking the rail, tie plate, joint bar or other adjacent material. Spikes shall not be struck after they have reached a bearing and the last blow on the spike shall be struck lightly so as to avoid breaking the head of the spike or injuring the adjacent material when the spike comes to a bearing. If, for any reason, a spike is drawn, the hole shall be filled with a square treated hardwood plug and the spike shall be redriven in the same location.

   2. Screw spikes shall be installed normal to the top surface of the tie except at special locations. If it is found necessary to unscrew any of the spikes, care shall be taken in replacing, not to destroy the thread in the wood. Under no circumstances shall a screw spike be driven by any other method than by screwing and it shall never be struck or pounded.

AA. Spring Fastener Assemblies
   1. Install rail fastener assemblies and guard rail fastener system in new construction per manufacturer’s instructions where and as shown on the Contract Drawings.

   2. Install clips per manufacturer’s instructions. Care shall be taken to not overdrive and stress clips.

   3. Loose or missing clips shall be promptly replaced.

BB. Handling Ties
   Ties shall be handled carefully. Throwing ties from cars or other conveyances will not be allowed. No picks, shovels, spike mauls or other tools shall be used for pulling or "bucking" ties. In order to protect the drilled holes in the ties from becoming blocked with foreign substances, the Contractor shall, when directed by the Engineer, furnish and place in these holes temporary wooden plugs or corks during the handling and until the permanent spikes or lag screws are installed. Storage of ties below grade will be permitted only as directed by the Engineer.

CC. Drilling of Ties
   Pilot holes shall be drilled in ties for spikes. The ties shall be accurately drilled from and normal to the top surface, which is the widest face farthest from the pith of the tree, whether or not the pith is present in the piece. The finished holes shall be 7/16 inch in diameter and 5 1/2 inches deep for pine ties and 9/16 inch in diameter and 5 1/2 inches deep for oak ties. All unused holes in ties shall be plugged with treated hardwood tie plugs.
DD. Placing Ties

The top surface of all ties shall be in a plane parallel to the plane across the top surface of the rails. Except for Special Trackwork, ties shall be placed square across the centerline of track on tangents and in a radial position on curves. In spacing and squaring the ties before spiking, the rails should be raised and ties shifted to their proper position without striking or pounding them with spike mauls, picks or any other implement. Any ties that are split or damaged shall be removed and new ties substituted at no expense to the Authority. The heart-side of all ties shall be turned down.

EE. Placing Ballast

1. Do not place ballast until the Engineer has approved the subgrade upon which the ballast is to be placed.
2. Place stone ballast to the limits and depths, and to the grade, shown on the Contract Drawings, or directed by the Engineer.
3. Ballast shall be placed to the elevation of the bottom of cross ties or switch timbers prior to placing ties or timbers on the ballast.
4. The Contractor may at his own option, line and surface the track prior to or during the ballasting operation.
5. In the ballasting operation, the Contractor shall add ballast to the tie cribs and shoulders in accordance with the ballast cross section shown on the Contract Drawings.
6. The Contractor shall tamp the ballast, and give a final lining and surfacing where required, and dress the ballast section.

FF. Connection to Existing Track or Special Trackwork

When jointing new track to existing track or Special Trackwork, the connection shall be performed as directed by the Engineer and as follows:

1. When connecting rails, the existing rails shall be top and side welded, and offset joint bars shall be installed as required, to achieve a smooth connection between new and existing rails.
2. Existing rails shall be removed and new rails installed, on existing tie plates with new tie pads and fasteners, to within 40 feet beyond the installation limits as shown on the Contract Drawings, to meet minimum rail length as required.
3. Existing ties shall be shifted on adjacent track as required, to accommodate new ties.
4. Track connection shall be made in a smooth manner and be lined and surfaced. Where new track joins existing track, any difference in horizontal or vertical alignment shall be run off in the existing track and yard lead tracks within 100 feet of the installation limit for main tracks and yard lead tracks and within 50 feet of the installation limit for yard lay-up tracks. Any difference in alignment shall be run off in the existing track at the rate of one inch in forty feet except for lay-up tracks where the rate shall be one inch in twenty feet, or as directed by the Engineer.
5. Where new rail joins existing rail of other cross-section, compromise joints shall be used and the head of the existing rail shall be built up by welding, if necessary, to provide a satisfactory running surface. No grinding of new rail shall be permitted.
6. Temporary realignment of adjoining existing Special Trackwork portions and tracks to be replaced, including associated contact rail and appurtenances, shall be made so as to accommodate installation of new Special Trackwork portions in proper alignment.
7. Temporary connections to existing tracks, switches, frogs, and crossings shall be made as required.

8. Temporary rail anchors shall be installed where the Contractor has removed rail anchors from existing rail or when directed by the Engineer.

9. Temporary insulated joints shall be installed where required.

GG. Pumping: The Contractor shall provide pumping to keep the site sufficiently dry to permit installation of track materials.

HH. Reused Track Components
Wherever existing track and contact rail components are to be reused, they shall be cleaned and inspected prior to reinstallation. Notify the Engineer of any components that are missing, damaged or unsuitable for reinstallation.

II. Mismatched Transition Joints
Where worn rail is replaced by new rail and the resulting temporary transition joint has a mismatch on either top or gage side of railhead then corrective measures shall be taken prior to placing rail in service. Top wear may be corrected by welding or by offset joint bar combined with rail shimming. Sidewear shall be corrected by side welding. Railhead of new rail which is to remain in the final track installation shall not be ground down. There shall be no permanent mismatched joints at the installation limits.

JJ. Removal of Ballasted Track
Subject to 3.01G, removing and disposing of existing ballasted track construction, complete, shall include removing track rail, ties, ballast to the invert or indicated grade, guard rail and all appurtenances beyond installation limits and new work limits shown on the Contract Drawings in order to meet minimum rail length requirements for both track and turnouts, and all other track materials and appurtenances; all power and signal materials and appurtenances, (cable, wire, conduit, trunking, track connections, rail bonding and other appurtenances secured to the ties or rails) that are in the trackway which will be required to be removed in order to provide for the changes in the tracks within the limits shown on the Contract Drawings and as determined by the Engineer; also all cleaning up, including the removal and disposal of all debris and incidental work. The Contractor's attention is a called to the fact that the tracks to be removed may be under operation and the contact rails (third rails) may be live, used for the transmission of electricity at approximately six hundred volts. The Contractor shall remove tracks only at such times and under such conditions as has been approved by the Engineer prior to starting such work.

KK. Shifting Ballasted Track
Shifting existing ballasted track, including contact rail with all appurtenances and maintaining all electrical and signal connections, in accordance with the Contract Drawings and this Specification, shall include shifting existing track and contact rail to the new alignment including maintaining all electrical and signal connections; cutting, bending, curving, fitting, drilling and altering rails, installing new ballast as required; shifting ties; making all connections to adjacent tracks; installing new nuts and bolts, spikes and drive lags; shifting the protection board and all other appurtenances needed for the complete shifting of the track and contact rail, filling and grading as required; also all cleaning up, including the removal and disposal of debris and all other work necessary for or incidental to the complete shifting of this type of track and contact rail. This work also includes temporary supporting and bracing of running rails, contact rails, and all other equipment necessary to maintain safe and continuous operation on the railroad.
3.02 OPEN AREA TRACKS

A.  General
1.  Track concrete-tie and timber-tie track to the limits shown on the Contract Drawings.

B.  Ballast
1.  Prior to placing ballast, compact subgrade to a firm hard surface to the satisfaction of the Engineer.
2.  Grade No. 4 stone ballast shall be used.
3.  Ballast shall be thoroughly tamped with tamping machines under and on both sides of the ties from the ends of the ties to a point at least 15 inches inside of the rails. The long ties for the support of the contact rails shall be tampered from a point opposite the ends of the standard ties to a point at least 15 inches inside of the rails. The ends of the contact rail ties outside of this area and the center of all ties shall not be tamped. Approved automatic tampers shall be used for tamping stone ballast. The rails shall be carefully raised in at least two lifts to the established grade. The ballast shall be leveled even with the top of the tie and neatly trimmed before final completion of the work.
4.  Not less than one month after ballasted track is completed, and placed in service on revenue or main tracks or 3 months for lay-up track, resurface track by retamping all new ties, ties shifted, disturbed or nearby undisturbed ties affected by original tie work, or nearby ties found to be pumping. Retamping shall be done mechanically under traffic.
5.  Ballast around new, shifted, disturbed and nearby undisturbed ties affected by the work or nearby ties found to be pumping, shall be properly tamped at the time of installation and mechanically retamped under traffic not less than one month after initial tamping.
6.  The minimum specified period required before retamping of ballast, shall not include the time when ground is frozen.
7.  Hand tamping with tamping picks will be permitted only when shown on the Contract Drawings or where permitted by the Engineer.

C.  Ties
1.  Except for Special Trackwork, treated ties, 7" x 9" x 8'-6" and 7" x 9" x 10'-0" for the support of the contact rail, shall be used unless otherwise shown on the Contract Drawings. The ends of the ties shall be lined on the side of the tracks opposite the contact rail location, except that the end of the contact rail tie on the contact rail side shall be 5 feet 9 inches from the center line of the track.
2.  Concrete ties shall be spaced at 24" spacing. Timber transition ties shall be spaced as shown on the Contract Drawings.

D.  Profile: The line on the profile shown on the Contract Drawings for the alignment, marked top of rail shall be taken as the line of the top of rail at the center line of the track or the top of the low rail in super elevated track.

E.  Paved Road Crossing
1.  Paved road crossing shall be constructed where and as shown on the Contract Drawings. Pavement construction is specified elsewhere in the Specifications.
2. Where paved road crossings are to be constructed upon existing tracks, the Contractor shall replace any deteriorated cross ties and missing track materials with new material, as shown on the Contract Drawings.

3. Contact rail gap for road crossings shall be provided by the Contractor as specified in 3.03 G.

4. In laying paved road crossing, it is essential that the track, with the required fittings, be aligned horizontally and vertically, set to proper gage and secured in position before placing the pavement. Care shall be taken to prevent disturbing the track after it has been set in final position. No pavement shall be placed in the tracks until the track has been checked for line and grade by the Engineer and in no case shall the pavement be placed without the approval of the Engineer.

5. Road crossings shall be maintained for the duration of the Contract.

6. Where shown on the Contract Drawings, the Contractor shall remove the paved road crossing and remove the contact rail gap upon completion of the Contract and at the direction of the Engineer. Removal of the contact rail gap shall include removal of end approaches, cable connections and ducts, back-fill of trenching and installation of contact rail and protection board.

F. Rubber Pad Road Crossing

1. Rubber pad road crossing shall be installed where and as shown on the Contract Drawings or as directed by the Engineer.

2. The Contractor shall furnish rubber railroad crossing pads for the installation, as manufactured by Goodyear Company "Super-Cushion" or approved equal.

3. Where rubber pad road crossing is to be constructed upon existing tracks, the contractor shall renew the track within crossing limits including new cross ties' ballast, drainage system, and new rail and fasteners.

4. Installation of the rubber pad road crossing shall be in accordance with the recommended instructions of the manufacturer and as directed by the Engineer.

5. Rails within the limits of the road crossing shall have welded joints. Rails may be field welded or shop welded at the Contractor's option. "Boulet" welding by the U.S. Thermit Company is an accepted method of welding. Manufacturer's recommendations shall be followed when welding rails. All other methods of welding shall have the Engineer's approval.

6. In installing rubber pad road crossing, it is essential that the track with the required fittings, be aligned horizontally and vertically, set to proper gage and secured in position before placing the pavement. Care shall be taken to prevent any disturbing of the track after it has been set in final position. The Contractor shall not begin to install the rubber pad road crossing upon the track until the track has been checked by the Engineer for line and grade and the other requirements.

G. Contact Rail at Road Crossings

1. Where and as shown on the Contract Drawings, provide a road crossing gap in the contact rail at all temporary and permanent road crossings.

2. This work shall include the installation of end approaches, cable connections to the contact rail, trenching, laying of cable conduit, and back-filling. In the case of existing contact rail, remove the contact rail and protection board within the limits of the road crossing.
3.03 INSTALLATION OF CONTACT RAIL

A. General
Contact rail and all appurtenances specified herein shall be installed where and as shown on the Contract Drawings, in accordance with the applicable requirements of 3.01, and as specified herein.

B. Contact Rail Insulators
1. Contact rail insulators shall be installed on the long ties provided for this purpose. The insulator shall be mounted on a protection board bracket base that is fastened to the tie by drive lags. Contact rail ties shall be drilled for drive lags. On the top of each insulator, install an insulator cap.

2. Additional insulators shall be installed for the support of the end approaches, and at other points where special conditions require them.

3. No insulators shall be installed on ties supporting joints in the running rails, unless otherwise shown on the Contract Drawings.

4. Paint or other injurious substances falling on the insulators shall be immediately wiped off to prevent damage to the insulators.

5. After completion of the Work and immediately before final acceptance, all insulators shall be inspected and thoroughly cleaned and all insulators chipped, broken or otherwise found to be defective shall be replaced.

C. Contact Rail
1. The contact rail shall be installed to proper alignment and grade, resting evenly and uniformly on all insulators. When the contact rail does not properly rest on the insulators, the Contractor shall furnish and install between the insulators and caps, suitable shims of a type approved by the Engineer, provided this condition cannot be otherwise corrected.

2. When, in order to obtain the prescribed height of contact rail relative to running rail, it is necessary to raise the insulator assembly, a treated exterior grade plywood shim 7-3/4 inches by 11 inches of suitable thickness shall be installed on the top of tie, beneath both the contact rail insulator and the protection board bracket, and the shims previously mentioned may be omitted.

3. The contact rail is made of comparatively soft metal requiring special care in handling to avoid denting, bending and twisting during installation. Only rails free from imperfections shall be installed in the work. On curves, the rail shall be bent, to conform to the exact radius of the curve, by means of an approved rail bender. Necessary cuts shall be made by sawing and shall be straight and at right angles to the longitudinal axis of the rail. Unnecessary cuts shall be avoided.

4. Provide gaps in the contact rail of Special Trackwork and at other locations shown on the Contract Drawings.

5. No contact rail less than 25 feet in length shall be used unless otherwise shown on the Contract Drawings or specifically authorized by the Engineer. Any cut rails less than 25 feet left over upon the completion of the work shall become the property of the Contractor and shall be disposed of away from PATH property.

D. Offset Joints
Where new 150 lb. contact rail is joined to worn existing 150 lb. contact rail, top surface of heads shall be lined flush and the existing contact rail assemblies shall be shimmed accordingly.
E. End and Side Approaches

1. The ends of contact rail sections shall be terminated with end approaches. The end approaches shall be of the proper length as shown on the Contract Drawings. They shall be assembled, ground, fitted and connected to the contact rail, so as to ensure a smooth-running surface. Where the contact rail is installed on the side of the track adjacent to a frog, the tip of the end approach shall be located at a point where the spread of the adjacent rails, measured from gage to gage, is not less than 5 feet 10 inches, measured on a line perpendicular to a line bisecting the angle between the two rails. At Special Trackwork, no part of the end approach or the protection board supports shall be less than 2 feet 9 inches from the gage line of an adjoining track.

2. Where shown on the Contract Drawings, side approaches will be attached to the contact rail. They shall be assembled, ground, fitted and connected to the contact rail, so as to ensure a smooth surface. Side approaches of the correct dimensions, as shown on the Contract Drawings, shall be used.

3. At all end approaches and at all side approaches, the top of the protection board and the field side of the kickboard, if any, shall be painted with warning marks. Warning marks shall consist of 3-inch broad diagonal stripes of weatherproof reflective white paint on 6-inch centers. The warning marks shall extend 3 feet along the boards from the tip of the end approaches, and shall extend along the boards for the entire length of the side approach.

F. Anchors

1. Install, approximately at points as shown on the Contract Drawings, anchors for 150 lb. contact rail of the type and construction shown thereon. Anchors shall be installed on the side of the contact rail facing the running rail.

2. If, due to conditions in the field, it is necessary to change the locations of any of the anchors as shown on the Contract Drawings, such anchors shall be installed as near as possible to the original locations as determined by the Engineer.

G. Clearance

At least 5 inches clearance shall be provided between the structure and any parts of the contact rail or its appurtenances which will be live when the current is on. At locations where such clearance is not possible, PVC protection shall be installed as shown on the Contract Drawings.

H. Contact Rail Joints

PATH will install all contact rail welds.

I. Protective Covering

1. Installation of contact rail fiberglass protection boards shall include supporting adjustable brackets, splice plates, drive lags, bolts, and other appurtenances.

2. Brackets:

Contact rail protection board brackets shall be placed on the ties supporting the contact rail insulators and the ties shall be drilled in the field by the Contractor. Brackets supporting protection boards shall be installed at each insulator but in no case shall be installed at each insulator but in no case shall be at greater than 10-foot intervals. The Contractor shall assemble the adjustable brackets with the proper adjustment so as to give correct relationship of protection board to contact rail as shown on the Contract Drawings.
3. **Alignment**
   Contact rail protection board brackets shall be gauged accurately before installation and the protection boards shall be set to proper alignment and elevation. Care shall be exercised to maintain the minimum clearance between the top of the contact rail and the underside of the protection board. The use of shims or wedges under protection board brackets solely will not be allowed. In all cases, protection boards shall be of sufficient length to be supported by not less than 2 brackets. On curves, the protection board shall be cut into short lengths so as to conform as closely as possible to the arc of the curve and where necessary, additional special brackets shall be installed. Special care shall be taken in installing brackets on curves, so that such clearances as the Engineer may direct, will be provided.

4. **Splicing of Protection Boards**
   a. All standard splices in the protection board shall be installed as shown on the Contract Drawings. Care shall be taken to locate and install all protection board splices no more than 24 inches from a bracket but not closer than 15 inches. The ends of all protection boards shall be properly squared. Expansion gaps between the ends of the boards shall not be less than 1/16 inch nor more than 1/4 inch unless otherwise directed by the Engineer.
   b. The splices shall be located immediately in front of the brackets, rather than immediately behind the brackets, when facing the direction of train travel. The direction of train travel will be as shown on the Contract Drawings.

5. **Drilling Protection Board**
   All holes in the protection board shall be 1/2-inch in diameter and shall be drilled straight and perpendicular to the surface. Redrilling, enlarging or burning these holes will not be permitted. All holes required for bolts of supporting brackets shall be drilled in the field after the brackets are in position.

6. **Overhang of Protection Boards**
   The end of the protection boards shall overhang the end-approaches 6 inches. The distance between the extreme end of the overhang of the protection board and the centerline of the nearest bracket shall not exceed 36 inches. The end of the board shall be suitably beveled on the underside so as to deflect the shoe downward if it should strike the same. Protection board shall be continuous over expansion gaps in contact rail.

J. **Holes Drilled in the Field**
   All holes drilled in the field in treated ties shall be filled with hot creosote oil as directed by the Engineer.

K. **Removing Contact Rail**
   Where the Contract Drawings require the removal of existing contact rail, contact rail appurtenances and protection board, these materials shall be disposed of as specified in 3.01 G. All unused holes in track ties remaining after removal of existing contact rail insulators shall be filled with suitable creosoted hardwood plugs.

END OF SECTION
SECTION 341111
OPEN AREA TRACKWORK (PATH RAIL TRANSIT)

APPENDIX "A"

SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

Shop Drawings

1. Shop drawings shall be submitted for approval. No manufacture and construction of track slabs or trackwork products shall be done until such drawings are approved, or until notification to proceed is received in writing from the Engineer.

2. Furnish one set of mylar tracings duplicated from the approved shop drawings.

3. The Contractor shall require his manufacturer of trackwork products to verify the Contract Drawings, including referenced PATH Standard Drawings, with respect to all details for accuracy. A statement to this effect shall be put on the shop drawings supplied. Any apparent discrepancies in the Contract Drawings shall be brought to the attention of the Engineer and all modifications shall be approved by the Engineer before the start of manufacture and construction of trackwork products.

4. General plans for Special Trackwork, including track slabs, shall be drawn to a scale of 1/4" = 10". A general plan shall be provided for each Special Trackwork portion and shall show the complete Special Trackwork portion and all connections with adjacent work. It shall include all rail lengths along gage of rail, tie lengths, tie spacings, tie plates using standard Authority nomenclature, all critical dimensions and necessary data, gage and flangeway, location of all insulated joints and switch machines, and a list of plans and references for all parts. All parts shall be marked for each portion and its location in that portion. Include all other information necessary or incidental to the manufacture and construction of the Special Trackwork portion, as required by the Engineer.

5. All Other Track Fittings and Appurtenances: Shop drawings for all other pieces for the track items required in the Contract will not have to be submitted if these pieces can be constructed and checked using PATH Standard Drawings supplied with the Contract Drawings.

6. A bill of materials shall tabulate item descriptions, quantity of item, part numbers and drawing numbers, for all Special Trackwork including spare parts, and for other trackwork products. Bill of materials shall be submitted, as part of the shop drawings, to the Engineer for approval.

Submit details of track bracing, where ballast of tie cribs is removed down to base of tie, to the Engineer for approval, in accordance with 3.01 B.2.
Submit shop drawings or catalog cuts of track and contact rail gages to the Engineer for approval, in accordance with 3.01 J.5.

Submit shop drawing showing rail layouts and joint locations to the Engineer for approval, in accordance with 3.01 L.2.

Samples

Submit to the Manager, Materials Engineering Division, Port Authority Technical Center, 241 Erie Street, Jersey City, New Jersey 07310-1397, a representative sample of stone ballast from each source proposed for use under this Contract subject to the following:
1. Submit sample in two clean, sturdy containers or bags which will not permit loss of any of the material and each of which contains 75 pounds of the sample.
2. Clearly label each container or bag of the sample with Contract location, Title and Number, the name of the material supplied and location of the source.
3. The Engineer will approve or disapprove within 21 days after receipt of sample.
4. Do not deliver ballast from any source until the Engineer has approved the sample from that source.

Manufacturer Test Reports

Submit to the Manager, Materials Engineering Division all certified test reports for chemical, physical and electrical tests required by Part 2 of this Specification.

Contact Information

Submit the name and the location of the Special Trackwork shop to the Engineer for approval, in accordance with 2.01A.

Submit the name and the location of the rail rolling mill to the Engineer for approval.

Submit the name and the location of the timber products mill to the Engineer for approval, in accordance with 2.13.

END OF APPENDIX "A"
DIVISION 34

SECTION 341130

CONCRETE CROSSTIES AND FASTENERS

PART 1. GENERAL

1.01 SUMMARY

A. This Section specifies requirements for design, fabrication of component parts, manufacturing, qualification testing, quality control, handling, shipping, and unloading and stockpiling of monoblock prestressed concrete crossties together with cast rail fastening shoulders and embedded inserts.

B. The monoblock prestressed concrete ties to be provided shall be standard 8-foot -- 6-inch crossties with embedded rail fastening shoulders and stainless steel threaded inserts for attachment of the third rail extension plate. Each tie shall include rail, fastening spring clips, spring clip insulators and insulating elastomeric rail pads. Each tie shall be provided with an under-tie pad for use in track type transitions.

1.02 SYSTEM DESCRIPTION

A. Track Configuration for Concrete Tie Design: Concrete cross tie design loading using AREMA's Flexural Performance Requirements are for use in ballasted track sections with 115 RE rail and 4 feet 8-1/2 inch gauge. For purposes of design of the concrete ties only, the design spacing shall be 30 inches.

1.03 REFERENCES

The following is a listing of the publications referenced in this Section:

American Association of State Highway Officials (AASHTO)

AASHTO T26 Concrete Standard Method for Test for Quality of Water to be used in

American Concrete Institute (ACI)

ACI 301 Specifications for Structural Concrete
ACI 305 Hot Weather Concreting
ACI 318 Building Code Requirements for Structural Concrete

American Railway Engineering and Maintenance-of-Way Association (AREMA)


American Society for Testing and Materials (ASTM International)

ASTM A421 Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete
ASTM A881 Specification for Steel Wire, Deformed, Stress-Relieved or Low-Relaxation for Prestressed Concrete Railroad Ties
ASTM C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33 Specification for Concrete Aggregates
ASTM C39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C78 Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C143 Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150 Specification for Portland Cement
ASTM C172 Practice for Sampling Freshly Mixed Concrete
ASTM C 231 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
ASTM C359 Test Method for Early Stiffening of Portland Cement (Mortar Method)
ASTM C 494 Specification for Chemical Admixtures for Concrete
ASTM C1293 Standard test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
ASTM D257 Test Methods for DC Resistance or Conductance of Insulating Materials.
ASTM D570 Standard Test Method for Water Absorption of Plastics
ASTM D732 Standard Test Method for Shear Strength of Plastics by Punch Tool
ASTM E122 Standard Practice for Calculating Sample Size to Estimate, with Specified Precision, the Average for a Characteristic of a Lot or Process.

Prestressed Concrete Institute (PCI)

PCI MNL 116 Manual for Quality Control for Plants and Production of Structural Precast Concrete Products

1.04 DESIGN CRITERIA

A. All crossties, except at locations specifically indicated otherwise in the Contract Drawings, shall have two inserts embedded in each end for mounting of third rail extension plates by others.

B. Installation and Track Maintenance: The compaction of ballast under and around the concrete ties shall be done by using hydraulic or electric activated tamping tools on a production ballast tamper. The tie shall resist these tamping forces without spalling of concrete on the sides and bottom corners.

C. Maximum tie spacing is 30 inches.

D. The design vehicle is a multiple unit electrically propelled train of up to 10 cars operating at speeds of up to 60 mph on mainline track.
E. The design axle loads are 26,000 pounds subject to a 300 percent minimum impact factor.

F. Annual tonnage on each track is approximately 10 million gross tons.

G. Design moments and test loads for the concrete ties, as calculated from the formulas in AREMA Manual Chapter 30. If the Contractor proposes to use the axle loads stated herein to design ties for bending moments other than those calculated by AREMA formulas, Contractor shall submit all of its proposed design loads and calculations showing the derivation of these moments, for review and acceptance by the Engineer. Calculations shall show all assumptions and cite relevant design standards.

H. Design Calculations
1. Prepare the final design of each of the types of concrete crossties, turnout ties and appurtenances required for use in ballasted track, including monoblock concrete crossties with Pandrol, or an approved equal, shoulders, e-clips and threaded inserts for attachment of the third rail extension plate.

2. Design moments and test loads for the concrete ties, as calculated from the formulas in AREMA Manual Chapter 30. If the Contractor proposes to use the axle loads stated herein to design ties for bending moments other than those calculated by AREMA formulas, Contractor shall submit all of its proposed design loads and calculations showing the derivation of these moments, for review and acceptance by the Engineer. Calculations shall show all assumptions and cite relevant design standards.

3. Calculations shall be prepared in accordance with AREMA Chapter 30, Part 4 including bending moments and loads for specified tests, and other required data in PDF files designed to print standard 8-1/2 by 11 inch sheets. Calculations shall include shear and moment analysis for the tie under no-cracking conditions and shall consider all long-term permanent prestress losses. Each sheet shall bear the information required by paragraph H.3 below, except that the 5 inch square blank space will not be required.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications
1. Concrete ties shall be produced in a plant or production facility by a manufacturer that has been regularly and continuously engaged in the manufacture of precast, prestressed concrete ties for a minimum of five years.

2. The plant shall meet and continue to meet PCI certification. Provide, or arrange for the tie manufacturer to provide, an ACT Level I Field Technician to perform Quality Control concrete testing.

3. If the manufacturer is not certified under one of the ISO 9000 Series of Quality System Standards or equivalent quality system standard, their Production and Quality Control Plans shall be submitted to the Engineer for approval.

4. The manufacturer shall have sufficient production capacity to produce the required number of ties in accordance with the quality requirements and without causing any delay in the work.

5. The manufacturer shall furnish certification that all aspects of the yard operation, including materials testing, storage, and handling conform to the quality control requirements herein, and current industry standards as defined in PCI MNL 116.
6. Current certification by PCI throughout the fabrication period will be accepted as evidence of conformance with this requirement.

B. Certification by a qualified, independent consultant or laboratory will also be accepted as evidence of conformance with this requirement. Initial certification shall be based on a plant inspection of yard operations and quality control procedures. The Engineer shall be notified prior to the inspection and may attend. At least two follow-up inspections shall be performed during the production run, and after each certificate of conformance submitted to the Engineer.

C. Quality Control Program - Develop and maintain a quality control program under which the Contractor shall perform sufficient inspections and tests of all items of work, including those by subcontractors, in order to assure conformance to applicable standards, Specifications and Contract Drawings with respect to material, workmanship, fabrication and identification. The control plan shall specifically provide for:

1. Manufacturer surveillance (e.g., shoulder inserts, contact rail bracket support plate inserts, and wire)
2. Drawing control (changes)
3. Mold Certification
4. Document control
5. Inspection Procedures – In Process and Final
6. Production test requirements
7. Segregation and disposition of defective material and products
8. Material and process control in plant identifying critical control points
9. Production equipment and instrumentation calibration, maintenance and data recording
10. Work procedures and instruction
11. Failure reporting analysis and corrective action
12. Sample plans and quality levels
13. Raw materials standards and controls
14. Records of test and inspection
15. Time and temperature control
16. Strength testing
17. Storage handling and shipment controls
18. Procedure and/or tests for determining within 24 hours that the condition necessary to achieve the 28-day strength have been met.
19. Assurance that the plant shall meet and continue to meet PCI certification. Provide, or arrange for the tie manufacturer to provide, an ACI Level I Field Technician to perform Quality Control concrete testing
20. Quality Control (QC) organization chart showing all QC personnel and their level of authority. QC organization shall report independently from Production to project manager level or above.

D. Production Program
1. Plant layout
2. Form design with tolerances
3. Raw material requirements
4. Primary and alternate sources for materials
5. Material handling
6. Material placement with tolerances
7. Curing method
8. Bond release method
9. Method of vibration
11. Daily production capability
12. Finished tie inventory plan
13. Plan for handling finished ties
14. Flow chart for production process indicating points of control for all significant operations
15. Production schedule

E. The Contractor shall provide weekly written reports to the Engineer documenting a strict adherence to the Quality Control and Production Control Programs.

F. Organization and Management

1. Submit plans for an organization and management program sufficiently comprehensive to meet and maintain the requirements and objectives of the Contract. This program shall employ the systems and techniques necessary to identify the product configuration; control changes to the product during development, production, testing and delivery; and monitor that the objectives of the Contract are being achieved.

G. Location for Inspection and Quality Control Testing

1. Arrange for quality control testing of production ties to be performed at the manufacturer's plant with the facilities and ASTM compliant test equipment approved by the Engineer prior to production of ties. Two copies of the results of all inspection and quality control tests shall be submitted to the Engineer within 48 hours of the performance of the tests. Notify the Engineer in writing at least 14 days in advance of dates scheduled for quality control tests. Facilities shall be provided for the Engineer to witness all testing.

H. Licensed Professional Qualifications

1. Design calculations shall be signed and sealed by a Professional Engineer licensed in the State of New Jersey.

I. Testing Agency Qualifications

1. Quality control testing shall be performed by an entity with at least 5 years of continuous concrete quality control testing experience.

J. Source Limitations

1. Delineate all primary suppliers and their locations as well as the intended alternate suppliers. Immediately notify the Engineer of any change in material sources from primary to alternate suppliers. Provide written documentation that any materials from alternate suppliers meet all specifications required and will yield a final product capable of performing as intended.

L. Daily Production Quality Control Tests
1. Acceptance Tests: At the start of any production contract, a minimum of 6 rail seat positive, 6 tie center negative, and 6 shoulder pull-out tests shall be undertaken by the Contractor on randomly selected ties to establish compliance with this specification. After the acceptance test load results are checked, additional loading shall be applied to the ties to produce the first crack greater than 2.5 mm (1 inch) in vertical length and these loads and crack lengths recorded.

2. Routine Production Testing: Routine acceptance testing shall be carried out on all beds cast. One tie selected from every 200 ties, or fraction thereof from one form, selected at random from each bed cast, shall be load tested as follows:
   i. Center Positive Bending Moment Test as detailed in Section 2.05 E of this specification.

3. If structural cracking occurs in the tests, two additional ties from the same lot shall be subjected to the same test and acceptance of the lot shall be based on the following conditions:
   i. If both retest ties meet the test requirements, the lot shall be accepted.
   ii. If either of the retest ties fails to meet the test requirements, the remaining ties shall be tested in accordance with a statistical sampling plan.

4. One tie selected at random from every 200 ties, or fraction thereof, produced each day shall be subjected to testing the distance from the center of track to the center of rail seats by use of a template. The rail seat configuration and shoulder insert location shall be verified.

5. Not less than 1% of the contract order shall be selected at random from those ties previously subjected to the Rail Seat Positive Bending Moment Test (one of every five of such ties) shall additionally be tested for Bond Development and Tension Anchorage as detailed in Section 2.05 G of this specification.
   i. If strand slippage does not exceed 0.001 inches, the requirements of this test will have been met.
   ii. If strand slippage exceeds 0.001 inches, three additional ties shall be tested. If any of the three ties does not meet the requirements of the test, the remaining ties in the lot shall be tested in accordance with a statistical sampling plan.

6. The Engineer must approve the method of packaging for shipment prior to production.

1.06 TIE AND COMPONENT DESIGN

A. Concrete ties

1. Concrete ties shall be of a prestressed monoblock design, provided with steel prestressing tendons and rail fastenings consisting of embedded cast iron shoulders, Pandrol standard e-clips, plastic insulators, and pads. Two inserts shall be provided at each end of each crosstie for attachment of third rail extension plates.

2. Existing concrete tie designs that have already passed tests equivalent to those specified herein may be excepted from certain tests if so approved by the Engineer.

3. For such acceptance to be given, certified laboratory test reports shall be submitted in sufficient detail as required by the Engineer to make the determination as to its equivalency.
4. The tie design and fabrication shall be subjected to the acceptance tests specified in Section 3.05. Failure of the concrete ties to pass the prescribed tests will be cause for rejection.

5. Location and tolerances of rail fastening shoulders shall be in accordance with the fastening manufacturer’s drawings and specifications.

B. Rail Fastening Assembly

1. Cross ties shall include cast shoulders for the Pandrol Type “e” Series rail clips.

2. Ties shall be designed so that the rail clips can be easily installed or replaced in the field by one worker using standard, readily available track tools. Clips shall also be capable of being installed by commercially available automated equipment. Clip installation and removal shall not damage the tie, shoulder, clip, or rail. The rail clip shall not notch or otherwise damage the rail base during installation or removal.

3. Rail Cant

a. Rail seats on crossties shall be sloped at 40:1 toward the gauge side of the rail.

4. Rail fastening assembly shall be subjected to the acceptance tests specified under Section 3.05. Failure of the fastening system to pass the prescribed tests will be cause for rejection.

a. Existing fastening designs which have already passed tests equivalent to those specified herein may be excepted from certain tests if so approved by the Engineer.

b. For such acceptance to be given, certified laboratory test reports shall be submitted in sufficient detail as required by the Engineer to make the determination as to its equivalency.

C. Cap plugs: Shall be furnished for each insert to prevent entry of moisture and debris.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Handling of Concrete Ties

1. Ship concrete ties with plastic caps or plugs securely installed in all inserts. Securely brace ties for transportation to prevent any movement that could cause damage.

2. Ship ties in a horizontal position, braced with wooden spacer blocks so that the switch plates, top surface or embedded shoulders do not come into contact with ties loaded above. Do not load ties higher than six layers deep.

3. Do not drop or skid the ties.

B. Delivery and Handling of Fastenings

1. Pack Pandrol fastenings separately in units convenient for handling. The fastenings shall be in weatherproof containers, banded on pallets for forklift handling.

2. All containers for Pandrol e-clips shall be clearly marked with the following: identification of item contained, manufacturer’s name, shipping date, number of pieces, designation, and gross weight.

3. All fastening shipments shall be adequately prepared to preclude damage during shipment. Handle all fastenings in a manner which will prevent damage during packaging, loading and transporting.

1.08 SUBMITTALS

A. See Appendix "A" for submittal requirements.
PART 2. PRODUCTS

2.01 MATERIALS

A. Concrete

1. The concrete used for concrete ties shall have a minimum 28-day compressive strength of 7,000 pounds per square inch as determined by ASTM C39 Test Method. The maximum water-cement ratio shall be 0.45 and maximum air content shall be 5.0%. The test cylinders shall be made and stored in accordance with ASTM C31. The Portland cement used shall be low alkali cement with a maximum alkali content of 0.6 percent conforming to ASTM C150, Type III low alkali. Conduct false set penetration tests per ASTM C359. False set penetration values shall not be less than 50 mm initially, 35 mm at intermediate times, and 40 mm after remix.

   a. Cement mill certificates shall be obtained and available for review for all cement use during the production. Under no circumstances shall any material substitution be permitted unless it has been pre-qualified through testing.

2. Concrete Aggregates: Fine and coarse aggregates shall be clean, hard, strong, durable, and free of deleterious material.

   a. Aggregates shall be natural aggregates conforming to ASTM C33 Class 4S.
   b. Soluble sulfates and chlorides shall not exceed the values given in Table 4.3.1 of ACI 318, for prestressed sections.
   c. The Contractor shall submit evidence that concrete containing aggregate from the proposed source, with a cement content and alkali burden similar to the job mix, has a satisfactory service history of at least 10 years. This evidence shall include concrete with Class 4S aggregate.
   d. The Contractor shall submit evidence that the fine and coarse aggregates do not react with alkalis in the cement, to the extent that excessive expansion in the concrete may result. The results shall be interpreted as outlined in ASTM C33, Concrete Aggregates.

(1) Evaluation of potential alkali-silica reactivity shall be made according to either ASTM C1260 or, if the design mix contains fly ash, ASTM C1567. Furnish results of successful testing that shall have been conducted no more than 60 days prior to the start date for concrete batching for this order.

(2) In the event that the mix fails ASTM C1260 or ASTM C1567 criteria, then certified test results shall be submitting showing that the aggregate has been tested in accordance with ASTM C1293 and that the requirements of that test have been met. The ASTM C1293 test shall have been concluded no more than one year prior to the start date for concrete batching on this order.

   e. The maximum size of aggregate shall be 3/4 inch (size number 67) for coarse aggregate gradation. If the coarse or fine aggregate is supplied in more than one size, each size shall be stored separately.
   f. Washed aggregate shall be allowed to drain in stockpiles before use. All aggregates shall be free from ice when used.

3. Water: Mixing water shall be fresh water complying with the requirements of AASHTO T26 and the following additional requirements:

   a. pH shall be between 6.0 and 8.0.
   b. Chloride content shall not exceed 500 ppm.
   c. Sulfate content shall not exceed 2,000 ppm.
d. Total solids content, including chlorides and sulfates shall not exceed 30,000 ppm.

4. Concrete Admixtures: Accelerating, Retarding, and Water-Reducing Admixtures: Water-reducing admixtures, retarding admixtures, and accelerating admixtures, if used, shall conform to ASTM C494. In no case shall admixtures containing chlorides be used. Air entraining agents shall conform to ASTM C260.

B. Mixes

1. Trial mixtures using aggregates, water, cement, and admixtures for the manufacture of the concrete ties shall be made using at least three different water-cement ratios which will produce a range of strengths. For each water-cement ratio, at least three specimens for each age shall be made, cured, and tested as described in Section 2.01.I. Each batch of concrete shall be mixed separately in a pan mixer.

2. Design compressive strength at the time proposed for transfer of prestress forces to the concrete shall be no less than 4,500 psi, or higher if so required by the tie design or manufacturing method. Design compressive strength at 28 days shall be not less than 7,000 psi. Design flexural strength at 28 days shall be not less than 600 psi.

3. Aggregates and cement shall be measured by weight. The weight of aggregate shall be based on the saturated surface dry condition corrected for free moisture. Water shall be measured by weight or volume and admixtures shall be measured by volume, unless otherwise directed by the admixture manufacturer.

4. Mix proportions shall be developed using the method of ACI 301.

5. For restrictions on design mix proportions see Section 2.01.A.

6. The proportions of aggregate to cement shall be such to produce a mixture that will work readily into corners and angles of the form and around the prestressing elements with the assistance of specified vibration, but without permitting the materials to segregate or excess of free water to collect on the surface.

7. The strength tests shall be made at 28 days. A curve shall be developed for each design mix showing the relationship between water-cement ratio and compressive strength.

8. Acceptance of trial mix: Substantiate attainment of all specified properties by designated ASTM test methods. Provide concrete that has 56-day compressive strengths that exceed the specified design strength (f'c) in accordance with ACI 318, Chapter 5, Table 5.3.2.2.

C. Prestressing Wire

1. The wire shall be deformed, stress relieved wire complying with ASTM A881 or uncoated complying with ASTM A421.

a. Acceptance of the wire shall be dependent on the tie manufacturer, showing that the wire meets the following strength requirements set forth in this Section and that the ties meeting all specified requirements can be produced using the wire. Monitor the wire used in production to ensure consistent quality.

b. The prestressing wire used shall be an indented wire 0.2 inch in nominal diameter with a minimum breaking load of 7070 pounds. These breaking loads correspond to a tensile strength of 225,000 pounds per square inch.

D. Pandrol Shoulders
1. Embedded ductile iron shoulders shall conform to ASTM A536 Grade 60-40-18 or 65-45-12 and shall be Pandrol part No.'s 4714 for standard shoulders and 7250 insulated for "pop-up" shoulders, or an approved equal. Weld on shoulders will be permitted in the frog toe, heel, and switch heel areas. The shoulders shall be marked, on non-bearing surfaces above the concrete level, with the part number, supplier's identification, and pattern number.
   a. The shoulders shall be free from burned-on sand, cracks, cavities, injurious blow holes, and other defects. All fins shall be removed from the vertical faces of the head of each shoulder. Fins across the top of the head shall not exceed 1/32 inch and below the head, fins shall not exceed 1/16 inch. At gates, there shall be no cavity in the shoulder more than 1/8 inch below the general surface level.
   b. Go and No-Go inspection gages shall be used to check that tolerances conform to the iron shoulder shop drawings. A sampling plan for Acceptable Quality Levels of 1 percent for major dimensions and 4 percent for minor dimensions shall be used (see ASTM E122). The major and minor dimensions shall be indicated on the shop drawings.
   c. Model 7250, or approved equal, shall be coated with a high-quality powder epoxy coating that covers the entire stem and extends a minimum of ½ inch above the top of tie. Coated rail shoulders shall be individually packed for shipment to the tie manufacturer and handled with all due care to avoid chips, cracks, holidays or other damage to the epoxy coating. The Engineer reserves the right to witness tie casting and to test epoxy-coated shoulders with a holiday tester. Rail shoulders with holidays shall be removed and replaced at no additional cost to the Authority.

2. Iron shoulders shall be free of mud, oil, loose rust, and other contamination when cast into ties. They shall be rigidly secured in the forms during casting and shall not move within the concrete when the securing device is released. Location within the ties shall comply with the Contract Drawings.
   a. The shoulder shall not be directly anchored to the pretensioned steel. The shoulder shall not come in contact with pretensioned steel.

E. Embedded Third Rail Inserts

1. Insert Material: ¾" x 2 ¾" long UNC stainless steel, Press-Seal Corporation NSS-34 or approved equal.
2. Inserts shall be covered with a watertight protective cap to protect insert threads from infiltration of concrete or other materials during production and installation.
3. Inserts shall be free-draining to the bottom of the tie.

F. Rail Fastening Components

1. The rail fastening system shall include rail pads, clips, insulators, and threaded inserts for switch, heel, and frog plates and the third rail extension plate.
2. Rail fastening shall be resilient, threadless and detachable. Component part shapes shall be such that they are easily recognizable and are difficult to install incorrectly.
   a. Fastening shall be comprised of as few components as economically and technically feasible for ease of assembly, disassembly, and maintenance. Furnish and install rail clips, rail seat pads, and insulators.
   b. Construct fastenings so that the rail clips can be installed or replaced in the field by one man using hand tools.
c. Fastenings shall have, on both sides of the rail base, a positive means of preventing more than 1/8-inch total lateral movement of the rail base relative to the shoulders in case of failure or loosening of one or both rail clips. The positive means of restraint shall extend at least 3/8 inch, but not higher than 1-3/4 inches above the base of rail in the installed position.

3. Rail Fastening Spring Clips shall be in accordance with Section 1.06.B.

4. Furnish and install insulators between fastening shoulder and rails.
   a. Insulator Configuration
      (3) Provide keys between the insulators and the fastening shoulder to prevent relative motion in any direction.
      (4) The insulators shall cover the full widths of the shoulders.
      (5) Except for surfaces in contact with the rail, the surfaces of the insulators shall be smooth, clearly finished and free of flash. Insulators shall be free of internal defects and cavities.
   b. Volume Resistivity: 1012 ohm-cm, minimum. Measure in accordance with ASTM D257.
   c. Water Absorption at Saturation: Three percent, maximum. Measure in accordance with ASTM D570.
   d. Dry Shear Strength: 6500 psi, minimum. Measure in accordance with ASTM D732.
   e. The insulator shall be capable of withstanding degradation from temperatures (-10 to +150 degrees F), oxidation, water, alkali, petroleum oils, synthetic lubricants, and sunlight without having detrimental effect on the performance of the insulator. The insulator shall be designed to withstand the rigors of application and reapplication of the rail clips and other components without breaking, cracking, or any other detrimental effect of the performance of the insulator.
   f. Heat Aging: Age for 10 days at 70°C using ASTM D573 as a guide. Compare properties before and after aging at 70°C. The tensile strength shall not decrease more than 10 percent. The Rockwell Hardness shall not change more than five points. There shall be no warping, cracking, discoloration, or exudation of plasticizer.

5. Rail Seat Pads:
   a. Provide rail seat pads compatible with the rail fastening system, that have a shape which provides positive means of preventing movement of the pad parallel to the rail. Pad thickness shall be at least 3/16 inch and not more than 1/2 inch, with a width identical to the distance between the shoulder faces on the rail seat (+0, -1/16 inch) and a length one inch longer than the rail seat bearing area (plus or minus 1/16 inch). Mark pads in a permanent manner to identify manufacturer, month and year manufactured, and pad designation.
   b. Use first quality new ingredients processed and cured in accordance with accepted good practice. Rail pads shall be 6.5 mm in thickness, composed of polyurethane or of a polyurethane base with a polyethylene top segment, with a history of installation and service on North American railways.
Material Properties Testing: Conduct the following tests on the batch of material used to manufacture the tie pad specimens. Test specimens shall be cured in the same manner as the final product. Conduct each specified test on three samples and report on each test. Arrange for all testing to be conducted by an independent testing laboratory approved by the Engineer. The following tests shall be conducted:

(1) Compression Set Test ASTM D395 (Method B) Type II. The test shall be conducted for 22 hours at 100 degrees F. The compression set shall not exceed 40%.

(2) Tensile Strength, Heat Aging, Tensile Strength Tests:
   (a.) Tensile Strength Test (before aging) ASTM D412. Tensile Strength shall be 1,500 psi/min. Elongation shall be 250% min.
   (b.) Heat Aging Resistance Test (2 days at 212 degrees F) ASTM D573
   (c.) Tensile Strength Test (after aging) ASTM D 412. Elongation shall be 200% min, and 60% of results of (1) (before aging). The change in tensile strength resulting from this test series shall not exceed 15% of test (1) (before aging).

(3) Compression Set at Low Temperature ASTM D1229. The test shall be conducted for 22 hours at 0 degrees F. The compression set shall not exceed 50% at time 30 minutes.

(4) Submit results of industry standard tests with acceptance criteria by the minimum/maximum range. Test shall include the following:
   (a.) Hardness (ASTM D2240)
   (b.) Abrasion resistance (ASTM D2228)
   (c.) Resistance to fluids such as water, acids, alkali, petroleum oils and synthetic lubricants (ASTM D471)
   (d.) Resistance to ozone (ASTM D518)

G. Under Tie Pads
1. Under tie pads shall be of a design shown to reduce track surface maintenance at track-type transitions. Pads shall be installed in green concrete and have integral embedments that bond to the concrete. The design shall be submitted to the Engineer for approval.

2. The manufacturer shall have at least 5 years of experience manufacturing tie pads.

3. Use dynamic analysis to select the required stiffness, considering the stiffness of the DF track slab, the stiffness of the timber and concrete tie track outside the transition areas, and the weight and speed of the PATH trains operating on the track.

4. Ties with under tie pads shall be given unique paint marking on the top of each end of the tie. If two or more pad types are used, a unique marking shall be used for each pad type.

H. Shop Finishing
1. Ties shall be removed from forms in a manner such as to avoid damage.

2. Surface Finishing
   a. All formed surfaces of the finished tie shall have a uniformly dense surface. The surface of the rail seat shall have a smooth finish and be free from honeycomb, surface irregularities, and air holes in excess of 1/8-inch diameter. Other formed surfaces shall have a smooth finish that may contain honeycomb not to exceed 2 percent of the surface and a maximum void diameter of 1/4 inch.
b. Two ties which, in the opinion of the Engineer, show the required surface finish and two ties, also in the opinion of the Engineer, show the maximum allowable rail seat defects shall be set aside as comparison standards for acceptance of ties. These four ties are in addition to those for bottom finish comparison.

3. Inspection and Repair of Surface Defects

a. Every tie produced shall be visually inspected.

b. The surface of the rail seat shall have a smooth, formed finish not inferior to the comparison standards. No rubbing, brushing, or other treatment shall be used on the rail seat.

c. Surface conditioning with a mixture of 3 parts sand and 1-part cement, mixed with 1-part latex cement mix and 1-part water shall be undertaken on surfaces containing air pockets. The maximum size of any one pocket shall not exceed 3/8-inch diameter by 1/4 inch deep.

d. Air voids may not exceed greater than 50% of the circumference of a prestressing strand nor than 1 inch in depth.

e. Corner breakage less than 1/2-inch-deep and 1-1/2 inch along the end faces need not be repaired providing reinforcing wire is not exposed. If the wire is exposed, the breakage shall be repaired.

f. Corner breakage from 1/2 to 1-1/2 inch in depth shall be repaired. Corner breakage in excess of that shall be rejected.

g. Prestressing wires protruding more than 1/4 inch beyond the concrete surface of the end of the tie shall be cut back. Sharp ends which would be hazardous in handling shall be smoothed or cut back.

I. Samples: Label each sample indicating:

a. Contract Name and Number.

b. Name of Contractor and Subcontractor.

c. Material or equipment represented.

d. Source.

e. Name of producer and brand.

f. Reference Specifications Section and Article Number.

PART 3. EXECUTION

3.01 CONCRETE PLACEMENT

A. Prior to the placing of concrete, all equipment for mixing the concrete shall be clean, all debris shall be removed from spaces to be occupied by the concrete, the forms shall be thoroughly coated with a bond-breaker, and the reinforcement shall be thoroughly cleaned of deleterious coatings. The iron shoulder and prestressing wire shall not be contaminated with bond-breaker or any other substance which would interfere with bond development. The forms shall be inspected for alignment, tightness of joints, and dimensional accuracy of the position of bulkheads, prestressing steel, and inserts shall be verified.

B. Proportioning of Component Materials:

1. Fine and coarse aggregates and cement shall be measured by weight. Weights of aggregates shall be based on a saturated surface dry condition corrected for free moisture.
2. Water and liquid admixtures may be measured by either weight or volume.

C. The accuracy of measurement of the various components of concrete shall be within the following limits:
   - Cement: 1%
   - Water: 1%
   - Fine aggregate: 2%
   - Coarse aggregate: 2%
   - Cumulative aggregate: 2%
   - Admixtures: 3%

3.02 DIMENSIONS AND TOLERANCES

A. Fabricate concrete ties within the tolerances indicated and specified. When not indicated or specified conform to tolerances specified in the AREMA Manual.

B. The tie design shall be within the following dimensional limits set forth in this Section. The finished tie shall not deviate in any dimension from that shown in the Contract Drawings for the approved tie design by more than the tolerance associated with that dimension.
   1. Nominal Length: Crossties shall be 8 feet 6 inches long. Tolerance shall be plus ½ inch, minus 1/8 inch.
   2. Width of Bottom: 10 inches minimum, 13 inches maximum plus or minus 1/8 inch.
   3. Width of Top: 9 inches minimum, 10 inches maximum plus or minus 1/8 inch.
   4. Depth of tie: 7 inches minimum at any location and 10 inches maximum.
   5. Track Gauge: 4 feet -8-1/2 inches, plus or minus 1/16 inch, exclusive of rail dimensional tolerances.
   6. Rail Cant: 1 in 40, plus or minus 5, towards the center line of the tie, for crossties.
   7. The center line of crossties shall be within 1/8 inch of the center line of track gauge.
   8. Chämfcr: 1 inch at 45 degrees nominal plus or minus ½ inch
   9. Rail Seat Plane: The rail seat shall be a smooth, flat surface, plus or minus 1/32 inch.
   10. Concrete cover: The minimum concrete cover for prestress strands shall be as specified in ACI Standard 318
   11. Weight: Weight of concrete crossties shall not exceed 700 pounds. Weight of concrete switch ties shall not exceed 100 pounds per foot of length.
   12. Surface finish on top and sides shall be smooth and uniform. A random scattering of surface voids will not be cause for rejection. Heavy concentration of surface voids or evidence of improper mixing, vibration, or curing shall be cause for rejection.
   13. Identification Marking: submit the identification system for approval. Markings shall be such that they will remain legible for the design life of the ties. Permanently label ties by indented or raised numerals or letters on the top surface to identify the following:
      a. Manufacturer's I.D.
      b. Line or Form Number
      c. Tie number
      d. Year of manufacture
      e. Date code traceable to day of manufacture
C. Method of Production: Monoblock ties shall be manufactured in accordance with AREMA Chapter 30, Part 4, Section 4.9.2.

D. Forms:
   1. Forms shall be rigid and constructed of material that will result in finished ties conforming to the configuration shown on the Contract Drawings.
   2. Forms shall be constructed to permit movement of the tie without damage during release of the prestressing force.
   3. Forms shall provide proper marking with indented or raised letters or numerals to identify the manufacturer and year of production. Marking shall be placed on top of tie surface.

3.03 PLACEMENT OF PRESTRESSING STEEL

A. Prestressing force in each of the strands shall be 16,750 pounds +/- 500 pounds.

B. The load shall be applied in two increments. An initial load of approximately 1,000 pounds shall be applied to the individual strands to straighten them, eliminate slack, and provide a starting or reference point for measuring elongation.

C. Prestressing force shall be determined by (1) measuring strand elongation and also (2) by either checking jack pressure on a calibrated gauge or by the use of a calibrated dynamometer. The cause of discrepancy that exceeds 5 percent shall be ascertained and corrected. Elongation requirements shall be taken from average load elongation curves for the steel used.

D. Strands shall be stretched either individually or simultaneously. If strands are stretched simultaneously, provision for taking up slack and equalizing stress shall be made individually as required to induce approximately equal stress in each strand.

E. Transfer of force from bulkheads of the pretensioning bed to the concrete shall be accomplished by gradual and simultaneous detensioning of all strands. Exposed strands shall be cut near the tie end. The projection of strands beyond the ends of the ties shall be no more than 1/4 inch.

3.04 MIXING OF CONCRETE

A. Mixing equipment shall be capable of combining all specified materials within the time specified by the equipment manufacturer into a thoroughly mixed and homogeneous mass, and discharging the mixture without segregation.

B. All concrete shall be mixed until there is a uniform distribution of the materials and shall be discharged completely before the mixer is recharged.

C. Optimum mixing time shall be established by the equipment manufacturer's recommendations. Generally, minimum mixing time shall be one minute for batches of one cubic yard or less. This mixing time shall be increased by at least 15 seconds for each cubic yard, or fraction thereof, of capacity in excess of one cubic yard. Mixing time shall not exceed three times the specified time.

D. Conveying
   1. Concrete shall be conveyed from the mixer to the place of final deposit in the shortest possible time by methods that will prevent segregation or loss of materials.
2. Equipment for chuting, pumping, and pneumatic conveying of concrete shall be of such size and design as to assure flow of concrete at the delivery location without segregation of materials.

E. Depositing
1. Concrete shall be deposited as nearly as practical in its final position to avoid segregation due to rehandling or flowing. No concrete that has partially hardened or has been contaminated by foreign materials shall be used.
2. Concrete shall not be placed when the ambient air temperature of the casting room is below 40°F. Concrete shall have a minimum temperature of 50°F, and a maximum temperature of 90°F. When concrete is placed at an ambient temperature of 90°F or greater, the “Hot Weather Concreting” procedures recommended by ACI 305 shall be followed to prevent rapid drying and other detrimental effects of elevated temperature on fresh concrete.

F. Consolidating
1. All concrete shall be thoroughly consolidated by vibration during placement, and shall be thoroughly worked around the prestressing elements and embedded fixtures, and into corners of the forms. Consolidation at the ends of ties is paramount to comply with the void tolerance specified in Section 3.06. B.1.
2. External form vibration, supplemented if necessary, by internal vibration shall be used to obtain uniform mix, and shall be sufficient to yield concrete with a density not less than 148 pounds per cubic foot.
3. Care shall be taken to assure that forms are not damaged during consolidation.

G. Surface Finishing-Bottom of Tie
1. The bottom surface of the tie shall have a rough broom finish, with broom marks perpendicular to the tie centerline.

H. Testing Fresh Concrete
1. The first batch on any bed shall be tested and if this requires no adjustment to the mix, a further test shall be made after approximately 25 cubic yards has been poured. If the first batch requires adjustment to the mix, each subsequent batch shall be tested until no further adjustment is necessary and then a further batch shall be tested after approximately 25 cubic yards has been poured.
2. Slump: When measured in accordance with ASTM C143, the slump shall not exceed 2 inches when concrete is placed in the forms.
3. Air Content: When measured in accordance with ASTM C231, the range of air content in the plastic concrete shall ensure a minimum 3.5 percent air void content in the hardened concrete.
4. Temperature: The temperature of freshly mixed concrete shall not exceed 90 degrees F.

I. Curing
1. Immediately after placing and consolidating the concrete, the exposed surface shall be covered with impermeable sheeting.
2. Concrete shall not be placed in forms whose temperature is less than 40 degrees F. and the concrete temperature shall not be allowed to fall below 50 degrees F. between casting and transfer of prestress.
3. The rate of temperature rise in the concrete shall not exceed 35 degrees F. per hour and the maximum concrete temperature shall not exceed 160 degrees F. Transfer of prestress shall not be carried out at a concrete temperature above 135 degrees F. The heating method used shall be such that all ties in a bed are at a similar temperature.

4. Curing shall be done in accordance with established procedures to produce concrete strength as specified.

J. Detensioning
1. Stress transfer shall be performed in a controlled manner with hydraulic jacks. The forms shall be free to move and the stress in all wires shall be transferred at the same time and same rate. No wire shall be cut until it is completely detensioned.

K. Cured Concrete Testing
1. Compressive and Flexural Strength tests shall be made to check the adequacy of the mix proportions and as a basis for acceptance. Samples for compressive test specimens shall be secured in accordance with ASTM C172. Samples for flexural tests specimens shall be secured and all specimens shall be made and laboratory cured in accordance with ASTM C31. Specimens made to check the adequacy of curing and protection of concrete shall be cured entirely under production conditions.
   a. Compressive Strength tests shall be made on 4 inch by 8 inch cylinders in accordance with ASTM C39. For each day of production at least nine cylinders shall be prepared; three for 28-day testing, and three for checking strength at transfer, and three spares.
   b. Flexural Strength tests shall be made on 6 by 6 by 20-inch beams in accordance with ASTM C78. Minimum flexural strength (modulus of rupture) at 28 days shall be 600 psi.
2. Durability of concrete shall be in accordance with AREMA Chapter 30, Part 4, Article 4.2.2.6. Testing for excessive sulfate content in the cement or excessive temperatures during the curing process shall be tested in accordance with Duggan Concrete Expansion Test as detailed in AREMA Chapter 30, Part 4, Section 4.2.3.

3.05 QUALITY CONTROL TESTING

A. Acceptance Tests
1. Testing shall be in accordance with AREMA Chapter 30, Part 4, Section 4.9.1. Prior to approval of the concrete tie design, the testing described in Sections B through L shall be performed. The tie samples submitted will be subjected to testing for compliance with this Specification.

3. The Engineer will select two crossoff ties at random for laboratory testing. For design testing of the fastening system, the Contractor shall furnish a section of a tie or a concrete block with rail seat and fastening system identical to the concrete ties furnished for testing.

4. Each of the four ties and the tie block submitted for testing shall be carefully measured and examined to determine their compliance this specification. Upon satisfactory completion of the examination, two switch ties, designated as Tie No. 1 and Tie No. 2, and two crossoffs, designated as Tie No. 3 and Tie No. 4, shall be subjected to the specified performance tests.

5. Prior to testing, all dimensions of the ties shall be taken and included in the report.

B. Sequence of Design Tests (Tie Nos. 1 and 3)
1. The sequence of design performance tests using Tie Nos. 1 and 3 shall be as follows:
a. Rail Seat Vertical Load Test as detailed in Section 3.05.H and AREMA Chapter 30, Article 4.9.1.4 shall be performed on one rail seat, hereinafter designated as rail seat A.
b. Center Negative Bending Moment Test as detailed in AREMA Chapter 30, Article 4.9.1.6 on rail seat A.
c. Center Positive Bending Moment Test as detailed in AREMA Chapter 30, Article 4.9.1.7 on rail seat A.
d. Rail Seat Vertical Load Test as detailed in Section 3.05.H and AREMA Chapter 30, Article 4.9.1.4 shall be performed on the other rail seat hereinafter designated as rail seat B.
e. Rail Seat Repeated Load Test as detailed in Section 3.05.I and AREMA Chapter 30, Article 4.9.1.5 shall be performed on rail seat B.
f. Bond Development, Tendon Anchorage and Ultimate Load Test as detailed in Section 3.05.G and AREMA Chapter 30, Article 4.9.1.8 shall be performed on rail seat A.

C. Sequence of Design Tests (Tie Nos. 2 and 4)
   1. The sequence of design performance tests using Tie Nos. 2 and 4 shall be as follows:
      a. Fastening Insert Test as detailed in Section 3.05.J and AREMA Chapter 30, Article 4.9.1.9 shall be performed on all inserts.
      b. Fastening Uplift Test as detailed in Section 3.05.K and AREMA Chapter 30, Article 4.9.1.10a and b shall be performed on one rail seat.
      c. Electrical Impedance Test as detailed in Section 3.05.L and AREMA Chapter 30, Article 4.9.1.14 shall be performed on one rail seat.

D. Sequence of Design Test (Tie Block)
   1. The sequence of design performance testing using tie block shall be as follows:
      a. Tie Pad Test as detailed in AREMA Chapter 30, Article 4.9.1.15.
      b. Fastening Uplift Test Part A as detailed in AREMA Chapter 30, Article 4.9.1.10
      c. Fastening Longitudinal Restraint Test as detailed in Section 3.08.G and AREMA Chapter 30, Article 4.9.1.12.
      d. Fastening Repeated Load Test as detailed in Section 3.05.F and AREMA Chapter 30, Article 4.9.1.11.
      e. Fastening Longitudinal Restraint Test as detailed in Section 3.08.G and AREMA Chapter 30, Article 4.9.1.12.
      f. Fastening Uplift Test Part A as detailed in Section 3.05.K and AREMA Chapter 30, Article 4.9.1.10.
      g. Fastening Lateral Load Restraint Test as detailed in Section 3.05.H and AREMA Chapter 30, Article 4.9.1.13.
      h. Tie Pad Test as detailed in AREMA Chapter 30, Article 4.9.1.15.
      i. Fastening tests previously conducted for other buyers will be considered as satisfactory evidence of passing this test if the Contractor submits the previous test results and a certification from the manufacturer that the fastening system tested therein is identical to the system to be provided for this Contract.

E. Center Positive Bending Moment Test
1. Summary of Test: With the tie supported and loaded as shown in AREMA Chapter 30, Figure 30-4-10, a load increasing at a rate not greater than 5 kips per minute shall be applied until the load required to produce the positive center design moment is obtained. This load shall be held for not less than three minutes, during this time an inspection shall be made to determine if structural cracking occurs. A five power magnifying glass may be used to locate cracks. If structural cracking does not occur, the requirements of this test will have been met.

2. Minimum test thresholds for the center positive bending test shall be as computed as described above but shall in no case be less than 90 in-kips for crossties.

F. Center Negative Bending Moment Test

1. Summary of Test: With the tie supported and loaded as shown in AREMA Chapter 30, Figure 3-4-9, a load increasing at a rate not greater than 5 kips per minute shall be applied until the load required to produce the specified negative center design moment is obtained. This load shall be held for not less than three minutes, during this time an inspection shall be made to determine if structural cracking occurs. A five power magnifying glass may be used to locate cracks. If structural cracking does not occur, the requirements of this test will have been met.

2. Minimum test thresholds for the center negative bending test shall be as computed as described above but shall in no case be less than 125 in-kips for crossties.

G. Rail Seat Positive Bending Moment Test (Bond Development, Tension Anchorage, and Ultimate Load)

1. Summary of Test: With the tie supported and loaded as shown in AREMA Chapter 30, Figure 30-4-8, a load increasing at a rate not greater than 5 kips per minute shall be applied until a total load of 1.5P is obtained. If there is no more than 0.001-inch strand slippage determined by an extensometer reading to 0.0001 inch, the requirements of this test will have been met. The measurements shall be made on the outermost tendons of the lower layer. The load shall be increased until ultimate failure occurs.

2. Minimum test thresholds for the rail seat positive bending test shall be as computed as described above but shall in no case be less than 163 in-kips for crossties.

H. Rail Seat Vertical Load Test

1. Summary of Test: With the tie supported and loaded as shown in AREMA Chapter 30, Figure 30-4-7, a load increasing at a rate not greater than 5 kips per minute shall be applied until the load (P) required to produce the specific rail seat negative moment as derived in Section 1.02.A of this specification is obtained. This load shall be held for not less than three minutes, during this time an inspection shall be made to determine if structural cracking occurs. A five power magnifying glass may be used to locate cracks. If structural cracking does not occur, the requirements of this test will have been met.

2. Minimum test thresholds for the rail seat negative bending test shall be as computed as described above but shall in no case be less than 101 in-kips for crossties.

I. Rail Seat Repeated-Load Test

1. Summary of Test: Following the vertical load test for positive moment on rail seat B, the load shall be increased at a rate of at least 5 kips per minute until the tie is cracked from its bottom surface up to the level of the lower layer of reinforcement.
2. After removal of the static rail seat load necessary to produce cracking, and substitution of \( \frac{1}{4} \)-thick plywood strips for those shown in AREMA Chapter 30, Figure 30-4-8, the tie shall be subjected to 3 million cycles of repeated loading with each cycle varying uniformly from 4 kips to the value of 1.1P. The repeated loading shall not exceed 600 cycles per minute. If after the application of 3 million cycles, the tie can support the rail seat load (1.1P), the requirement of this test will have been met.

J. Fastening Insert Test

1. Summary of Test: The pull-out test shall be performed on each insert as indicated in AREMA Chapter 30, Figure 30-4-11. An axial load of 12 kips shall be applied to each insert separately and held for not less than 3 minutes, during which time an inspection shall be made to determine if there is any slippage of the insert or any cracking of the concrete. Following successful completion of the insert pull-out test, the torque test shall be performed on each insert. A torque of 250 ft-lb shall be applied about the vertical axis of the insert by means of a calibrated torque wrench and a suitable attachment to the insert. The torque shall be held for not less than 3 minutes. Ability of the insert to resist this torque without rotation, cracking of the concrete or permanent deformation shall constitute passage of this test.

K. Fastening Uplift Test

1. Summary of Test: A 19-inch section of 115 RE rail shall be secured to one rail seat using a complete rail fastening system including pads, clips, and associated hardware, as recommended by the manufacturer of the rail fastening system. In accordance with the loading diagram and method described in AREMA Chapter 30, Figure 30-4-12, an incremental load shall be applied to the rail. The load \( P \) (measured load plus unsupported tie weight plus frame weight) at which separation of the rail from pad or pad from rail seat occurs (whichever occurs first) shall be recorded. The load shall then be completely released. A load of 1.5P not to exceed 10 kips shall then be applied. The inserts shall not pull out or loosen in the concrete and no component of the fastening system shall fracture nor shall the rail be released.

L. Electrical Impedance Test

1. Summary of Test: Secure two short pieces of 115 RE rail to the tie using complete concrete tie fastenings. The rail pieces shall be no longer than the width of the tie. Immerse the complete tie and rail assembly in water for a minimum of 6 hours. Clean contact points on each rail and attach test cables. Apply 10 volts AC 60-hertz potential between the two running rails for 15 minutes, measure the current flow between the two rails, and calculate the impedance by dividing the applied 10 volts by the current flow in amperes. The minimum impedance shall be 20,000 ohms.

3.06 FASTENINGS

A. Fastenings shall be subjected to the acceptance tests as specified below. Failure of fastening system to pass tests will be cause for rejection. Certified laboratory test reports shall be submitted in sufficient detail to the Engineer.

B. Acceptance of design testing of the fastening system consists of testing of components cast into the concrete tie, in addition to tests conducted on the external components and consists of the following tests.

C. Tie Pad Test
1. Summary of Test: The tie pad shall be loaded vertically using a section of 115RE rail and applying a cyclic load varying from 4 to 30 kips at a rate of 4 to 6 cycles per second for a total of 1,000 cycles. A static load shall be applied at a rate between 3 and 6 kips/min. in increments of 1 kip up to a maximum of 50 kips. For each load increment, vertical pad deflection shall be measured to the nearest .0001 inch and recorded values for vertical loads versus deflection shall be plotted on a graph. Spring rate shall be calculated as determined by the slope of the line connecting the points representing pad deflections at 24 and 44 kips. The load shall be released and pad deflection and temperature recorded 10 seconds after load removal. The requirements will be met if:

j. The pad returns to within .002 inch of its original position 10 seconds after load removal;

k. Spring rate values determined from both pad tests, conducted as part of the design performance tests specified in AREMA Chapter 30, Article 4.9.1.3, do not vary by more than 25%;

l. Spring rate values determined from initial tests in AREMA Chapter 30, Article 4.9.1.3.a conducted on the three test pads, as part of the design performance tests specified do not vary more than 25%;

m. Spring rate values determined from final tests in Article 4.9.1.3.h conducted on the two test pads, as part of the design performance tests specified do not vary by more than 25%.

2. Tie Pad Attenuation Test

a. Test procedure and acceptance criteria are shown in AREMA Chapter 30, Part 2, Section 2.5.2 Test 4B and Figure 30-2-6.

3. Fastening Repeated Load Test

a. Summary of Test: A 19 inch section of 115 RE rail, from which loose mill scale has been removed by wiping with a cloth, shall be secured to the rail seat in the tie block using a complete rail fastening assembly. Three million cycles of loading shall be applied in accordance with the loading diagram in AREMA Chapter 30, Figure 30-4-13, alternating downward and upward loads at an angle of 20 degrees to the vertical axis of the rail at a rate not to exceed 300 cycles per minute for 3 million cycles. Rupture failure of any component of the fastening system shall constitute failure of the test.

4. Fastening Longitudinal Restraint Test:

a. In accordance with AREMA Chapter 30, Article 4.9.1.12, test procedure and acceptance criteria shall be in accordance with AREMA Chapter 30, Part 2, Section 2.6.2, Test 5B.

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b. Summary of Test: Conduct test before and after the Rail Fastening Repeated Load Test as detailed in AREMA Chapter 30, Part 2.6.3 Test 5C without disturbing the rail fastening assembly in any manner. A longitudinal pull load shall be applied in increments of .4 kip increments with readings taken of longitudinal rail displacement after each increment. Refer to AREMA Chapter 30, Figure 30-2-8. The rail displacement readings shall be the average of two dial indicator readings measured to .001 inch. The dial indicators shall be placed on each side of the rail with plungers parallel to the longitudinal axis of the rail. The load shall be increased incrementally until a load of 2.4 kips is reached. The load shall not be held for less than 15 minutes. The fastenings shall meet the requirements of this test in either direction of loading. The fastenings will have successfully passed this test if the rail movement is less than 0.2 inch during the loading and initial 3 minute period.

5. Fastening Lateral Load Restraint Test
   a. In accordance with AREMA Chapter 30, Article 4.9.1.13, test procedure and acceptance criteria shall be in accordance with AREMA Chapter 30, Part 2, Section 2.6.4, Test 5D.

   b. Summary of Test: A 19-inch section of 115 RE rail shall be secured to one rail seat using a complete fastening assembly. The entire assembly shall be supported and loaded as indicated in Figure 30-2-10 of AREMA Chapter 30, Part 2, Section 2.6.4, Test 5D. A preload of 20 kips shall be applied to the rail to seat the rail in the fastening. Upon release of the preload, a zero reading shall be taken on the dial indicators which measure rail translation. Load shall be applied at a rate not to exceed 5 kips per minute until either 41 kips has been applied or the rail base has translated 1/8 inch, whichever occurs first. With all load removed from the rail, a roller nest is shall be placed between the fixed loading head and the wood block on the rail head. The roller nest shall not offer resistance to lateral movement of the rail head. After taking zero reading on the dial indicators a load of 20.5 kips shall be applied at a rate not to exceed 5 kips per minute. Inability of the fastening assembly to carry a 41 kip load with 1/8 inch or less or rail translation shall constitute failure. Rail rotation, gauge widening less rail translation, greater than 1/4 inch shall constitute failure of the unrestrained lateral load test. Complete failure of any component of the tie or fastening is cause for rejection.

3.07 INSPECTIONS

The Engineer may inspect the fabrication plant and manufacturing processes. The Contractor shall provide the Engineer one week notice prior to commencing tie fabrication.

END OF SECTION
SECTION 341130
CONCRETE CROSSTIES AND FASTENERS

APPENDIX "A"
SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

Shop Drawings
341130A01 Submit shop drawings for concrete ties in accordance with Part II for approval. These drawings are to be complete and detailed. Shop drawings shall consist of fabrication diagrams, all dimensions, including a layout of the steel prestressing tendons, rail fastening components, inserts, and any other pertinent information. Shop drawings showing dimensions and configuration for each turnout tie.

1. Shop Drawings shall show the general arrangement and such details as are necessary to provide a comprehensive description of the work to be performed.

2. Prepare Shop Drawings including design calculations and other data as may be required by the Specifications as are necessary to adequately perform the work.

Samples
341130C01 Unless otherwise indicated, submit not less than two identical samples of each type of component references in sections 2.01 C, D, E, F, and G.

Product Data
341130D01 Submit concrete mix composition as outlined in section 2.01.

341130D02 Submit documentation confirming the quality of the material used in the components references in sections 2.01 C, D, E, F, and G.

Certificates
341130E01 Certificates of compliance that the concrete ties and shoulders satisfy all test requirements as specified herein, and submit to the Engineer prior to shipment.

Manufacturer Test Reports
341130F01 Submit test reports and/or certificates of compliance indicating that the tests identified in sections 1.05 L, 3.05 and 3.06 of this specification have been performed and that the test reports and other specified documents comply with these specifications.
Construction and Installation Procedures
341130G01 Submit method of packaging for shipment to the Engineer prior to production.

Calculations
341130H01 Furnish tie design calculations in accordance with section 1.04 H.

Quality Assurance-Quality Control
341130L01 Submit Manufacturer's Qualifications, Quality Control Program, Production Control Program, and Organization and Management Plan, Certification by a qualified, independent consultant or laboratory in accordance with section 1.05.

END OF APPENDIX "A"