PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

.1 The Work of this Specification includes the supply and delivery of new prestressed monoblock concrete ties inclusive of the cast-in shoulders and associated fastening system for standard gauge 1,435 mm (56 ½ in.) mainline track in accordance with the requirements of this Specification.

.2 The concrete ties shall be as specified on GO Transit's Standard Drawing, and in accordance with the requirements of this Specification.

.3 Two (2) distinct standard concrete ties will be designed and provided; one to support a 6 in. rail base and one to support a 5½ in. rail base as per Contract Requirements.

.4 Two (2) distinct concrete guardrail ties will be designed and provided; one to support a 6 in. rail base and one to support a 5½ in. rail base as per Contract Requirements.

.5 The Manufacturer shall furnish all labor, materials, equipment, facilities and transportation necessary to furnish and deliver the concrete ties to the project.

1.2 RELATED SECTIONS

Comply with the following sections:

.1	General Requirements	Section 01000
.2	Submittals	Section 01300
.3	Quality Control and Assurance	Section 01400
.4	Railway Track Construction	Section 02950

1.3 REFERENCES

Where applicable the Manufacturer shall comply with the latest issue of the following Standards, which are invoked and form part of this specification:

.1 GO Transit, Design Requirements Manual (DRM), Latest Version.

.2 AREMA, American Railway Engineering and Maintenance-of-Way Association – Manual for Railway Engineering.

.3 American Association of State Highway and Transportation Officials (AASHTO):

.1 T-26, Standard Method of Test for Quality of Water to Be Used in Concrete.

.2 T-277, Permeability of HPC: Rapid Chloride Ion Test vs. Chloride Ponding Test.

.4 American Concrete Institute (ACI):

.1 211.1, Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.

.2 214, Standard Practice for Evaluation of Strength Test Results of Concrete.

.3 301, Specifications for Structural Concrete.

.4 318, Building Code Requirements for Structural Concrete.

.5 American Society for Testing and Materials International (ASTM):

.1 A 421, Standard Specification for Uncoated Stress- Relieved Steel Wire for Prestressed Concrete.

.2 A 536, Standard Specification for Ductile Iron Castings.

.3 A 881, Specification for Steel Wire, Deformed, Stress-relieved or Low-relaxation for Prestressed Concrete Rail road Ties.

.4 A 886, Standard Specification for Steel Strand, Indented, Seven-Wire Stress-Relieved for Prestressed Concrete.

.5 C 29, Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate.

.6 C 31, Standard Practice for Making and Curing Concrete Test Specimens in the Field.

.7 C 33, Standard Specification for Concrete Aggregates.

.8 C 39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

.9 C 109, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).

.10 C 114, Methods for Chemical Analysis of Hydraulic Cement.

.11 C 117, Standard Test Method for Materials Finer than 75 m (No. 200) Sieve in Mineral Aggregates by Washing.

.12 C 136, Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates.

.13 C 143, Standard Test Method for Slump of Hydraulic- Cement Concrete.

.14 C 150, Standard Specification for Portland Cement.

.15 C 172, Sampling Fresh Concrete.

.16 C 191, Standard Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle.

.17 C 192, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.

.18 C 227, Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).

.19 C 231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

.20 C 260, Standard Specification for Air-Entraining Admixtures for Concrete.

.21 C 295, Standard Guide for Petrographic Examination of Aggregates for Concrete.

.22 C 316, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

.23 C 359, Standard Test Method for Early Stiffening of Hydraulic Cement (Mortar Method).

.24 C 403, Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance.

.25 C 430, Standard Test Method for Fineness of Hydraulic Cement by the 45-µm (No. 325) Sieve.

.26 C 451, Standard Test Method for Early Stiffening of Hydraulic Cement (Paste Method)

.27 C 457, Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete.

.28 C 494, Standard Specification for Chemical Admixtures for Concrete.

.29 C 496, Splitting Tensile Strength of Cylindrical Concrete.

.30 C 617, Standard Practice for Capping Cylindrical Concrete Specimens.

.31 C 618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

.32 C 666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.

.33 C 856, Petrographic Examination of Hardened Concrete.

.34 C 1105, Standard Test Method for Length Change of Concrete Due to Alkali-Carbonate Rock Reaction.

.35 C 1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.

.36 C 1218/C1218M-99, Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.

.37 C 1231, Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders.

.38 C 1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).

.39 C 1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.

.40 C 1524, Standard Test Method For Water-Extractable Chloride in Aggregate (Soxhlet Method).

.41 C 1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).

.42 C 1602, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

.43 C 5329, Recommended Practice for Inspection and Testing Agencies for Concrete, Steel and Bituminous Materials used in Construction.

.44 D 75, Standard Practice for Sampling Aggregates.

.45 E 994, Standard Guide for Calibration and Testing Laboratory Accreditation Systems General Requirements for Operation and Recognition.

.6 Association of American Railroads (AAR):

.1 M-1003, Quality Assurance

.7 Canadian Standards Association (CSA):

.1 CSA-A23.1, Concrete Materials and Methods of Concrete Construction.

.2 CSA-A23.2, Methods of Test for Concrete.

.3 CSA-A23.4, Precast Concrete – Materials and Construction.

.4 CSA-A251, Qualification Code for Manufacturers of Architectural and Structural Precast Concrete.

.8 ISO 9001, Quality Management Systems - Requirements

.9 ISO 9004, Quality Management Systems – Guidelines for Performance Improvements

.10 Precast/Prestressed Concrete Institute (PCI):

.1 MNL 116, Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products.

1.4 DEFINITIONS

.1 Definitions of the invoked references above apply to this Specification.

1.5 QUALITY CONTROL

.1 The Manufacturer shall be responsible to plan, establish, implement and maintain their own quality control program to ensure all materials and products meet the requirements of the specifications.

.2 Production quality control shall be as identified in AREMA Specifications for Concrete Ties, Part 4, Chapter 30 of the AREMA Manual.

.3 Records of inspection work by the Manufacture shall be kept complete and made available to the Owner during the performance of the Contract.

.4 The Owner reserves the right to perform additional testing and periodic inspection if deemed necessary.

1.6 SUBMITTALS

.1 The following submittals are in addition to the requirements of Section 01300 Submittals.

.2 Within **30 days** of Notice to Proceed, prior to concrete tie and rail fastener assembly qualification testing:

.1 Letter with supporting documentation stating that the concrete tie Manufacturer meets or exceeds the requirements of Section 1.7 of this Specification.

.2 Shop drawings for the standard and guardrail ties including all information necessary for fabrication and handling. This shall include, but not be limited to, plan, elevation and cross section with reinforcing wires, rail fastener assemblies, and embedded items. Show dimensions, weight, details, tolerances, surface finishes, concrete strength and material specifications as applicable. Indicate part numbers.

.3 Shop drawings for a guardrail convergence set of concrete ties to allow the convergence of the guardrail beyond the protected area.

.4 Shop drawings shall be submitted in hardcopies, PDF and CAD formats. All original data and documents prepared and submitted by the Manufacturer shall be, and remain, the property of the Owner.

.5 General arrangement drawings for tie fastening components, product data, and how these fasteners shall be installed and replaced on the ties.

.6 Provide a letter confirming that the rail fastener assemblies are compatible with the Manufacturer's shop drawings.

.3 Within **45 days** of Notice to Proceed:

.1 Concrete mix design with certified concrete and concrete components qualification test results and certificates.

.2 Manufacturer's Quality Assurance and Control Plan. The plan shall be revised whenever there are changes in personnel, responsibilities, or other items contained in it

.3 Manufacturer's Test Program Plan. The Plan shall, at a minimum, conform to the requirements of this Specification and shall provide sufficient detail of the Manufacturer's quality assurance program.

.4 Detailed design calculations that demonstrate that the concrete ties and fastenings meet all the requirements of this Specification. This shall include pre-stress/flexural strength calculations.

.4 Prior to the production of any tie and/or fastening system, and after approval of the shop drawings, submit qualification test results for certified concrete tie and rail fastener assembly.

.1 Tests for concrete ties shall be as identified in AREMA Specifications for Concrete Ties, Part 4, Chapter 30 of the AREMA Manual. Test reports for all tests shall be provided from an independent certified laboratory prior to manufacture and/or prior to delivery of the ties, fastening system and its components, as applicable.

.2 An independent Professional Engineer's design verification certificate to verify that the ties and fastener assemblies have been designed in accordance with the requirements of this Specification.

.5 Prior to shipping the concrete ties and rail fastening system, submit production test results for certified concrete tie and rail fastener assembly, certified tie pad production, and certified material test reports.

.6 At least thirty (30) days prior to shipment, submit method of handling, loading, shipping, unloading and stacking, including working drawings showing the concrete tie stacking arrangement.

.7 Inventory records of concrete ties shipped at the time of each shipment.

.8 Compliance certificates for all concrete ties.

.9 Monthly production quality reports. Submit reports for each month in which the specified ties are produced within fifteen (15) days after the last day of the month.

1.7 MANUFACTURER QUALIFICATIONS

.1 Concrete Tie Manufacture's Qualifications:

.1 A minimum of ten (10) years of experience, in one location, of the large scale manufacture of prestressed monoblock concrete ties by the long line process with 5 to 8 lines per bed.

.2 The Manufacturing Plant has supplied concrete ties to a Class 1 Freight or Commuter Railroad within the last five (5) years.

.3 Has sufficient production capacity to produce the required number of ties in accordance with the quality requirements and without causing any delay in the Work.

.4 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 the PCI Manual for Quality Control of Plants and Production of Prestressed, Precast Concrete Products, MNL 116, AAR-M-1003, Quality Assurance and/or ISO 9001:2008 equivalent. Current certification by PCI throughout the fabrication period will be accepted as evidence of conformance with this requirement.

.5 The Certificate of Qualification as a concrete tie supplier for GO Transit. Approved Manufacturers include:

.2 Rail Fastener Assembly Manufacture's Qualifications:

.1 A minimum of five (5) years of experience, in one location, of the large scale manufacture of rail fastener assemblies for use in prestressed monoblock concrete ties.

.2 Has supplied the rail fastener assemblies used on prestressed monoblock concrete ties of a Class 1 Freight or Commuter Railroad within the last five (5) years.

.3 Approved Manufacturers include Pandrol.

1.8 DELIVERY, STORAGE AND HANDLING

.1 Concrete ties shall be handled in such manner to prevent chipping, spalling, cracking or other damage during loading, shipping, unloading and stockpiling. Do not drop or skid ties. Use only lifting devices appropriate for handling ties.

.2 Concrete ties shall be shipped in open-top cars or flatbed truck trailers.

.3 Concrete ties shall be securely braced for transportation to prevent any movement that will cause damage.

.4 Concrete ties shall be shipped in a horizontal position and braced with spacer blocks in such a manner that the top surface or cast-in-place hardware does not contact ties loaded above. Ties shall not be loaded higher than the top of the cars and not more than six (6) layers deep.

.5 When required, concrete ties shall be stacked on firm level ground, not more than ten (10) ties high and supported with spacers at the rail seats only.

.6 Package rail fastener assembly parts separately to prevent damage during shipment and to facilitate handling. Do not mix different parts in the same package. Hardware shall be packaged in waterproof containers.

.7 Segregate ties by types and lengths.

.8 The Manufacturer shall replace all concrete ties and rail fastener assemblies damaged during loading, shipping and, if required as per Contract Requirements, unloading and stockpiling with new concrete ties and rail fastener assemblies, respectively, at no additional cost to the Owner.

1.9 WARRANTY

.1 Guarantee all concrete ties against defective materials and workmanship for a minimum period of five (5) years, or as approved by the Owner, from the date the ties and associated fastening assemblies have been accepted by the Owner, except when a longer guarantee is provided by the Manufacturer.

.2 Guarantee all concrete tie fastening assemblies against defective materials and workmanship for a minimum period of one (1) year, or as approved by the Owner, from the date the ties and associated

fastening assemblies have been accepted by the Owner, except when a longer guarantee is provided by the supplier or Manufacturer.

.3 Upon notice of non-conformity, the supplier or Manufacturer shall repair or replace the materials or issue credit to the Owner for the purchase price of non-conforming goods, all at no additional cost to the Owner.

1.10 SPARE PARTS

.1 Furnish and deliver as spares each of the following, separately packaged and clearly marked "SPARE PARTS"

.1 For every 5,000 ties:

.1 100 clips.

.2 50 insulators.

.3 50 tie pads.

PART 2 - DESIGN CRITERIA

2.1 GENERAL

.1 The concrete ties shall be designed in accordance with AREMA Specifications for Concrete Ties, Part 4, Chapter 30 of the AREMA Manual and the requirements of this Specification as applicable.

.2 The electrical properties of the concrete ties shall not interfere with the track signal circuits. Future railway electrification should be a viable option.

.3 The concrete ties shall have a concave center.

.4 The concrete ties shall have scallops suitable to increase lateral stability and prevent track buckling.

.5 Guardrail ties shall be constructed using the same means and methods, materials, length and tolerances, except the cross section will be modified to meet the requirements as indicated on GO Transit's Standard Drawing.

.6 Guardrail ties shall have fasteners (inserts, bolts, washers & clips) suitable for fastening the guardrails in addition to the fasteners for the running rails. Caps to plug guardrail inserts shall be provided and fitted prior to storage and/or shipping.

.7 The fastening system shall meet the following requirements as a minimum:

.1 Resilient type.

.2 Fix the rail to the concrete ties using a one-piece spring-tension fastener as manufactured by Pandrol or approved equivalent.

.3 Spring-leaf-with-bolt style fasteners shall not be used.

.4 Designed to ensure that none of its components fail under fatigue during the service life of 40 years.

.5 Provide adequate torsion resistance not only to hold the correct track gauge under specified loads and conditions but also to provide sufficient lateral strength to the track to resist buckling.

.6 The rail pads shall be designed so that they not only attenuate the dynamic effect on the ties but also reduce the water entrapment within the rail seat to prevent initiation of rail seat abrasion.

.7 The rail fastener assembly shall allow for the rail clips to be installed, loosened or removed but not be able to vibrate loose under operating conditions.

.8 The Manufacturer is responsible for the manufacturing design of the concrete ties and fastenings and shall undertake all additional manufacturing design required to ensure compliance with this Specification. This shall include, but not be limited to; the supply and testing of all components including water, aggregate, sand, cement, reinforcement and the concrete mix design including calculations of prestress loss and dimensional strain in order to comply with the tie dimensions, tolerances and testing as specified in this Specification.

.9 The Manufacturer shall submit such information in support of the manufacturing process and test results upon request by the Owner.

2.2 PERFORMANCE REQUIREMENTS

.1 The concrete tie and fastenings shall be designed, tested and manufactured to meet the requirements specified in the AREMA Specifications for Concrete Ties, Part 4, Chapter 30 of the AREMA Manual, and the following service loads and track conditions:

.1 Axle loads of 30 tonnes (metric).

.2 In-track tie spacing 610 mm (24 in.) (minimum) O.C.

.3 Minimum annual tonnage of 20 mgt (metric)/year.

.4 Maximum permissible speed of 160 km/h (100 mph).

.5 6 in. or 5½ in. base steel rails, set at 1:40 rail cant at a standard gauge of 1,435 mm (56 ½ in.) and continuously welded mainline track.

.6 Minimum ballast depth, below the bottom of tie, of 300 mm (12 in.).

.7 Minimum ballast shoulder width of 300 mm (12 in.).

.8 Minimum design service life of 40 years.

.2 Ties shall be designed and tested to meet the following key minimum strength requirements:

TEST	MINIMUM REQUIREMENTS
Rail Seat Positive Bending Moment (M_{R+})	220 inch kips
Rail Seat Positive Test Load	41 kips
Tie Center Negative Bending Moment (M_{C-})	170 inch kips
Tie Center Negative Test Load	12 kips

2.3 TIE DIMENSIONS

.1 The dimensions, configuration and weight of the conforming concrete tie shall be in general accordance with AREMA Specifications for Concrete Ties, Section 4.3, Part 4, Chapter 30 of the AREMA Manual. The preferred tie dimensions are;

.1 Length 2,515 mm (8 ft. 3 in.)

.2 Base width (below rail seat) 265 mm (10½ in.)

.3 Height at rail seat 203 mm (8 in.)

.2 The rail seat shall provide for a cant of 1:40 toward the centerline of the concrete tie.

.3 The preferred weight is 277 kg to 295 kg (610 lb. to 650 lb.) including shoulders.

.4 Alternative designs shall have a successful history of performance of at least 10 years of service under comparable service conditions.

.5 Dimensions for setting the guardrail shall be as indicated on GO Transit's Standard Drawing.

.6 Any alternative design shall be specifically approved by the Owner.

.7 Final dimensions shall be confirmed by the Manufacturer in their design submission.

2.4 TOLERANCES

.1 Dimensional tolerances shall be in accordance with the following:

.1 Tie:

.1 Length: $\pm$ 3 mm ($^1/_8$ in.).

.2 Cross Section Dimensions: $\pm$ 3 mm ($^1/_8$ in.).

.3 Gauge: $\pm$ 1.5 mm ($^1/_{16}$ in.).

.2 Rail Seat:

.1 Cant: 1:40 +/- 5 toward center line of tie.

.2 The differential tilt in the direction of the rail of one seat to another shall not exceed 1.5 mm ($^1/_{16}$ in.).

.3 The rail seat shall be a flat smooth surface and plane to a tolerance of +/- 0.8 mm ($^1/_{32}$ in.) for the portion directly under the rail.

.3 Shoulder:

.1 Inside face to inside face of outside shoulders measured at the base of the shoulder (concrete surface) $\pm$ 1.5 mm ($^1/_{16}$ in.).

.2 Inside face to inside face of Cast-in shoulders over each rail seat $\pm$ 1.5 mm ($\pm$ $^1/_{16}$ in.).

.3 Placement: 90° $\pm$ 0.5° in plan to rail foot and $\pm$ 0.5 mm vertically to the concrete surface.

.4 Prestressing Wire:

.1 Projection: Less than 3 mm ($^1/_8$ in.) beyond the ends of the ties.

.2 Depth: $\pm$ 3 mm ($^1/_8$ in.).

.3 Location of individual tendons: $\pm$ 3 mm ($^1/_8$ in.).

.4 Concrete cover: 19 mm (¾ in.) minimum.

2.5 SURFACE FINISH

.1 The bottom surface of the tie shall be a rough screeded finish such as may be obtained with a broom. Projections from, or indentations into, the general level of the surface shall not exceed 6.5mm (¼ in). Two ties, which show the required bottom surface finish, shall be set aside from an early batch as a comparison standard for the acceptance of later ties.

.2 The surface of the rail seat shall have a smooth finish and plane to a tolerance of 0.8mm (1/32 in.).

.3 The top and side surfaces shall present a smooth, uniform appearance which may contain holes less than 6.4 mm (¼ in.) deep and less than 6.4 mm (¼ in.) in diameter to a limited extent, excluding rail seats and bottom of the tie. A heavy concentration of surface voids or evidence of improper mixing, vibrating, or curing will be cause for rejection.

.4 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 done on surfaces containing air pockets greater than the allowable tolerances. The maximum size of any one pocket shall not exceed 9.5 mm ($^3/_8$ in.) in diameter and 6.4 mm (¼ in.) deep.

.5 Ties with voids not deeper than 38 mm (1½ in.) around not more than 2 end wires shall be repaired with a silicone rubber sealant. Ties with voids beyond this limit shall be rejected.

.6 Corner breakage less than 13 mm (½ in.) deep and 38 mm (1½ in.) along the end faces need not be repaired providing reinforcing wire is not exposed and minimum cover is maintained. If the reinforcing wire is exposed or the minimum cover is not maintained, the breakage shall be repaired at no additional cost to the Owner.

Corner breakage from 13-38 mm (½ - 1½ in.) in depth shall be repaired at no additional cost to the Owner. Corner breakage in excess of that shall be rejected.

.7 The prestressing wires shall not protrude more than 3 mm ($^1/_8$ in.) beyond the concrete surface of the end of the tie. The wire ends shall not have sharp ends which would be hazardous in handling.

2.6 IDENTIFICATION

.1 The concrete ties shall be marked, or cast, with indented or raised letters and numerals on an upper inclined surface to ensure that the concrete cover is not reduced below the specified minimum and to the approval of the Owner. These markings shall identify:

Marking Item	Example
Owner	Owner's Logo
Manufacturer	Manufacturer's Name/Logo
Date Code & Year	XXXX
Tie type	XXXX
Fastener Code	XXXX

2.7 FASTENING SYSTEM

RUNNING RAIL

.1 All components of the running rail fastening system shall be of threadless design, and manufactured by a single Manufacturer to ensure compatibility to the ties. Written certification of the approval of such compatibility shall be submitted to the Owner.

.2 The components listed below may be different due to subsequent production changes. Any proposed or replacement components shall meet or exceed the specified, and shall be as recommended, in writing, by the Manufacturer, and submitted to the Owner for approval.

.3 Rail Clips – Pandrol e2009L, Pandrol J267 (5½ in. rail base) and Pandrol J273 (6 in. rail base) at standard splice (joint) bars and Pandrol E2063 at insulated joints, or approved equivalent, complying with the following requirements:

.1 Rail clips shall be threadless, one-piece elastic, heat treated, alloy spring steel clip.

.2 Where specified in Contract Requirements, rail clips shall be galvanized to protect against corrosion.

.3 Spring-wedge clips are not acceptable.

.4 Clip installation and removal shall not damage the tie, shoulder, clip, insulators or rail.

.4 Rail Tie Pads (Seat Pads) – Pandrol 16146 for a 5½ in. rail base and Pandrol 37693 for a 6 in. rail base, or approved equivalent, minimum 5 mm thick polyurethane, complying with the following requirements:

.1 Rail seat pads shall be compatible with the fastening system to minimize abrasion of the rail seat area, reduce wheel impact loads and vibration effects on the track structure and provide electrical insulation of the rail.

.2 Rail seat pads shall provide a positive means of preventing movement of the pad parallel to the rail.

.3 Rail seat pads shall be manufactured from natural rubber thermoplastics, to provide the required chemical and physical properties to resist effects of temperature ranging from -40º C to +70º C (-40º F to +160º F), as well as oxidation, water, alkali, petroleum products, synthetic lubricants, sunlight and climatic conditions typical of Southwestern Ontario, Canada.

.4 Oil-extended rubber, reclaimed rubber, or rubbers containing wax are not acceptable.

.5 Insulators – Pandrol HD-8, or approved equivalent, complying with the following requirements:

.1 Insulators shall provide electrical isolation, reduce abrasion, position the rail to the required gauge and transfer dynamic loading from the rail to the rail clip to prevent relative motion in any direction.

.2 Insulators shall be protected against degradation from oxidation, water, alkali, petroleum oils, synthetic lubricants, and sunlight without having detrimental effect on the performance and electrical insulation properties of the insulator.

.3 Recycled materials are not acceptable.

.6 Embedded Shoulders – Pandrol 13294, or approved equivalent, complying with the following requirements:

.1 Embedded shoulders shall be twin-stem, threadless, casted to provide and maintain proper position and alignment of the rail, rail clip, insulators, tie pad and running rail base.

.2 Shoulders shall be made of ductile cast iron conforming to ASTM A536 Grades 80-55-06 or 65-45-12.

.3 Shoulders shall not be directly anchored to the pretensioned steel.

GUARDRAIL

.1 Provide fasteners suitable to fasten emergency guardrail.

.2 The guardrail fastening system shall be shown on the submitted shop drawing for approval, including, but not limited to, the following components:

.1 Insert: 7/8” UNC Thread, to be submitted for approval

.2	Bolt:	7/8” UNC Thread, to be submitted for approval
.3	Washer:	To be submitted for approval
.4	Clip:	To be submitted for approval
.5	Cap Plugs:	To be submitted for approval

PART 3 - MATERIALS

3.1 CONCRETE

.1 Concrete shall meet the requirements of the AREMA Specifications for Material, Section 4.2, Chapter 30 of the AREMA Manual.

.2 The choice of materials, concrete mix design, manufacturing process and prestressing details shall all aim to minimize cracking which may be associated with delayed ettringite formation (DEF), alkali aggregate reactivity (AAR) air-entrainment, other admixtures, sulphate reactions, alkali-silica reactivity (ASR) and De-icing chemicals (chlorides) in accordance with CSA-A23.1, CSA-A23.4 and Industry Standards.

.3 Concrete shall accommodate class of exposure C-1, in accordance with CSA-A23.1-09.

.4 Concrete Mix Design:

.1 Qualify concrete mix design based on tests on trial batches, which shall show that concrete mix achieves the specified strengths and properties, including shrinkage and permeability.

.2 The mix design submittal shall include at least the following data to demonstrate conformance with the specified requirements:

.1 Qualification testing of all concrete components, including admixtures.

.2 Proportions of all concrete components.

.3 Concrete strength.

.4 Range of air contents. In no case shall the air content be less than 4.5% in the plastic concrete.

.5 Minimum air void content of 3.5% in the hardened concrete.

.6 Air void spacing factor not exceeding 0.2 mm (0.008 in.).

.3 Submit a new mix design to qualify the mix if any constituents of the concrete are changed during concrete tie production.

.5 Compressive Strength, tested in accordance with ASTM

.1 Minimum 28-Day Design Compressive Strength: 48 MPa (7000 psi).

.2 Samples for compressive strength testing shall be obtained in accordance with ASTM C 172. Specimens shall be made and laboratory cured in accordance with ASTM C 31. Specimens made to check the adequacy of curing and protection of concrete shall be cured entirely under production conditions. Concrete temperature shall be recorded during curing.

.3 Strength tests shall be performed on 6 in. by 12 in. cylinders, or 4in. by 8in. cylinders, in accordance with ASTM C39. For each day of production, at least six cylinders shall be prepared and capped in accordance with ASTM C 617: two for 28-day strength tests, two for checking strength at prestress transfer and two for spares.

.4 Minimum transfer requirement is f'c = 31 MPa (4,500 psi) for wire and strand.

.6 Flexural Strength, tested in accordance with ASTM

.1 Minimum 28-Day Flexural Strength: 5 MPa (750 psi).

.2 Samples from which flexural strength test specimens are molded shall be obtained in accordance with ASTM C 31. Specimens to check the adequacy of curing and protection of concrete shall be cured entirely under production conditions.

.3 Strength tests shall be made on 152 mm by 152 mm by 508 mm (6 in. by 6 in. by 20 in.) beams in accordance with ASTM C 78. One beam shall be tested for every new mix design.

3.2 CEMENT

.1 Cement shall meet the requirements of the AREMA Specifications for Material, Section 4.2, Chapter 30 of the AREMA Manual.

.2 Cement shall be Portland cement and conform with ASTM C150. Cement alkali content shall be as low as possible, and less than 0.6% Na_2O equivalent.

.3 False set penetration, when tested in accordance with ASTM C451, shall not be less than 50 mm initially, 35 mm at intermediate times, and 40 mm after remix.

.4 The Manufacturer shall retain typical analysis reports, including alkali content, of the cement as supplied by the cement producer. At the start of production and at least once every 3 months during production, the Manufacturer shall determine the alkali content of a randomly chosen shipment of cement.

.5 Under no circumstances shall substitution of cement be permitted unless it has been pre-qualified through appropriate testing.

3.3 ADMIXTURES

.1 Admixtures shall meet the requirements of the AREMA Specifications for Concrete Admixtures, Section 1.7, Chapter 8 of the AREMA Manual.

.2 Chemical admixtures for concrete shall conform to ASTM C 494.

.3 Additives containing chlorides shall not be used.

.4 To combat freeze-thaw conditions, an air entraining agent according to ASTM C 260 shall be used.

3.4 AGGREGATE

.1 Fine and coarse aggregates shall meet the requirements of the AREMA Specifications for Material, Section 4.2, Chapter 30 of the AREMA Manual.

.2 The maximum size of aggregate in the mix shall be 20 mm (¾ in.).

.3 The Manufacturer shall have determined 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 the specific standards and ASTM C 33.

.4 At the time of the trial mixes the Manufacturer shall have the aggregates sampled and tested according to CSA-A23.1, CSA-A23.2, ASTM C 1260 and ASTM C 1293.

.5 Coarse aggregates shall be gravel, crushed gravel, crushed stone, or a combination thereof.

.6 The Manufacturer shall provide a petrographic report on the proposed aggregates in accordance with ASTM C 295.

.7 Should the source of materials - cement, fine or coarse aggregate – change, required material testing shall be repeated prior to the continuing manufacture of ties. A change in source is defined as a new pit/quarry and or new stratum or excavation face in an existing pit/quarry.

3.5 MIXING WATER

.1 Mixing water shall meet the requirements of the AREMA Specifications for Material, Section 4.2, Chapter 30 of the AREMA Manual.

.1 Mixing water shall conform to the requirements of ASTM C 1602.

.2 The mixing water, including that portion of the mixing water contributed in the form of free moisture on the aggregates, shall not contain deleterious amounts of chloride ion.

3.6 PRESTRESSING WIRE (REINFORCEMENT)

.1 Prestressing wire shall meet the requirements of the AREMA Specifications for Material, Section 4.2, Chapter 30 of the AREMA Manual.

.2 Prestressing wire shall comply with ASTM A 881.

.3 Prestressing wire shall be pretensioned, indented and only from one source on each bed.

.4 No joints in wire are permitted within a tie bed.

3.7 CLEANLINESS

.1 The embedded iron shoulders and prestressing wire shall not be contaminated with form oil or any other deleterious substance which would interfere with bond development.

3.8 CURING

.1 Curing shall meet the requirements of the AREMA Specifications for Material, Section 4.2, Chapter 30 of the AREMA Manual.

.2 Accelerated curing shall be in accordance with Standard CSA-A23.4.

PART 4 - INSPECTION AND TESTING

4.1 INSPECTION AND TESTING

.1 Testing of materials is the Manufacturer's responsibility. Samples shall be of a suitable size to ascertain compliance with the specification. The Manufacturer shall conduct all required tests and the results of these tests shall be made available to the Owner upon request.

.2 Material which does not comply with this specification or material which, notwithstanding tests, inspection or acceptance at any time or location, is found to contain deficiencies will be subject to rejection and return to the Manufacturer. The Manufacturer shall assume all expenses of handling and transportation in both directions

END OF SECTION