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16. Abstract

This report is part of a program sponsored by the Office of Rail and Construction Technology, Office of Technology Development and Deployment of the Urban Mass Transportation Administration. The report was prepared as part of an ongoing research effort to develop standard concrete ties for rapid transit use. The overall objective of this research is to fabricate and evaluate, by laboratory tests, standard ties of different designs intended for transit use. The tie designs, a pre-tensioned mono-block, a post-tensioned two-block, and preliminary specifications for tie manufacture were developed under an earlier contract from the Transit Development Corporation.

These revised specifications cover requirements for component materials, manufacturing procedures, and handling of mono-block and two-block concrete (prestressed) cross ties, pads, and insulators for rapid transit use. It also includes requirements for rail fastenings for securing running rails, and the inserts for anchoring both the rail fastenings and the traction power contact rail support bracket.

These specifications are preliminary and will be modified, as necessary, on the basis of in-track tests.

This report contains Appendix A: "Details of Concrete Ties", Appendix B: "Report of New Technology", and a Listing of References.

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PREFACE

This report was prepared by the Construction Technology Laboratories, a division of the Portland Cement Association, under contract No. DOT-TSC-1442 managed by the Transportation Systems Center, Cambridge, Massachusetts. The contract is part of a program sponsored by the Office of Rail and Construction Technology, Office of Technology Development and Deployment, Urban Mass Transportation Administration of the U.S. Department of Transportation to develop standard concrete ties for rapid transit use.

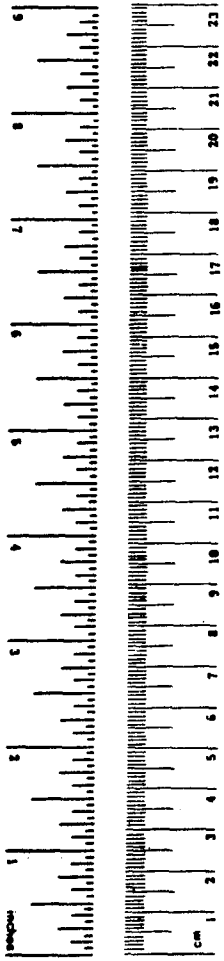
The overall objective of this contract is to fabricate and evaluate, by laboratory tests, standard ties of different designs intended for transit use. The tie designs, a pretensioned monoblock and a post-tensioned two-block, and preliminary specifications for tie manufacture were developed under an earlier contract from the Transit Development Corporation. This report presents revised specifications for the materials, manufacture and handling of prestressed concrete cross ties. It also includes requirements for rail fastenings for securing running rails, and the inserts for anchoring both the rail fastenings and the traction power contact rail support bracket.

Mr. P. Witkiewicz and Mr. G. Saulnier of the Transportation Systems Center were the technical monitor and alternate technical monitor, respectively, for the work reported herein. Their cooperation and suggestions are gratefully acknowledged. Mr. F. J. Cihak of the American Public Transit Association and representatives of several transit properties also deserve recognition for their assistance and suggestions.

METRIC CONVERSION FACTORS

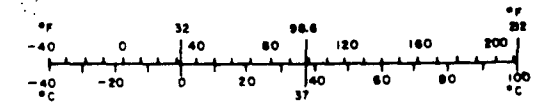
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. GENERAL REQUIREMENTS

1.1 GENERAL

These specifications set forth requirements for materials, manufacture, and handling of prestressed concrete cross ties, together with rail fastenings for securing running rails, and the inserts for anchoring both rail fastenings and the traction power contact rail support bracket. These specifications are preliminary and will be modified, as necessary, on the basis of in-track tests.

1.2 SCOPE

These specifications cover requirements for component materials, manufacturing procedures, and handling of monoblock and two-block concrete cross ties, rail fastenings, pads, and insulators for rapid transit use.

1.3 TRACK CONFIGURATION

Concrete ties are designed for use in ballasted track sections with 115 RE rail and 4 ft 8-1/2 in. gage. Ties have been designed for a spacing not to exceed 30 in.

1.4 CROSS TIE COMPONENTS AND DIMENSIONS

1.4.1 Concrete ties shall be of pretensioned monoblock or post-tensioned two-block design, provided with steel prestressing tendons, threadless inserts for rail fastenings, and stainless steel inserts for a contact rail support bracket.

1.4.2 Dimensional requirements of the concrete cross ties shall be as shown in Appendix A - Details of Concrete Ties.

1.4.3 Location and tolerences of rail fastening inserts shall be in accordance with fastening manufacturer's drawings and recommendations.

1.4.4 If required by the operating transit property, concrete ties shall be provided with inserts for guard rails. At the option of the property, inserts may be placed by drilling and grouting. Location of inserts shall be specified by the transit property.

1.5 RAIL FASTENING COMPONENTS

1.5.1 The rail fastening system shall include pads, clips, and insulators.

1.5.2 Rail fastening shall be resilient, threadless and detachable.

1.5.3 Fastening inserts shall be coated with epoxy resin for additional electrical insulation. Other materials shall be approved by the operating transit property.

1.5.4 Fasteners shall be subjected to the acceptance tests specified in Section 12. Failure of fastening system to pass tests will be cause for rejction.

2. MATERIALS

2.1 PORTLAND CEMENT

Portland cement shall conform to ASTM Designation: C150, Specification for Portland Cement. Types I, II, or III may be used. However, use of Type III is recommended to accelerate strength gain.

2.2 CONCRETE AGGREGATES

Fine and coarse aggregates shall be clean, hard, strong, durable and free of deleterious material. Aggregates shall conform to ASTM Designation: C33, Specification for Concrete Aggregates. Coarse aggregate shall consist of either crushed gravel or crushed stone. Size number 67 (3/4 in. to No. 4) is recommended for coarse aggregate gradation.

2.3 WATER

Water used in mixing concrete shall be potable and free from harmful amounts of oils, acids, alkalis, salts, organic materials, or other substances that may be deleterious to concrete or steel. In addition, mixing water shall not contain chloride ion in excess of 500 ppm.

2.4 AIR-ENTRAINING ADMIXTURES

Air-entraining admixtures, if used, shall conform to ASTM Designation: C260, Specification for Air-Entraining Admixtures for Concrete.

2.5 ACCELERATING, RETARDING, AND WATER-REDUCING ADMIXTURES

Water-reducing admixtures, retarding admixtures, accelerating admixtures, water-reducing and retarding admixtures, and

water-reducing and acelerating admixtures, if used, shall conform to ASTM Designation: C494, Specification for Chemical Admixtures for Concrete. In no case shall admixtures containing chlorides be used.

2.6 PRESTRESSING STEEL

2.6.1 Grade 270, uncoated seven-wire stress-relieved strands shall be used for pretensioning in the monoblock tie. Strands shall have a nominal diameter of 3/8 in., and shall conform to ASTM Designation: A416, Specification for Uncoated Seven-Wire Stress-Relieved Strand for Prestressed Concrete, and the following minimum properties:

Breaking strength	23,000 lb
Yield strength (1% extension)	19,550 lb

Proper prestress transfer by bond shall be assured by appropriate treatment of the surface of strands. This may be accomplished by using indented wire-strands. Other means shall be approved by the operating transit property.

2.6.2 Grade 160, high-strength alloy steel bars shall be used for post-tensioning the two-block tie. Bars, during manufacture, shall be cold stretched (proof-stressed) to the minimum yield strength. Bars shall have a nominal diameter of 3/4 in., and the following minimum properties:

Breaking strength	71 kips
Yield strength (at 0.7% extension)	60.4 kips
Elongation in 20 diameters after rupture	4%
Reduction of area at rupture	20%

The bars shall be fabricated and processed to meet the described physical properties and conform to ASTM Designation: A29, Specification for General Requirements for Hot-Rolled and Cold-Finished Carbon and Alloy Steel Bars. The bars shall be provided with a rolled on thread at both ends for anchorage.

2.7 STEEL PIPE

Steel hot dip galvanized tube with a nominal inside diameter of 2-1/2 in. shall be used to connect the blocks of the two-block tie. Pipe shall conform to Grade B of ASTM Designation: A53, Specification for Welded and Seamless Steel Pipe, and shall have the following minimum properties:

Tensile strength	60,000 psi
Yield strength	35,000 psi

2.8 ANCHORAGES

2.8.1 Anchorage for the post-tensioning rod of the two-block tie shall be obtained with a high strength nut bearing against a washer and a steel plate. Anchorage fittings shall be capable of transferring to the concrete a load not less than 90% of the minimum specified breaking strength of the prestressing rod.

2.8.2 After tensioning and seating, the anchorage shall be able to sustain the applied load without slippage, distortion, or other changes that will permit loss of stress.

2.8.3 Anchorage and fittings shall be permanently protected against corrosion. Anchorage zone shall be encased in concrete, grout, or epoxy mortar and the encasement shall be free from any chlorides.

2.9 METAL REINFORCEMENT

Grade 60, deformed steel bars shall be used for reinforcement in the two-block tie. Bars shall have a nominal diameter of 3/8 in. (size number 3), and conform to ASTM Designation: A615, Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement. Bars shall have the following minimum properties:

Tensile strength	90,000 psi
Yield strength	60,000 psi
Elongation (measured in 8 in.)	9%

3. CONSTRUCTION REQUIREMENTS

3.1 CONCRETE QUALITY

3.1.1 Water content shall be kept to a minimum consistent with the strength requirements and placement needs. Concrete mixes shall be proportioned to produce a compressive strength of at least 7000 psi measured at 28 days on standard 6x12 in. cylinders (see Section 3.4).

3.1.2 Concrete strength at transfer shall be adequate for the requirements of anchorages and for the transfer through bond. Strength at the time prestress is transferred to the concrete shall be no less than 4000 psi.

3.1.3 Flexural strength of concrete shall be at least 750 psi measured at 28 days on beam specimens (see Section 3.4).

3.1.4 Air entrainment shall be required, where conditions warrant, to increase resistance to freezing and thawing. Concrete shall contain 4% $\pm$ 1% of entrained air.

3.2 PROPORTIONS OF CONCRETE MIX

3.2.1 Unless previous data are available to show that a concrete mix will be satisfactory for the production of concrete ties, concrete mix designs shall be established by tests on trial batches to achieve the required specified strengths (see Section 3.1).

3.2.2 The cement content shall not be less than 600 lbs per cubic yard.

3.2.3 The maximum size of aggregate shall be 3/4 in.

3.2.4 Water-cement ratio shall not exceed 0.40 by weight.

3.2.5 Trial mixtures using aggregate, water, cement, and admixtures proposed 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 encompassing those specified in Section 3.1. For each water-cement ratio, at least three specimens for each age to be tested shall be made, cured, and tested (see Section 3.4).

The strength tests shall be made at (a) 28 days and (b) the age at which transfer shall be made. A curve shall be established showing the relationship between water-cement ratio and compressive strength. The maximum permissible water-cement ratio for the concrete to be used shall be that shown by the curve to produce average strengths of 110% of those specified in Section 3.1, provided that water-cement ratio shall be no greater than that required by Section 3.2.4.

3.3 CONCRETE PROPORTIONS AND CONSISTENCY

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.

3.4 STRENGTH TESTS OF CONCRETE

3.4.1 Compressive 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 Designation: C172, Method of Sampling Fresh Concrete. Specimens shall be made and laboratory cured in accordance with ASTM Designation: C31, Method of Making and Curing Concrete Compressive and Flexural Strength Test Specimens in the Field. Specimens made to check the adequacy of curing

and protection of concrete shall be cured entirely under production conditions.

Strength tests shall be made on 6x12-in. cylinders in accordance with ASTM Designation: C39, Method of Test for Compressive Strength of Cylindrical Concrete Specimens. For each day of production at least six cylinders shall be tested; three for 28-day testing, and three for checking strength at transfer.

3.4.2 Flexural strength tests shall be made to check the adequacy of the mix proportions and as a basis for acceptance. Samples from which flexural test specimens are molded shall be secured in accordance with ASTM Designation: C31, Method of Making and Curing Concrete Compressive and Flexural Strength Test Specimens in the Field. Specimens made to check the adequacy of curing and protection of concrete shall be cured entirely under production conditions.

Strength tests shall be made on 6x6x30-in. beams in accordance with ASTM Designation: C78, Method of Test for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading). For each day of production at least three beams shall be tested at 28 days.

4. FABRICATION AND FORMS

4.1 METHOD OF PRODUCTION

Monoblock ties shall be manufactured by the long line process.

4.2 FORMS

4.2.1 Forms shall be rigid and shall be constructed of material that will result in finished ties conforming to the shape, lines and dimensions called for on the plans. In no case shall tolerances in excess of those specified on the drawings be allowed.

4.2.2 Rail seat portions of the forms shall consist of removable plates to permit accommodation of embedded inserts for different fastening systems.

4.2.3 Forms for monoblock ties shall be constructed to permit movement of the tie without damage during release of the prestressing force.

4.2.4 Forms shall provide proper marking with indented or raised letters or numerals to identify the manufacturer and month and year of production. Marking shall be placed on tie top surface in the middle portion and/or near tie ends.

5. PLACEMENT OF PRESTRESSING STEEL

5.1 MONOBLOCK TIES

Pretensioning strands in the monoblock tie shall be accurately placed and adequately secured in position. Prior to placing concrete, the dimensional accuracy of the position of prestressing steel, bulkheads, inserts, etc. shall be verified. Prestressing tendons shall be inspected for proper surface condition. Tendons contaminated with form release agents and other substances that will reduce bond shall be cleaned.

5.2 TWO-BLOCK TIES

5.2.1 Post-tensioning rod in the two-block tie shall be lubricated by properly applied coating of bituminous or other suitable bond breaking material. The coating shall remain ductile and free from cracks and shall not become fluid over the entire anticipated range of temperatures. The coating shall be chemically stable and non-reactive to cement. The coating material shall adhere to and be continuous over the entire unthreaded length of the rod.

5.2.2 Prior to placing concrete for the two-block tie, the post-tensioning rod shall be properly positioned in the center of the pipe and the reinforcing bars shall be adequately secured in position. The pipe shall then be filled with grout consisting of a mixture of cement, sand, and water. Proportions of the mixture shall be based on tests made before the grouting operation is begun. The water content shall be the minimum necessary for proper placement, the water-cement ratio shall not exceed 0.45. The consistency shall be such that it can easily fill the pipe and shall have a minimum of shrinkage or settlement. Grout shall have a minimum compressive strength of 4500 psi at seven days. Grouting may be performed while the pipe is being held in a vertical position.

5.2.3 The steel pipe holding the post-tensioning rod and reinforcing bars shall be accurately placed and adequately secured in position. Anchorage devices shall be aligned with the direction of the axis of the prestressing rod at the point of attachment. Concrete surfaces, against which the anchorage devices bear, shall be normal to this line of direction.

6. APPLICATION AND MEASUREMENT OF PRESTRESSING FORCE

6.1 MONOBLOCK TIES

6.1.1 Prestressing force in each of the five strands shall be 16,750 lb.

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

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

6.1.4 Strands may be stretched either individually or simultaneously. If strands are stretched simultaneously, provision must be made to induce approximately equal stress in each.

6.1.5 Transfer of force from bulkheads of the pretensioning bed to the concrete shall be carefully 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 1/2 inch.

6.2 TWO-BLOCK TIES

6.2.1 Prestressing force in the prestressing bar shall be 39,000 lb.

6.2.2 An initial load of approximately 3,000 lb. shall be applied to the prestressing rod to take up slack and provide a starting point for the measurement of elongation.

6.2.3 The final load shall be measured by jacking pressure and elongation, and shall check within 5%. If measurements cannot be reconciled within this range, the procedure shall be examined and sources of error determined so that the measured force can be verified within this limit.

7. MIXING, PLACING, AND CURING OF CONCRETE

7.1 PREPARATION FOR PLACING CONCRETE

Prior to the placing of concrete, all equipment for mixing the concrete shall be clean, all debris and ice shall be removed from spaces to be occupied by the concrete, the forms shall be thoroughly oiled, and the reinforcement shall be thoroughly cleaned of ice or other deleterious coatings. The forms shall be inspected for alignment and tightness of joints and dimensional accuracy of the position of bulkheads, prestressing steel, inserts, etc. shall be verified.

7.2 PROPORTIONING OF COMPONENT MATERIALS

7.2.1 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.

7.2.2 Water and liquid admixtures may be measured by either weight or volume.

7.2.3 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%

7.3 MIXING OF CONCRETE

7.3.1 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.

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

7.3.3 Optimum mixing time shall be established by the equipment manufacturer's recommendations. Generally, minimum mixing time shall be 1 min. for batches of 1 cu.yd. 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.

7.4 CONVEYING

7.4.1 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.

7.4.2 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 end without segregation of materials.

7.5 DEPOSITING

7.5.1 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.

7.5.2 Concrete shall not be placed when the ambient air temperature of the casting room is below 40F. Concrete shall have a minimum temperature of 50F, and a maximum temperature of 90F. When concrete is placed at an ambient temperature of 90F or greater, special efforts to prevent rapid drying must be used.

7.6 CONSOLIDATING

7.6.1 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.

7.6.2 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 lb. per cu.ft.

7.6.3 Care shall be taken to assure that forms are not damaged during consolidation.

7.7 CURING

7.7.1 Curing by low pressure steam, radiant heat and moisture, or other accepted process shall be employed to accelerate strength gain so that removal of forms and tensioning can be accomplished at early age.

7.7.2 Curing shall be done in accordance with established procedures to produce concrete strength as specified in Section 3.1.

8. REMOVAL OF TIES FROM FORMS AND FINISHING

8.1 REMOVAL FROM FORMS

Ties shall be removed from forms in a manner such as to avoid damage.

8.2 FINISHING

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 surface irregularities and air holes. Other surfaces shall have a smooth finish that may contain honeycomb not to exceed 2% of the surface and a maximum void diameter of 1/4 in.

8.2.2 Bottom surface of the tie shall have a rough finish such as may be obtained with a broom.

9. HANDLING AND STORAGE

9.1 HANDLING

Ties shall be lifted and supported during manufacture, storage, transportation and placing operations in such a way as to prevent chipping, spalling, cracking or other damage.

9.2 STORAGE

9.2.1 When stacked in multiple tiers, each tier shall be separated using scrap lumber having sufficient thickness to clear fastening shoulders.

9.2.2 Ties shall not be exposed to temperatures below freezing for at least six days after casting.

10. ACCEPTANCE TESTS FOR MONOBLOCK TIES

10.1 DAILY PRODUCTION QUALITY CONTROL TESTS

10.1.1 One tie selected at random from every 200 ties or fraction thereof produced each day, shall be tested within 30 days of casting in bending at both rail seats and tie center in an approved machine. Also, dimensional tolerences shall be verified.

10.1.2 The distance from the center of track to the center of rail seats shall be verified and by use of a template, the rail seat configuration and insert location shall be verified.

10.1.3 Rail seat vertical load test shall be performed as follows:

With the tie supported and loaded as shown in Figure 10-1, a load shall be applied at a uniform rate and in such a manner to avoid shock. The load may be applied rapidly up to 18,000 lb after which it shall be applied at a rate not greater than 5,000 lb per minute until a load of 26,000 lb is obtained. This load shall be held for not less than 3 minutes, during this time an inspection shall be made to determine if cracking occurs. A 5-power illuminated magnifying glass shall be used to locate cracks.

10.1.4 Tie center vertical load test shall be performed as follows:

With the tie supported and loaded as shown in Figure 10-2, a load shall be applied at a uniform rate and in such a manner to avoid shock. The load may be applied rapidly up to 6,000 lb, after which it shall be applied at a rate not greater than 3,000 lb per minute until a load of 9,500 lb is obtained. This load shall be held for not less than 3 minutes, during this time an inspection shall be made to determine if cracking occurs. A 5-power illuminated magnifying glass shall be used to locate cracks.

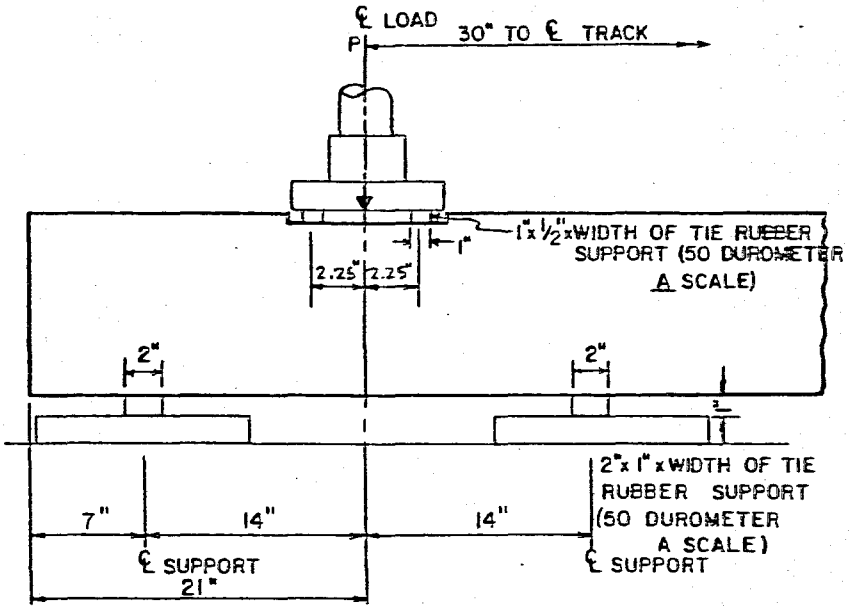


FIGURE 10-1. MONOBLOCK TIE RAIL SEAT VERTICAL LOAD TEST

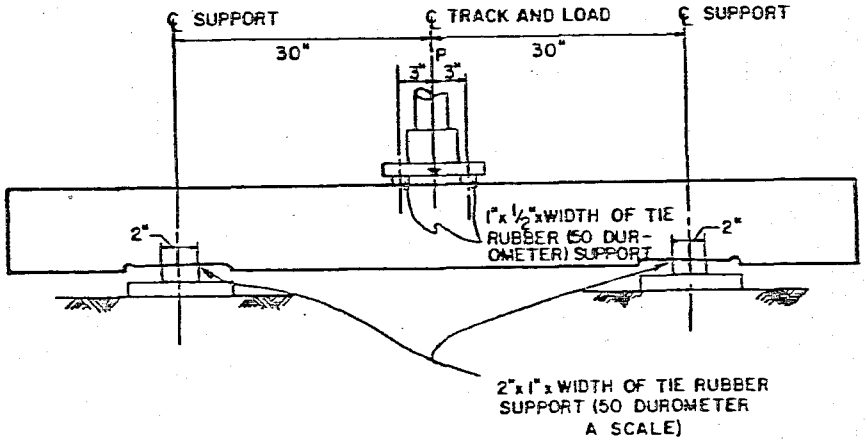


FIGURE 10-2. MONOBLOCK TIE CENTER VERTICAL LOAD TEST

10.1.5 If cracking does not occur in any of the tests, the requirement of the tests will have been met and the entire lot shall be accepted.

10.1.6 If cracking occurs in any of the tests, two additional ties from the same lot shall be subjected to that test and acceptance of the lot shall be based on the following conditions:

1. If both of the retest ties meet the test requirement, the lot shall be accepted.
2. If either of the retest ties fails to meet the test requirement, the entire lot shall be rejected, unless the maufacturer tests each of the remaining ties in the lot and only those meeting the test requirement shall be accepted.

10.2 BOND DEVELOPMENT AND ULTIMATE LOAD TEST

10.2.1 One tie selected at random from every 2,000 produced and accepted on the basis of meeting requirements for 10.1 shall be tested for bond development and ultimate strength.

10.2.2 With the tie supported and loaded as shown in Figure 10-1, load shall be applied as specified in 10.1.3 and increased until a load of 39,000 lb is obtained. The load shall be held for not less than 3 minutes. Strand slippage shall be determined by an extensometer reading to 0.0001 in., suitably attached to the end of the tie.

10.2.3 If strand slippage does not exceed 0.001 in., the requirement of the test will have been met.

10.2.4 If strand slippage exceeds 0.001 in., three additional ties shall be tested. If any of the three ties does not meet the requirement of the test, the entire lot may be rejected at the option of the engineer.

10.2.5 The load shall then be increased until ultimate failure occurs, and the maximum load obtained shall be recorded.

11. ACCEPTANCE TESTS FOR TWO-BLOCK TIES

11.1 DAILY PRODUCTION QUALITY CONTROL TESTS

11.1.1 One tie selected at random from ever 200 ties or fraction thereof produced each day shall be tested within 30 days of casting in bending at both rail seats in an approved machine. Also, dimensional tolerences shall be verified.

11.1.2 The distance from the center of track to center of the rail seats shall be verified and by use of a template, the rail seat configuration and insert location shall be verified.

11.1.3 With the tie supported and loaded as shown in Figure 10-3, a load shall be applied at a uniform rate and in such a manner to avoid shock. The load may be applied rapidly up to 20,000 lb after which it shall be applied at a rate not greater than 5,000 lb per minute until a load of 28,000 lb is obtained. This load shall be held for not less than 3 minutes, during this time an inspection shall be made to determine if cracking occurs. A 5-power illuminated magnifying glass shall be used to locate cracks.

11.1.4 If cracking does not occur, the requirement of the test will have been met, and the entire lot shall be accepted.

11.1.5 If cracking occurs, two additional ties from the same lot shall be tested and acceptance of the test shall be based on the following conditions:

1. If both of these test ties meet the test requirement, the lot shall be accepted.
2. If either of the retest ties fails to meet the test requirement, the entire lot shall be rejected, unless the manufacturer tests each of the remaining ties in the lot and only those meeting the test shall be accepted.

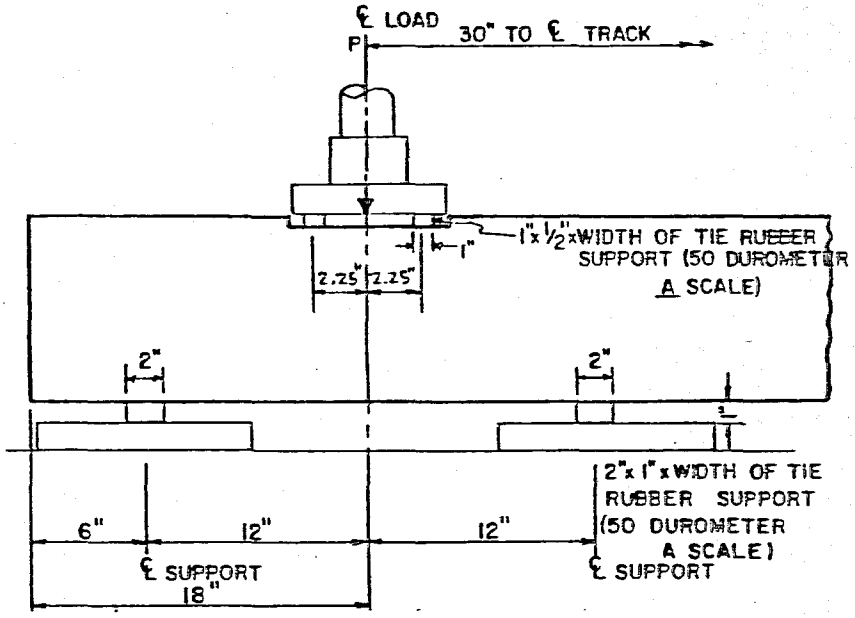


FIGURE 11-1. TWO-BLOCK TIE RAIL SEAT VERTICAL LOAD TEST

11.2 TENDON ANCHORAGE AND ULTIMATE LOAD TEST

11.2.1 One tie selected at random from every 2,000 ties produced and accepted on the basis of meeting requirements for 11.1 shall be tested for tendon anchorage and ultimate strength.

11.2.2 With the tie supported and loaded as shown in Figure 10-3, a load shall be applied as specified in 11.1.3 and increased until a load of 42,000 lb is obtained. The load shall be held for not less than 3 minutes.

11.2.3 If the tie supports the load without visual signs of failure of tendon anchorage, the requirement of the test will have been met.

11.2.4 If failure of tendon anchorage occurs, three additional ties shall be tested, and if any of the three ties does not meet the requirement of the test, the entire lot may be rejected at the option of the engineer.

11.2.5 The load shall then be increased until ultimate failure occurs, and the maximum load obtained shall be recorded.

12. ACCEPTANCE TESTS FOR FASTENING SYSTEMS

12.1 TEST SEQUENCE

Design qualification testing of fasteners shall be performed using one tie and fastening components in the following sequence:

a. Rail Fastening Insert Test as described in Section 12.2
b. Contact Rail Support Bracket Insert Test as described in Section 12.3
c. Rail Fastening Uplift Test as described in Section 12.4
d. Rail Fastening Repeated Load Test as described in Section 12.5
e. Rail Fastening Longitudinal Restraint Test as described in Section 12.6
f. Rail Fastening Lateral Restraint Test as described in Section 12.7
g. Electrical Resistance and Impedance Test as described in Section 12.8.

12.2 RAIL FASTENING INSERT TEST

The following test shall be performed on each insert as indicated in Figure 12-1 to determine the ability of inserts to resist tension. An axial load of 8 kips shall be applied to each insert separately and shall be held for not less than three minutes. The embedded insert shall not move and the concrete shall not crack, as observed by visual inspection.

12.3 CONTACT RAIL SUPPORT BRACKET INSERT TEST

Axial loads shall be applied as indicated in Figure 12-2 to determine the ability of inserts to resist the contact rail bracket loads. An axial load of 6 kips shall be applied to each insert separately and held for not less than three minutes.

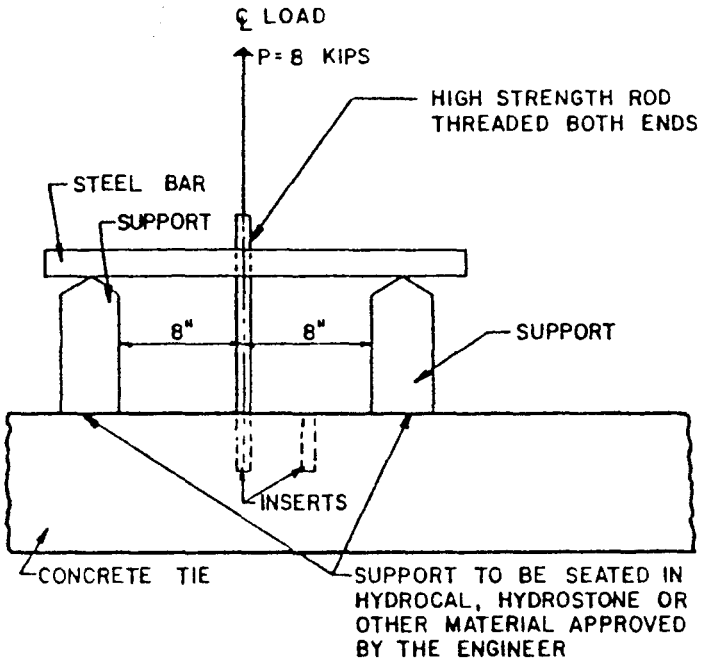


FIGURE 12-1. RAIL FASTENING INSERT TEST

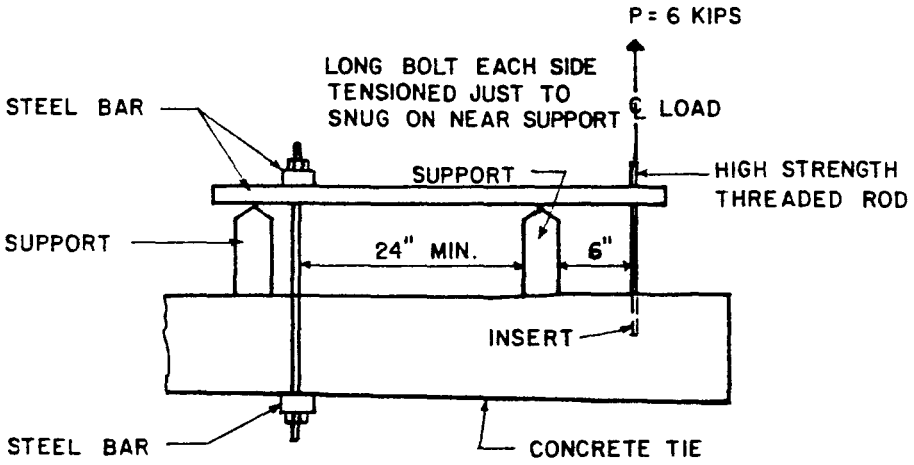


FIGURE 12-2. CONTACT RAIL SUPPORT BRACKET INSERT TEST

The embedded inserts shall not move and the concrete shall not crack.

12.4 RAIL FASTENING UPLIFT TEST

An 18 to 20 in. 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 in Figure 12-3, an incremental load shall be applied to the rail. The load P at which separation of the rail from pad or pad from rail seat (whichever occurs first) shall be recorded. The load shall then be completely released. A load of 1.5P 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.

12.5 RAIL FASTENING REPEATED LOAD TEST

12.5.1 An 18 to 20 in. 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 using a complete rail fastening assembly. In accordance with the loading diagram in Figure 12-3, determine the load P that will cause minute separation of the rail from the rail seat pad or the pad from the rail seat, whichever occurs first. This load may be determined during the Fastening Uplift Test described in Section 12.4 in which case a new set of fastening clips shall be used for the repeated load test.

12.5.2 An 18 to 20 in. section of 115 RE rail, from which loose mill scale had been removed by wiping with a cloth, shall be secured to the rail seat using a complete rail fastening assembly. In accordance with the loading diagram in Figure 12-4, alternating downward and upward loads shall be applied at

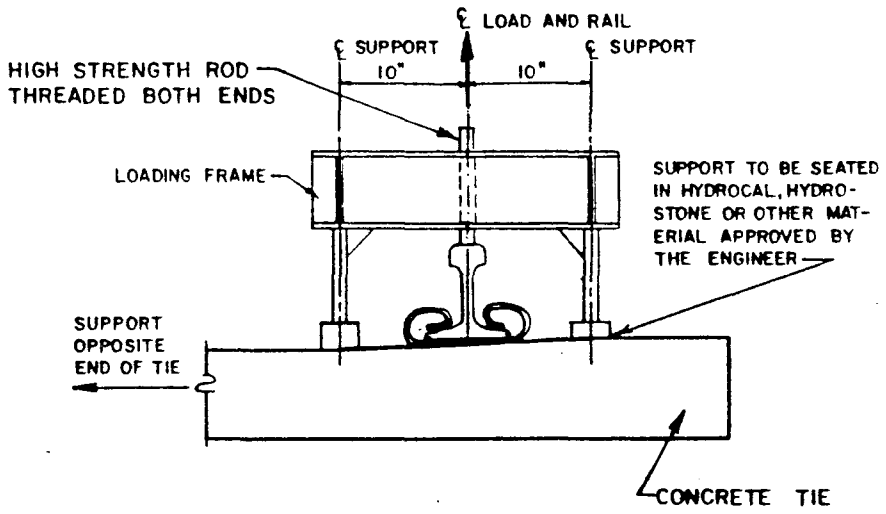


FIGURE 12-3. RAIL FASTENING UPLIFT TEST

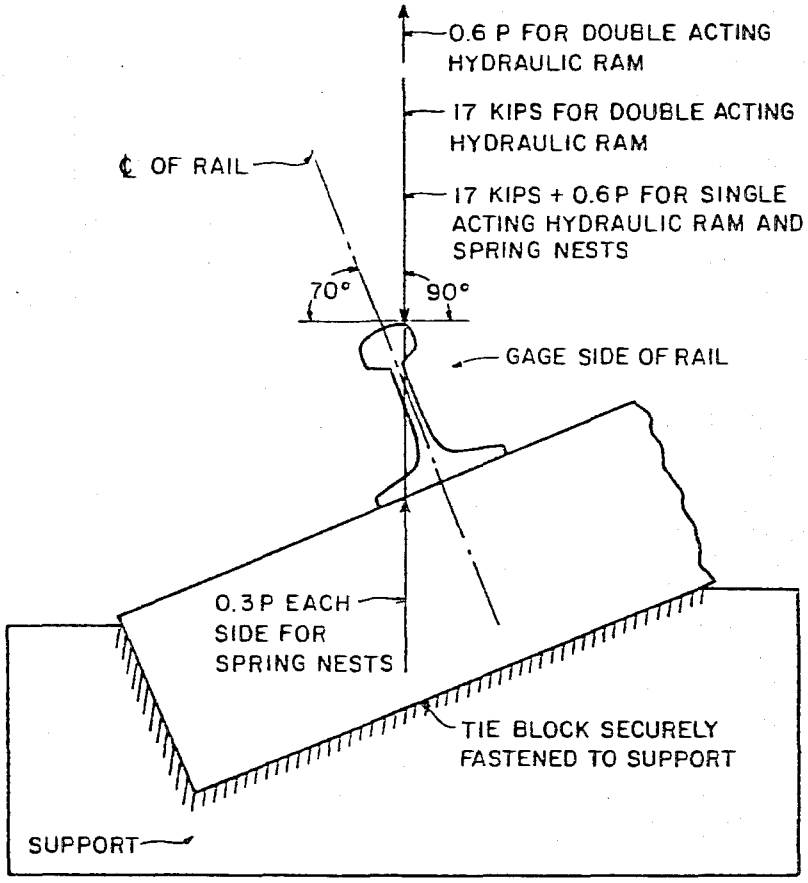


FIGURE 12-4. RAIL FASTENING REPEATED LOAD TEST

an angle of 20 degrees to the vertical axis of the rail at a rate not to exceed 300 cycles per minute for five million cycles. The rail shall be free to rotate under the applied loads. One cycle shall consist of both a downward and upward load. The magnitude of the upward load shall be 0.6P where P is the load determined in Section 12.5.1. If springs are used to generate the upward load, the downward load shall be 17 kips plus 0.6P. If a double-acting hydraulic ram is used to generate both the upward and the downward load, the downward load shall be 17 kips.

12.5.3 The repeated load test may generate heat in elastometric rail seat pads. Heat build-up in such pads shall not be allowed to exceed 120F. Heat build-up may be controlled by reducing the rate of load application or by providing periods of rest to allow cooling of the pad.

12.5.4 Rupture failure of any component of the fastening system shall constitute failure of the test.

12.6 RAIL FASTENING LONGITUDINAL RESTRAINT TEST

After successful completion of the Rail Fastening Repeated Load Test specified in Section 12.5 and without disturbing the rail fastening assembly in any manner, the tie and fastening shall be subjected to a longitudinal restraint test. A longitudinal load shall be applied as indicated in Figure 12-5, in increments of 400 pounds with readings taken of longitudinal rail displacement after each increment. Readings of rail displacement shall be the average of the readings of two dial indicators reading to 0.001 in. One dial indicator shall be placed on each side of the rail with the dial indicator plungers parallel to the longitudinal axis of the rail. The load shall be increased incrementally until a load of 2.4 kips is reached. This specified load shall be held for not less than 15 minutes. The rail shall not move more than 1/8 in. during this period.

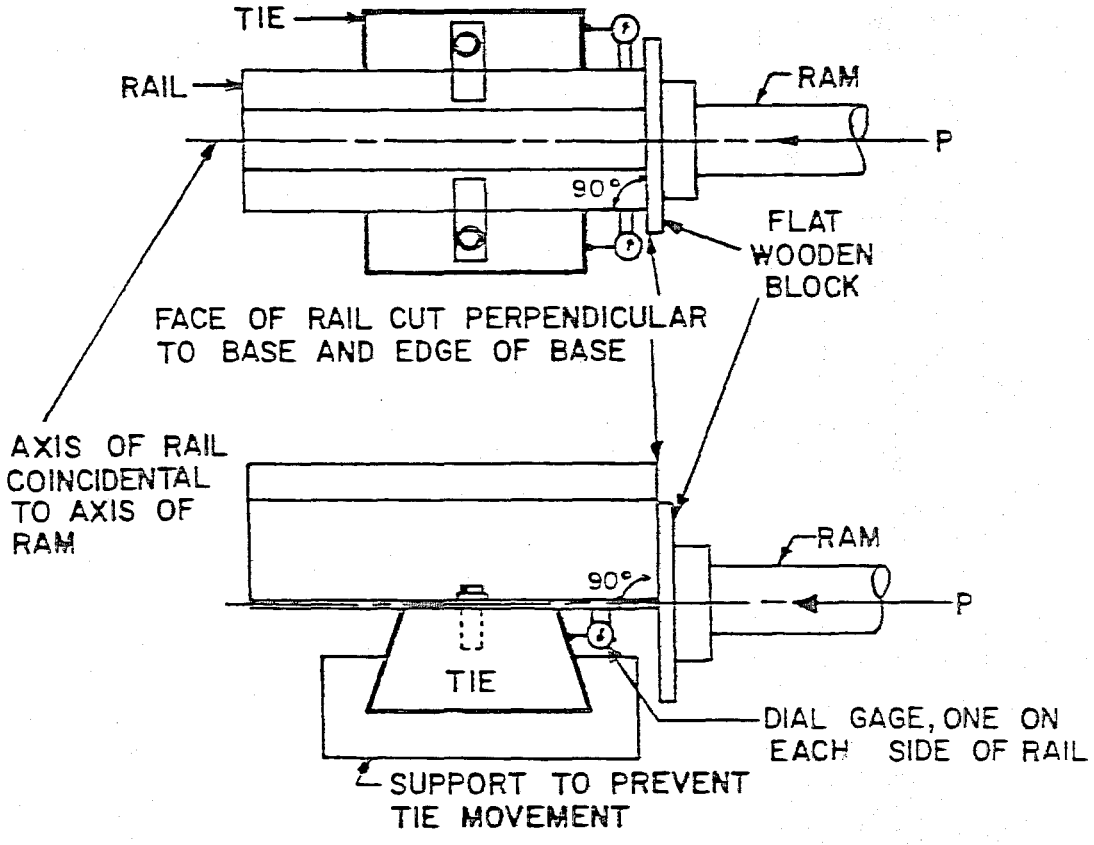


FIGURE 12-5. RAIL FASTENING LONGITUDINAL RESTRAINT TEST

The fastening shall be capable of meeting the requirements of this test in either direction of loading. The tie and fastenings will have successfully passed this test if the specified criteria are met.

12.7 RAIL FASTENING LATERAL RESTRAINT TEST

12.7.1 A 18 to 20 in. section of 115 RE rail shall be secured to the tie block in a manner appropriate to the fastening being used. The entire assembly shall be supported and loaded as indicated in Figure 12-6. The loading head shall be fixed against translation and rotation. The wood block shall be 10-in. x 10-in. x 3/4-in. thick, five ply exterior grade plywood.

12.7.2 A preload of 10 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 that measure rail translation. Load shall be applied at a rate not to exceed 5 kips per minute until either 19 kips have been applied or the rail base has translated 1/8-in. whichever occurs first. Inability of the fastening to carry the 19 kip load with 1/8-in. or less of rail translation shall constitute failure of this test. Complete failure of any component of the tie or fastening is cause for rejection.

12.7.3 With all load removed from the rail, a roller nest 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 readings on the dial indicators, that measure gauge widening and rail translation, a load of 10 kips shall be applied at a rate not to exceed 5 kips per minute. Rail rotation, gage widening less rail translation, greater than 1/4 in. shall constitute failure of this test.

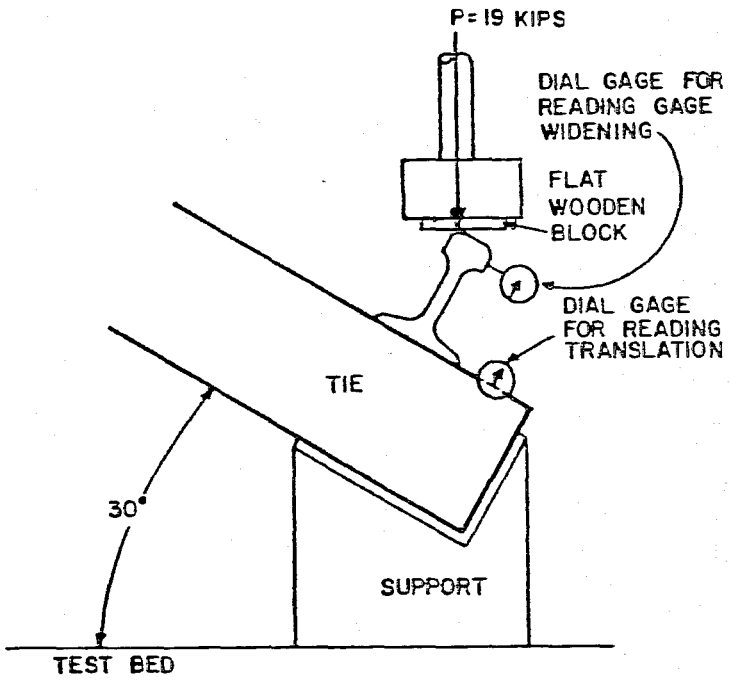


FIGURE 12-6. RAIL FASTENING LATERAL RESTRAINT TEST

12.8 ELECTRICAL RESISTANCE AND IMPEDANCE TEST

12.8.1 Concrete test tie shall be assembled with insulating components, rail clips and section of 115 RE rail. The rail section lengths shall be greater than the width of the tie.

12.8.2 The complete assembly shall be immersed in water for a minimum of 6 hr.

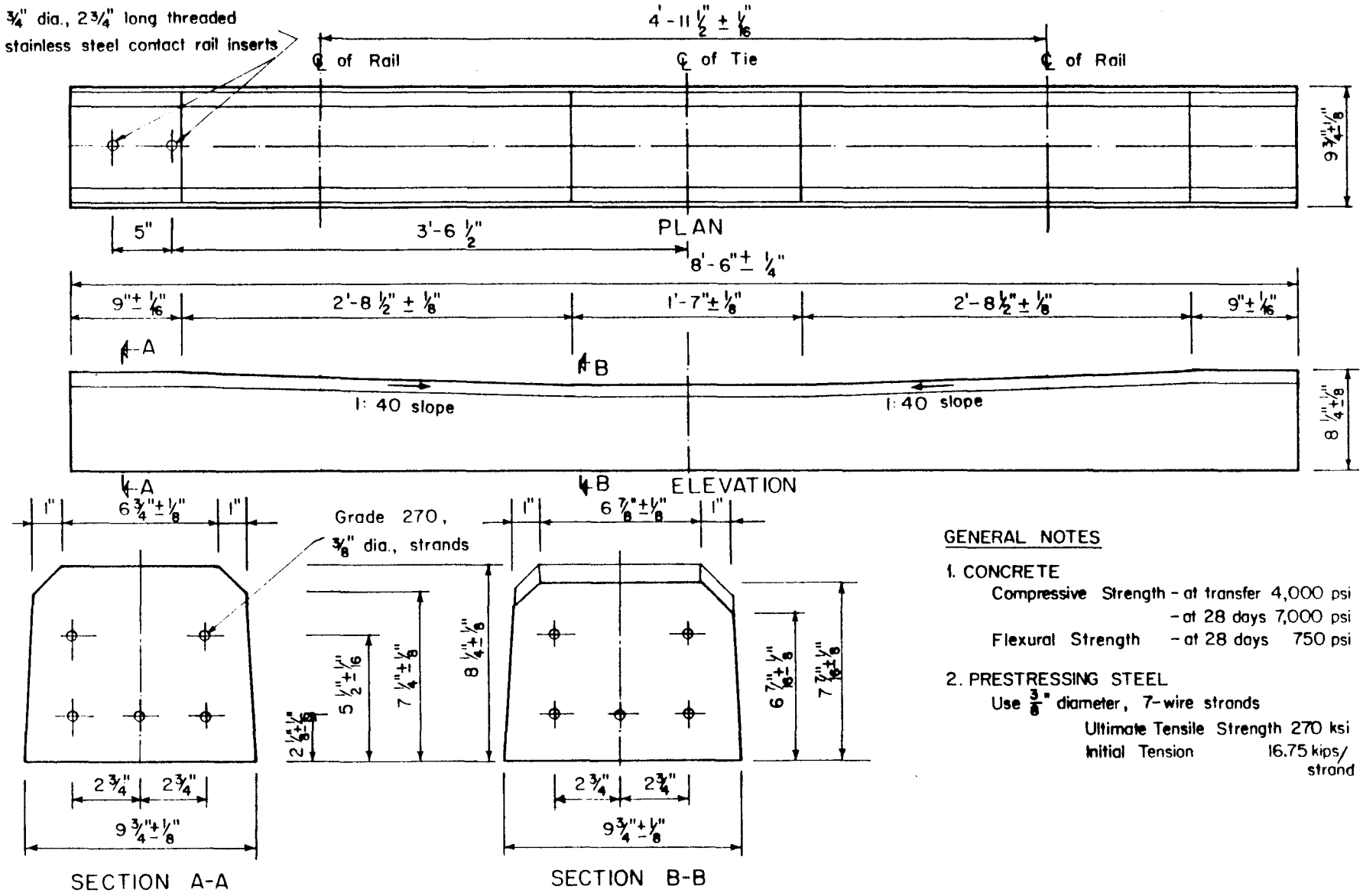
12.8.3 Within 1 hr. after removal from water an a-c 10-volt 60-Hertz potential is applied across the two rails for a period of 15 minutes. If the rails are rusty or contain mill scale, the contact points must be cleaned.

12.8.4 The current flow in amperes shall be read using an a-c ammeter and the impedance determined by dividing the voltage by the current flow in amperes.

12.8.5 If the impedance determined in 12.8.3 exceeds 40,000 ohms, the tie will have passed the test.

APPENDIX A - DETAILS OF CONCRETE TIES

Details of pretensioned monoblock and post-tensioned two-block concrete ties are shown in Figures A-1 and A-2, respectively.

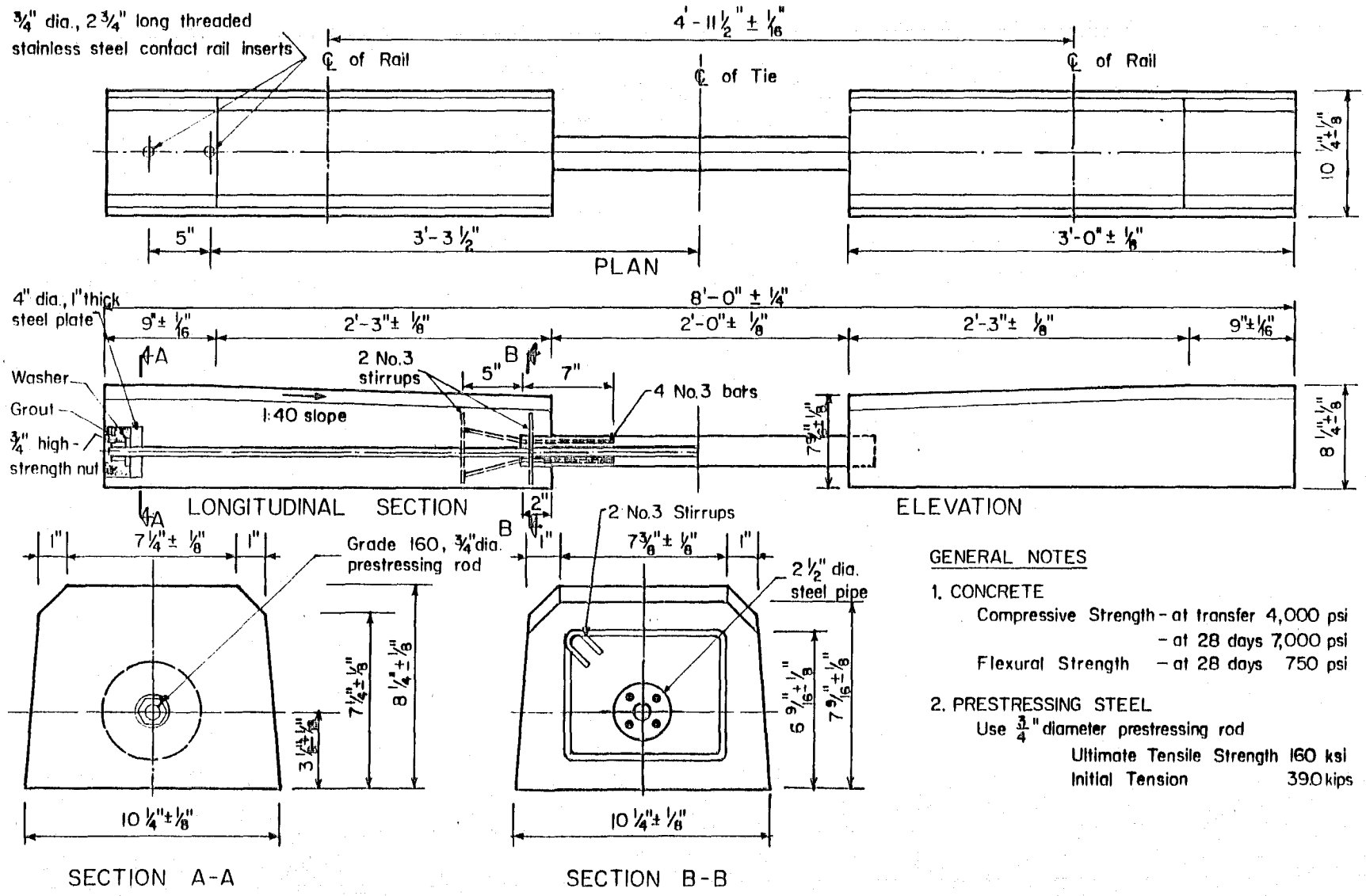


GENERAL NOTES

1. CONCRETE
   - Compressive Strength - at transfer 4,000 psi
   - at 28 days 7,000 psi
   - Flexural Strength - at 28 days 750 psi

2. PRESTRESSING STEEL
   - Use ⅜" diameter, 7-wire strands
   - Ultimate Tensile Strength 270 ksi
   - Initial Tension 16.75 kips/strand

FIGURE A-1. DETAILS OF MONOBLOCK TIE



GENERAL NOTES

1. CONCRETE
   - Compressive Strength – at transfer 4,000 psi
   - Compressive Strength – at 28 days 7,000 psi
   - Flexural Strength – at 28 days 750 psi
2. PRESTRESSING STEEL
   - Use ¾" diameter prestressing rod
   - Ultimate Tensile Strength 160 ksi
   - Initial Tension 390 kips

FIGURE A-2. DETAILS OF TWO-BLOCK TIE

APPENDIX B - REPORT OF NEW TECHNOLOGY

This report presents revised specifications for the materials, manufacture, and handling of prestressed concrete ties. It also includes requirements for rail fastenings. A careful review of the work performed under this contract indicated that no discoveries or inventions have been made. However, the work provides useful information pertaining to the development of standard concrete ties for transit use. This work is a step towards the development of a nationally acceptable standard or recommended practice for rapid transit concrete ties and fastenings.

REFERENCES

Specifications of the American Society for Testing and Materials (ASTM) referred to in these specifications are listed in this Appendix. Standards of the American Concrete Institute (ACI) and other technical publications which are related to these specifications are also listed.

ASTM A29-76 "Specification for General Requirements for Hot-Rolled and Cold-Finished Carbon and Alloy Steel Bars"

ASTM A53-77a "Specification for Black and Hot-Dipped, Zinc-Coated Welded and Seamless Steel Pipe"

ASTM A185-73 "Specification for Welded Steel Wire Fabric for Concrete Reinforcement"

ASTM A416-74 "Specification for Uncoated Seven-Wire Stress-Relieved Strand for Prestressed Concrete"

ASTM A615-76a "Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement"

ASTM C31-69 "Method of Making and Curing Concrete Compressive and Flexural Strength Test Specimens in the Field"

ASTM C33-78 "Specification for Concrete Aggregates"

ASTM C39-72 "Test Method for Compressive Strength of Cylindrical Concrete Specimens"

ASTM C78-75 "Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)"

ASTM C88-76 "Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate"

ASTM C117-76 "Test Method for Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing"

ASTM C127-77 "Test Method for Specific Gravity and Absorption of Coarse Aggregate"

ASTM C131-76 "Test Method for Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine"

ASTM C136-76 "Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregate"

ASTM C142-78 Test Method for Clay Lumps and Friable Particles in Aggregates"

ASTM C150-78a "Specification for Portland Cement"

ASTM C172-71 "Method of Sampling Fresh Concrete"

ASTM C192-76 "Method of Making and Curing Concrete Test Specimens in the Laboratory"

ASTM C235-68 "Test Method for Scratch Hardness of Coarse Aggregate Particles"

ASTM C260-77 "Specification for Air-Entraining Admixtures for Concrete"

ASTM C494-77a "Specification for Chemical Admixtures for Concrete"

ASTM C535-69 "Test Method for Resistance to Abrasion of Large Size Coarse Aggregate by Use of the Los Angeles Machine"

PCA Bulletin D62 "Optimum Steam Curing Procedure in Precasting Plants," by J. A. Hanson

ACI 211.1-77 "Recommended Practice for Selecting Properties for Normal and Heavyweight Concrete"

ACI 304-73 "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete"

ACI 308-71 "Recommended Practice for Curing Concrete"

ACI 309-72 "Recommended Practice for Consolidation of Concrete"

ACI 317-70 "Recommended Practice for Atmospheric Pressure Steam Curing of Concrete"

ACI 318-77 "Building Code Requirements for Reinforced Concrete"

PCI-MNL 116-70 "Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products:

ACI-ASCE Committee 423 "Tentative Recommendations for Concrete Members Prestressed with Unbonded Tendons," Journal of the ACI, February 1969