QUEEN & CRESCENT ROUTE.

The Cincinnati, New Orleans and Texas Pacific Railway Company.

(LESSEE CINCINNATI SOUTHERN RAILWAY.)

Alabama Great Southern Railroad Company.

SPECIFICATIONS

—FOR—

STEEL BRIDGES AND VIADUCTS.

1911.

250. 6-6-10. G. & P. Co. 99262.

QUEEN & CRESCENT ROUTE.

The Cincinnati, New Orleans and
Texas Pacific Railway Company.

(LESSEE CINCINNATI SOUTHERN RAILWAY.)

Alabama Great Southern Railroad Company.

SPECIFICATIONS

—FOR—

STEEL BRIDGES AND VIADUCTS.

1911.

250. 6-6-10. G. & P. Co. 99262.

CONTENTS.

QUEEN & CRESCENT ROUTE.

The Cincinnati, New Orleans and Texas Pacific Railway Company.

(Lessee Cincinnati Southern Railway.)

Alabama Great Southern Railroad Company.

1911.

PROPOSALS.

Proposals.

In general, all bids will be per pound price for the bridge superstructure, delivered f. o. b. on the line of the { Cincinnati / Alabama } Southern Railway / Great Southern Railroad Co. } including all members complete, all field rivets and bolts, pilot nuts, anchor bolts, floor bolts and washers, lead for bed plates, and shop coat of paint.

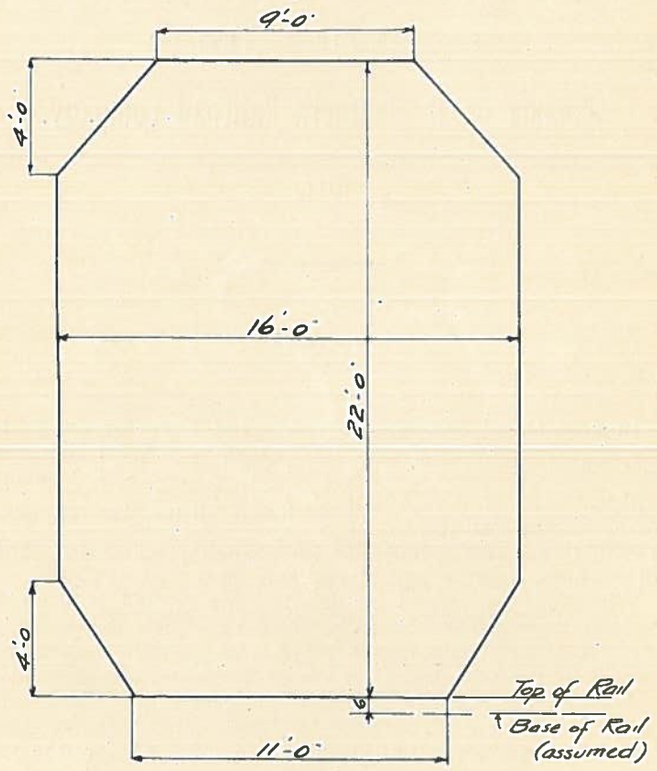
When bids are invited for the structure erected, it is understood the superstructure is to be erected complete ready for the floor, except field painting, as hereinafter specified.

All bids must be based on these specifications and on data furnished by the Railway Company. In case of any discrepancy in the data or any uncertainty as to the meaning of the specifications, the same must be settled with the Engineer before the contractor submits his bid.

When required, the contractor shall furnish a stress sheet with his bid. Each pound price proposal shall state the estimated weight of the structure. No free transportation for men, tools or materials will be allowed unless so stated in the invitation to bidders.

The word Engineer as used in these specifications means the Chief Engineer of the Railway Company.

DIAGRAM OF CLEARANCE.



PART FIRST—DESIGN.

I. GENERAL.

Materials.

1. The material in the superstructure shall be structural steel, except rivets, and as may be otherwise specified. (See Article V, paragraph 104.)

Clearances

2. When alignment is on tangent, clearances shall not be less than shown on the diagram. The width shall be increased so as to provide the same minimum clearances on curves for a car 80 ft. long, 14 ft. high, and 60 ft. center to center of trucks, allowance being made for curvature and superelevation of rails.

Drawings.

3. Except in cases where the drawings are prepared by the Railway Company, the contractor shall prepare stress sheet and complete detail drawings of all parts of the structure.

The stress sheet must show assumed dead load, maximum live and dead load stresses and impact; and the proposed sections and areas of all members; also sketches of such details as are necessary for a clear understanding of the structure.

Detail drawings must show every part of the structure and give complete dimensions and sizes of all material.

All drawings are to be 24 x 35 inches between borders.

Blue prints in duplicate of all drawings must be submitted to the Engineer for approval, and no work shall be done or material ordered until the drawings have been approved by the Engineer except at the contractor's risk.

The contractor shall furnish the Railway Company as many blue prints of the approved drawings as may be necessary for the proper inspection and supervision of the work, and when work is completed the original tracings shall be furnished free of cost to the Railway Company.

Classes of Structures

4. The following classes of structures are preferred for the different lengths of spans:

For single track:

Spans up to 110 feet.....Plate Girders.
Spans from 110 feet to 200 feet.....Riveted Trusses.
Spans over 200 feet.....Pin Connected Trusses.

For double track:

Spans up to 110 feet.....Plate Girders.
Spans from 110 feet to 180 feet.....Riveted Trusses.
Spans over 180 feet.....Pin Connected Trusses.

5. Double intersection trusses will not be permitted. Adjustable members will not be used except by special permission.

6. Generally, floor beams and stringers will be used on all structures except deck girders. Spans will generally have end floor beams.

Spacing Girders.

7. Stringers will be generally spaced 6 feet 6 inches center to center.

Deck girders on tangent alignment will be spaced as follows:
Spans up to 65 feet.....6 feet 6 inches.
Spans from 65 feet to 80 feet.....8 feet
Spans over 80 feet.....9 feet

Deck girders on curves will be spaced as directed.

Spacing Trusses.

8. The width center to center of girders and trusses shall in no case be less than one-twentieth of the effective span, nor less than is necessary to prevent overturning under the assumed lateral loading.

Skew Bridges.

9. Ends of deck plate girders and track stringers of skew bridges at abutments shall be square to the track, unless a ballasted floor is used.

Timber Floors.

10. The cross ties will be 8 in. wide and spaced not more than 6 in. apart in the clear. They shall be 10 ft. long and have a minimum depth of 10 in. for girders spaced 6 ft. 6 in. center to center, 12 ft. long, and have a minimum depth of 12 in. for girders spaced 8 ft. center to center, and 12 ft. long, and have a minimum depth of 13 in. for girders spaced 9 ft. center to center.

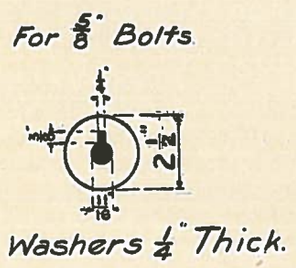
Ties shall be dapped at least one-half inch and not more than one and one-half inches over the supporting girders or stringers. The depth of ties shall be increased towards the ends of the girders where necessary to secure proper dapping.

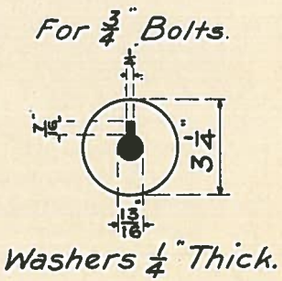
Ties shall be secured to each girder by a three-fourths inch bolt every fourth tie.

There shall be a 6 in. x 8 in. guard timber on each side of the track, placed with its inner face 4 ft. 3 in. from the center line of track and attached to each tie with a $\frac{5}{8}$ in. bolt or with a $\frac{5}{8}$ in. lag screw in case the bolt interferes with the girder flange; 8 lag screws shall be furnished to attach the guard rails to ties on the masonry backwalls.

Standard Washers.

All floor bolts will have square nuts and heads and be provided with washers as per detail below.





When necessary to superelevate the outer rail, beveled ties will be used as far as practicable, and where greater superelevation is needed, separate elevation blocks of the same width as the ties will be bolted to the underside, using two ¾ in. bolts to secure each block to the tie.

Superelevation.

For beveled ties the minimum depth given above shall obtain over the girder on the inside of the curve.

II. LOADS.

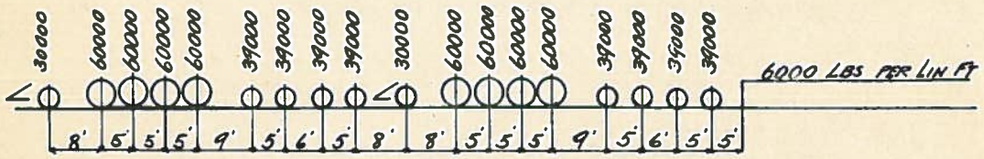
Dead Load.

11. The dead load shall consist of the estimated weight of the entire suspended structure. Timber shall be assumed to weigh 4½ lbs. per ft. B. M.; ballast 100 lbs. per cu. ft., reinforced concrete 150 lbs. per cu. ft., and rails and fastenings, 150 lbs. per linear ft. of track.

Live Load.

12. The live load for each track shall consist of two typical engines followed by a uniform train load, Cooper's E-60 loading, as shown in the following diagram:

DIAGRAM OF LOADS (See Table No. 1).



Impact.

13. The dynamic increment of the live load shall be added to the maximum computed live load strains and shall be determined by the formula $I = S\frac{300}{L+300}$,

where I=impact or dynamic increment to be added to live-load strains.

S=computed maximum live-load strain.

L=loaded length of track in feet producing the maximum strain in the member. For bridges carrying more than one track, the aggregate length of all tracks producing the strain shall be used.

Impact shall not be added to strains produced by longitudinal, centrifugal and lateral or wind forces.

Lateral Forces.

14. All spans shall be designed for a lateral force on the loaded chord of 200 lbs. per linear foot plus 10 per cent. of the

specified train load on one track, and 200 lbs. per linear foot on the unloaded chord; these forces being considered as moving.

Wind Force. 15. Viaduct towers shall be designed for a force of 50 lbs. per sq. ft. on one and one-half times the vertical projection of the structure unloaded; or 30 lbs. per sq. ft. on the same surface plus 400 lbs. per linear ft. of structure applied 7 ft. above the rail for assumed wind force on train when the structure is either fully loaded or loaded on either track with empty cars assumed to weigh 1,200 lbs. per linear ft., whichever gives the larger strain.

Longitudinal Force. 16. Viaduct towers and similar structures shall be designed for a longitudinal force of 20 per cent. of the live load applied at the top of the rail.

17. Structures located on curves shall be designed for the centrifugal force of the live load applied at the top of the high rail. The centrifugal force shall be considered as live load and be derived from the speed in miles per hour given by the expression $60-2\frac{1}{2}D$, where "D"=degree of curve.

III. UNIT STRESSES AND PROPORTION OF PARTS.

Unit Stresses. 18. All parts of structures shall be so proportioned that the sum of the maximum stresses produced by the foregoing loads shall not exceed the following amounts in pounds per sq. in., except as modified in paragraphs 26 to 29:

Tension. 19. Axial tension on net section.....16,000

Compression. 20. Axial compression on gross section of....

columns .....$16{,}000-70\frac{l}{r}$

with a maximum of.....14,000

where "l" is the length of the member in inches,

and "r" is the least radius of gyration in inches.

Direct compression on steel castings.....16,000

Bending. 21. Bending: on extreme fibers of rolled shapes, built sections, girders and steel castings; net section..16,000

on extreme fibers of pins.....24,000

Shearing. 22. Shearing: shop driven rivets and pins....12,000

field driven rivets and turned bolts.....10,000

plate girder webs; gross section.....10,000

Bearing. 23. Bearing: shop driven rivets and pins.....24,000

field driven rivets and turned bolts.....20,000

expansion rollers; per linear inch..... $600\,d$

where "d" is the diameter of the roller in inches.

on masonry..... 600

Limiting Length of Members. 24. The lengths of main compression members shall not exceed 100 times their least radius of gyration, and those for wind and sway bracing 120 times their least radius of gyration.

25. The lengths of riveted tension members in horizontal or inclined positions shall not exceed 200 times their radius of

gyration about the horizontal axis. The horizontal projection of the unsupported portion of the member is to be considered as the effective length.

Alternate Stresses. 26. Members subject to alternate stresses of tension and compression shall be proportioned for the stresses giving the largest section. If the alternate stresses occur in succession during the passage of one train, as in stiff counters, each stress shall be increased by 50 per cent. of the smaller. The connections shall in all cases be proportioned for the sum of the stresses.

27. Wherever the live and dead load stresses are of opposite character, only two-thirds of the dead load stresses shall be considered as effective in counteracting the live load stress.

Combined Stresses. 28. Members subject to both axial and bending stresses shall be proportioned so that the combined fiber stresses will not exceed the allowed axial stress.

29. For stresses produced by longitudinal and lateral or wind forces combined with those from live and dead load and centrifugal force, the unit stress may be increased 25 per cent. over those given above; but the section shall not be less than required for live and dead loads and centrifugal force.

Net Section at Rivets. 30. In proportioning tension members the diameter of the rivet holes shall be taken $\frac{1}{8}$ in. larger than the nominal diameter of the rivet.

Rivets. 31. In proportioning rivets the nominal diameter of the rivet shall be used.

Net Section at Pins. 32. Pin-connected riveted tension members shall have a net section through the pin-hole at least 25 per cent. in excess of the net section of the body of the member, and the net section back of the pin-hole, parallel with the axis of the member, shall be not less than the net section of the body of the member.

Plate Girders. 33. Plate girders shall be proportioned either by the moment of inertia of their net section; or by assuming that the flanges are concentrated at their centers of gravity; in which case one-eighth of the gross section of the web, if properly spliced, may be used as flange section. The thickness of web plates shall be not less than 1/160 of the unsupported distance between flange angles.

Compression Flange. 34. The gross section of the compression flanges of plate girders shall not be less than the gross section of the tension flanges; nor shall the stress per sq. in. in the compression flange of any beam or girder exceed $16{,}000-200\frac{l}{b}$, when flange consists of angles only or if cover consist of flat plates, or $16{,}000-150\frac{l}{b}$, if cover consists of a channel section, where l=unsupported distance and b=width of flange.

Flange Rivets.

35. The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer the total shear at any point in a distance equal to the effective depth of the girder at that point combined with any load that is applied directly on the flange. The wheel loads, where the ties rest on the flanges, shall be assumed to be distributed over three ties.

Depth Ratios.

36. Trusses shall preferably have a depth of not less than one-tenth of the span. Plate girders and rolled beams, used as girders, shall preferably have a depth of not less than one-twelfth of the span. If shallower trusses, girders or beams are used, the section shall be increased so that the maximum deflection will not be greater than if the above limiting ratios had not been exceeded.

IV. DETAILS OF DESIGN.

GENERAL REQUIREMENTS.

Open Sections.

37. Structures shall be so designed that all parts will be accessible for inspection, cleaning and painting.

Pockets.

38. Pockets or depressions which would hold water shall have drain holes, or be filled with waterproof material.

Symmetrical Sections.

39. Main members shall be so designed that the neutral axis will be as nearly as practicable in the center of section, and the neutral axes of intersecting main members of trusses shall meet at a common point.

Counters.

40. Rigid counters are preferred; and where subject to reversal of strain shall preferably have riveted connections to the chords. Adjustable counters shall have open turnbuckles.

Strength of Connections.

41. The strength of connections shall be sufficient to develop the full strength of the member, even though the computed stress is less, the kind of stress to which the member is subjected being considered.

Minimum Thickness.

42. The minimum thickness of metal shall be ⅜ in., except for fillers.

Size of Rivets.

43. In general ⅞ in. rivets will be used. The diameter of the rivets in any angle carrying calculated stress shall not exceed one-quarter the width of the leg in which they are driven. In minor parts ⅞-in. rivets may be used in 3-in. angles, and ¾-in. rivets in 2½-in. angles.

Pitch of Rivets.

44. The minimum distance between centers of rivet holes shall be three diameters of the rivet; but the distance shall preferably be not less than 3 in. for ⅞-in. rivets and 2½ in. for ¾-in. rivets. The maximum pitch in the line of stress for members composed of plates and shapes shall be 6 in. for ⅞-in. rivets and 5 in. for ¾-in. rivets. For angles with two gauge lines and rivets staggered the maximum shall be 10 inches for ⅞-in. rivets and 9 inches for ¾-in. rivets. Where two or more plates are used in contact, rivets not more than 12 in. apart in either direction shall be used to hold the plates well together. In tension members, composed of two angles in contact, a pitch of

12 in. will be allowed for riveting the angles together. (See paragraph 93.)

Edge Distance.

45. The minimum distance from the center of any rivet hole to a rolled edge shall be 1¼ inches for ⅞-in. rivets and 1⅛ inches for ¾-in. rivets and to a sheared edge, the minimum distance shall be preferably not less than two diameters of the rivet, and in no case less than 1½ inches for ⅞-in. rivets and 1¼ inches for ¾-in. rivets. The maximum distance from any edge shall be eight times the thickness of the plate, but shall not exceed 6 in.

Long Rivets.

46. Rivets carrying calculated stress and whose grip exceeds four diameters shall be increased in number at least one per cent. for each 1/16-in. of grip.

Pitch at Ends.

47. The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivets, for a length equal to one and one-half times the maximum width of member.

Countersunk Rivets.

48. No value will be given to ⅞-in. rivets countersunk in plates less than ⅝ in. thick nor to ¾-in. rivets countersunk in plates less than ½ in. thick.

Compression Members.

49. In compression members the metal shall be concentrated as much as possible in webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between its connections to the flanges. Cover plates shall have a thickness not less than one-fortieth of the distance between rivet lines.

Minimum Flange Thickness.

50. Flanges of girders and built members without cover plates shall have a minimum thickness of one-twelfth of the width of the outstanding leg.

Tie-Plates.

51. The open sides of compression members shall be provided with lattice and shall have tie-plates as near each end as practicable. Tie-plates shall be provided at intermediate points where the lattice is interrupted. In main members the end tie-plates shall have a length not less than the distance between the lines of rivets connecting them to the flanges, and intermediate ones not less than one-half this distance. Their thickness shall not be less than one-fiftieth of the same distance.

Lattice.

52. The latticing of compression members shall be proportioned to resist the shearing stresses corresponding to the allowance for flexure for uniform load provided in the column formula in paragraph 20 by the term $70\frac{l}{r}$. The minimum width of lattice bars shall be 2½ in. for ⅞-in. rivets, or 2¼ in. for ¾-in. rivets, and 2 in. if ⅝-in. rivets are used. The thickness shall not be less than one-fortieth of the distance between end rivets for single lattice, and one-sixtieth for double lattice. Shapes of equivalent strength may be used.

53. Three-fourths-inch rivets shall be used for latticing flanges 2½ to 3½ in. wide; ⅞-in. rivets shall be used in flanges

3½ in. and over, and lattice bars with at least two rivets shall be used for flanges over 5 in. wide.

54. The inclination of lattice bars with the axis of the member shall not be less than 45 degrees, and when the distance between rivet lines in the flanges is more than 15 in., if single rivet bar is used, the lattice shall be double and riveted at the intersection.

55. Lattice bars shall be so spaced that the portion of the flange included between their connection shall be as strong as the member as a whole.

Faced Joints.

56. Abutting joints in compression members when faced for bearing shall be spliced on four sides sufficiently to hold the connecting members accurately in place. All other joints in riveted work, whether in tension or compression, shall be fully spliced.

Pin Plates.

57. Pin-holes shall be reinforced by plates where necessary, and at least one plate shall be as wide as the flanges will allow and be on the same side as the angles. They shall contain sufficient rivets to distribute their portion of the pin pressure to the full cross-section of the member.

Forked Ends.

58. Forked ends on compression members will be permitted only where unavoidable; where used, a sufficient number of pin plates shall be provided to make the jaws of twice the section area of the member. At least one of these plates shall extend to the far edge of the farthest tie-plate, and the balance to the far edge of the nearest tie-plate, but not less than 6 in. beyond the near edge of the farthest plate.

Pins.

59. Pins shall be long enough to insure a full bearing of all the parts connected upon the turned body of the pin. They shall be secured by chambered nuts or be provided with washers if solid nuts are used. The screw ends shall be long enough to admit of burring the threads.

60. Members packed on pins shall be held against lateral movement.

Bolts.

61. Where members are connected by bolts, the turned body of these bolts shall be long enough to extend through the metal. A washer at least ¼-in. thick shall be used under the nut. Bolts shall not be used in place of rivets except by special permission. Heads and nuts shall be hexagonal.

Indirect Splices.

62. Where splice plates are not in direct contact with the parts which they connect, rivets shall be used on each side of the joint in excess of the number theoretically required to the extent of one-third of the number for each intervening plate.

Fillers.

63. Rivets carrying stress and passing through fillers shall be increased 50 per cent. in number; and the excess rivets, when possible, shall be outside of the connected member.

Expansion

64. Provision for expansion to the extent of ⅛-in. for each 10 ft. shall be made for all bridge structures. Efficient means shall be provided to prevent excessive motion at any one point.

Expansion Bearings.

65. Spans of 80 ft. and over resting on masonry shall have turned rollers or rockers at one end; and those of less length shall be arranged to slide on smooth surfaces. These expansion bearings shall be designed to permit motion in one direction only.

Fixed Bearings.

66. Fixed bearings shall be firmly anchored to the masonry.

Rollers.

67. Expansion rollers shall be not less than 6 in. in diameter. They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be readily cleaned. Segmental rollers shall be geared to the upper and lower plates.

Bolsters.

68. Bolsters or shoes shall be so constructed that the load will be distributed over the entire bearing. Spans of 80 ft. or over shall have hinged bolsters at each end.

Wall Plates.

69. Wall plates may be of cast steel or built up of rolled shapes or bars, and shall be so designed as to distribute the load uniformly over the entire bearing. They shall be secured against displacement. Their thickness shall not be less than one-eighth their greatest dimension with a minimum of 3 in. Cast wall plates shall be cored with metal not less than ¾ in. thick and shall have all corners rounded. Sheet lead ⅛ inches thick shall be used under all wall plates unless otherwise directed.

Anchorage

70. Anchor bolts for viaduct towers and similar structures shall be long enough to engage a mass of masonry the weight of which is at least one and one-half times the uplift.

Inclined Bearings.

71. Bridges on an inclined grade without pin shoes shall have the sole plates beveled so that the masonry and expansion surfaces may be level.

Name Plate.

72. All bridges must have a cast name plate on each end indicating the name of the builder and the date of manufacture.

FLOOR SYSTEM.

Floor Beams.

73. Floor beams shall preferably be square and riveted directly to the girders or trusses.

Stringers.

74. Stringers shall preferably be riveted to the webs of all intermediate floor beams by means of connection angles not less than ½-in. in thickness. Shelf angles or other supports provided to support the stringer during erection shall not be considered as carrying any of the reaction.

Stringer Frames.

75. Where end floor beams cannot be used, stringers resting on masonry shall have cross frames near their ends. These frames shall be riveted to girders or truss shoes where practicable.

76. Where the rail is on wooden crossties, the base of rail must clear steel work by at least 1½ in.

BRACING.

Rigid Bracing.

77. Lateral, longitudinal and transverse bracing in all structures shall be composed of rigid members.

Portals.

78. Through truss spans shall have riveted portal braces rigidly connected to the end posts and top chords. They shall be as deep as the clearance will allow.

79. Where a double system of bracing is used each system shall be proportioned to resist in tension the total shear in the panel.

80. Top lateral bracing in through trusses shall be composed of at least two angles laced and of a depth equal to the depth of the chord with knee braces at each intermediate vertical member.

81. Laterals must be riveted to stringers at points of intersection with at least four rivets.

Transverse Bracing.

82. Intermediate transverse frames shall be used at each panel of through spans having vertical truss members where the clearance will permit.

End Bracing.

83. Deck spans shall have transverse bracing at each vertical and end inclined post, the bracing between the end inclined posts designed to carry the lateral load to the support.

Laterals.

84. Deck girders 80 ft. long and over and all viaduct girders shall have bottom lateral bracing. The minimum sized angle to be used in lateral bracing shall be 3½ by 3½ by ⅜-in. Not less than four rivets through the end of the angles shall be used at the connection.

85. Lateral bracing shall be far enough below the flange to clear the ties.

Tower Bracing.

86. Viaduct towers shall preferably have the longitudinal and transverse bracing, consisting of horizontal compression struts and double diagonal tension members.

The tower girders may serve as top longitudinal struts if properly riveted to the columns.

Double track towers shall have horizontal diagonal bracing at the top.

PLATE GIRDERS.

Camber

87. Plate girder spans over 50 ft. in length shall be built with a camber at the rate of 1/16-in. per 10 ft. of length.

Top Flange Cover.

88. Where flange plates are used, one cover plate of top flange shall extend the whole length of the girder.

Web Stiffeners.

89. There shall be web stiffeners, generally in pairs, over bearings, at points of concentrated loading, and at other points where the thickness of the web is less than 1/60 of the unsupported distance between flange angles. The distance between stiffeners shall not exceed that given by the following formula, with a maximum limit of six feet (and not greater than the clear depth of the web):

$$d = \frac{t}{40}(12{,}000 - s),$$

Where d=clear distance, between stiffeners or flange angles.
t=thickness of web.
s=shear per sq. in.

The stiffeners at ends and at points of concentrated loads shall be proportioned by the formula of paragraph 20, the effective length being assumed as one-half the depth of girders. End stiffeners and those under concentrated loads shall have their outstanding legs as wide as the flange angles will allow and shall fit tightly against them. Intermediate stiffeners shall have their outstanding legs not less than one-thirtieth of the depth of girder plus 2 in. All stiffeners shall be on fillers.

Cross Frames.

90. Cross frames with at least four angles shall be placed at the ends of deck girders and at intermediate points about twelve feet apart and be connected to both flanges.

Stays for Top Flanges.

91. Through plate girders shall have their top flanges stayed at each end of every floor beam, or in case of solid floors, at distances not exceeding 12 ft., by knee braces or gusset plates.

Rivets in Flanges.

92. At least two rows of staggered rivets shall be used in each leg of flange angles that are 6 in. wide or over to connect to web or cover plates.

93. Where four rows of rivets are used in cover plates of girders, alternate pitch at no point exceeding 4½ in. shall be used in each angle.

94. The rivet spacing at the ends of cover plates shall not exceed four diameters of the rivets for a length equal to at least twice the width of the plates.

95. In girders with flange plates it is preferred that no more than one-half the flange section be in the horizontal cover plates.

96. The ends of through girders shall be provided with cover plates. The shore ends shall be curved at the top to approved radius.

97. Web splice plates shall have at least two rows of rivets each side the splice.

TRUSSES.

Camber.

98. Truss spans shall be given a camber by so proportioning the length of the members that the stringers will be straight when the bridge is fully loaded.

Rigid Members.

99. Hip verticals and similar members, and the two end panels of the bottom chords of single track pin-connected trusses shall be rigid.

Eye-Bars.

100. The eye-bars composing a member shall be so arranged that adjacent bars shall not have their surfaces in contact; they shall be as nearly parallel to the axis of the truss as possible, the maximum inclination of any bar being limited to one inch in 16 ft.

Pony Trusses.

101. Pony trusses shall be riveted structures, with double webbed chords, and shall have all web members latticed or otherwise effectively stiffened.

102. Bottom chord end pins must project beyond the nuts or some suitable device provided by which the structure may be lifted by jacks.

103. All posts having the floor beams riveted between them must have their flanges turned in and have a diaphragm between the segments of the posts at the floor beam connection.

PART SECOND.—MATERIALS AND WORKMANSHIP.

V. MATERIAL.

Steel.

104. Steel shall be made by the open-hearth process.

Properties.

105. The chemical and physical properties shall conform to the following limits:

Elements Considered	Structural Steel	Rivet Steel	Steel Castings
Phosphorus, max. Basic	0.04 per cent.	0.04 per cent.	0.05 per cent.
Phosphorus, max. Acid	0.06 " "	0.04 per cent.	0.08 per cent.
Sulphur, maximum	0.05 " "	0.04 per cent.	0.05 per cent.
Ultimate tensile strength. Pounds, per square inch	Desired 60,000 1,500,000*	Desired 50,000 1,500,000	Not less than 65,000
Elong., min. %, in 5". Fig. 1	Ult. tensile str'gth 22	Ult. tensile str'gth	15 per cent.
" " " 2", " 2			
Charucture of fracture	Silky	Silky	Silky or fine granular
Cold Bends without Fracture	180° flat†	180° flat‡	90° $d=3t$

* See paragraph 115 † See paragraph 116, 117 and 118. ‡ See paragraph 119.

The yield point, as indicated by the drop of beam, shall be recorded in the test reports.

106. In order that the ultimate strength of full-sized annealed eye-bars may meet the requirements of paragraph 182, the ultimate strength in test specimens may be determined by the manufacturers; all other tests than those for ultimate strength shall conform to the above requirements.

Allowable Variations.

107. If the ultimate strength varies more than 4,000 lbs. from that desired, a retest shall be made on the same gauge, which, to be acceptable, shall be within 5,000 lbs. of the desired ultimate.

Chemical Analyses.

108. Chemical determination of the percentages of carbon, phosphorus, sulphur and manganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector. Check analyses shall be made from finished material, if called for by the Engineer, in which case an excess of 25 per cent. above the required limits will be permitted.

Specimens.

109. Plate, shape and bar specimens for tensile and bending tests shall be made by cutting coupons from the finished product, which shall have both faces rolled and both edges milled to the form shown by Fig. 1; or with both edges parallel; or they may be turned to a diameter of ¾-in. for a length of at least 9 in., with enlarged ends.

110. Rivet rods shall be tested as rolled.

111. Pin and roller specimens shall be cut from the finished rolled or forged bar, in such manner that the center of the specimen shall be one inch from the surface of the bar. The specimen for tensile test shall be turned to the form shown by Fig. 2. The specimen for bending test shall be one inch by ½-in. in section.

112. For steel castings the number of tests will depend on the character and importance of the castings. Specimens shall be cut cold from coupons molded and cast on some portion of one or more castings from each melt or from the sink heads, if the heads are of sufficient size. The coupon or sink head, so used, shall be annealed with the casting before it is cut off. Test specimens to be of the form prescribed for pins and rollers.

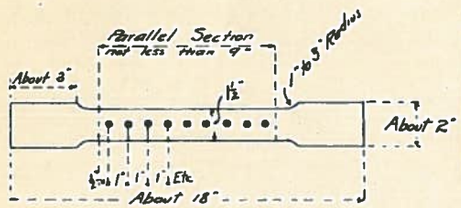


Fig. 1

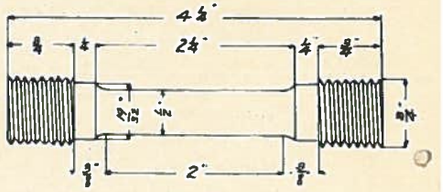


Fig. 2

Specimens of Rolled Steel.

113. Rolled steel shall be tested in the condition in which it comes from the rolls.

Number of Tests.

114. At least one tensile and one bending test shall be made from each melt of steel as rolled. In case steel differing ⅜-in. and more in thickness is rolled from one melt, a test shall be made from the thickest and thinnest material rolled.

Modification in Elongation

115. A deduction of 1 per cent. will be allowed from the specified percentage for elongation, for each ⅛-in. in thickness above ¾-in.

Bending Tests.

116. Bending tests may be made by pressure or by blows. Plates, shapes and bars less than one inch thick shall bend as called for in paragraph 105.

Thick Material.

117. Full-sized material for eye-bars and other steel one inch thick and over, tested as rolled, shall bend cold 180 degrees around a pin, the diameter of which is equal to twice the thickness of the bar, without fracture on the outside of bend.

Bending Angles.

118. Angles ¾-in. and less in thickness shall open flat, and angles ½-in. and less in thickness shall bend shut, cold, under blows of a hammer, without sign of fracture. This test shall be made only when required by the inspector.

Nicked Bends.

119. Rivet steel, when nicked and bent around a bar of the same diameter as the rivet rod, shall give a gradual break and a fine silky uniform fracture.

Finish.

120. Finished material shall be free from injurious seams, flaws, cracks, defective edges or other defects, and have a smooth, uniform and workmanlike finish. Plates 36 in. in width and under shall have rolled edges.

Melt Numbers.

121. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it. Steel for pins and rollers shall be stamped on the end. Rivet and lattice steel and other small parts may be bundled with the above marks on an attached metal tag.

Defective Material.

122. Material which, subsequent to the above tests at the mills, and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected at the shop and shall be replaced by the manufacturer at his own cost.

Variation in Weight.

123. A variation in cross-section or weight of each piece of steel of more than 2½ per cent. from that specified will be sufficient cause for rejection, except in case of sheared plates, which will be covered by the following permissible variations, which are to apply to single plates, when ordered to weight:

124. Plates 12½ lbs. per sq. ft. or heavier:

(a) Up to 100 in. wide, 2½ per cent. above or below the prescribed weight.

(b) One hundred inches wide and over, 5 per cent. above or below.

125. Plates under 12½ lbs. per sq. ft.:

(a) Up to 75 in. wide, 2½ per cent. above or below.

(b) Seventy-five inches and up to 100 in. wide, 5 per cent. above or 3 per cent. below.

(c) One hundred inches wide and over, 10 per cent. above or 3 per cent. below.

126. Plates when ordered to gauge will be accepted if they measure not more than 0.01 in. below the ordered thickness.

127. An excess over the nominal weight, corresponding to the dimensions on the order, will be allowed for each plate, if not more than that shown in the following table, one cu. in. of rolled steel being assumed to weigh 0.2833 lb.:

Thickness Ordered	Nominal Weights	Width of Plate			
		Up to 75"	75" and up to 100"	100" and up to 115"	Over 115"
¼-inch	10.20 lbs.	10 per cent.	14 per cent.	18 per cent.	.....
5/16 "	12.75 "	8 "	12 "	16 "	.....
⅜ "	15.30 "	7 "	10 "	13 "	17 per cent.
7/16 "	17.85 "	6 "	9 "	10 "	13 "
½ "	20.40 "	5 "	7 "	9 "	12 "
9/16 "	22.95 "	4½ "	6½ "	8½ "	11 "
⅝ "	25.50 "	4 "	6 "	8 "	10 "
Over ⅝ "	.....	3½ "	5 "	6½ "	9 "

Cast-Iron.

128. Except where chilled iron is specified, casting shall be made of tough gray iron, with sulphur not over 0.10 per cent. They shall be true to pattern, out of wind and free from flaws and excessive shrinkage. If tests are demanded, they shall be made on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar 1¼ in. in diameter and 15 in. long. The transverse test shall be made on a supported length of 12 in. with load at middle. The minimum breaking load so applied shall be 2,900 lbs., with a deflection of at least 1/10 in. before rupture.

Wrought-Iron.

129. Wrought iron shall be double-rolled, tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1, or in full-sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lbs. per sq. in., an elongation of at least 18 per cent. in 8 in., with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent. fibrous.

VI. INSPECTION AND TESTING AT THE MILLS.

Mill Orders.

130. The Railway Company shall be furnished complete copies of mill orders, and no material shall be rolled nor work done before the Engineer has been notified where the orders have been placed, so that he may arrange for the inspection.

Facilities for Inspection.

131. The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of all material at the mill where it is manufactured. He shall furnish a suitable testing machine for testing the specimens, as well as prepare the pieces for the machine, free of cost.

Access to Mills.

132. The Railway Company's inspector shall have full access, at all times, to all parts of the mills where material to be inspected by him is being manufactured.

VII. WORKMANSHIP.

General. 133. All parts forming a structure shall be built in accordance with approved drawings. The workmanship and finish shall be equal to the best practice in modern bridge works. Material arriving from the mills shall be protected from the weather and shall have clean surfaces before being worked in the shops.

Straightening. 134. Material shall be thoroughly straightened in the shop, by methods that will not injure it, before being laid off or worked in any way.

Finish. 135. Shearing and clipping shall be neatly done, and all parts of the work exposed to view, neatly finished. No sharp or unfilleted re-entrant corners will be allowed.

Size of Rivets. 136. The size of rivets, called for on the plans, shall be understood to mean the actual size of the cold rivet before heating.

Rivet Holes. 137. The diameter of the punch shall not be more than 1-16 in. greater than the diameter of the rivet, nor the diameter of the die more than ⅛ in. greater than the diameter of the punch.

Punching. 138. Punching shall be accurately done. Drifting to enlarge unfair holes will not be allowed. If the holes must be enlarged to admit the rivet, they shall be reamed. Poor matching of holes will be cause for rejection.

Thick Material. 139. Material ⅝-in. thick or more shall be sub-punched, and reamed or drilled from the solid.

Reaming. 140. When sub-punching and reaming are required, the punch used shall have a diameter not less than 3-16 in. smaller than the nominal diameter of the rivet. Holes shall then be reamed to a diameter not less than 1-16 in. larger than the nominal diameter of the rivet. Reaming shall be done with twist drills without using any lubricant. (See 155.)

141. The outside burrs on reamed holes shall be removed to the extent of making a 1/16-in. fillet.

Edge Planing 142. Sheared edges of all plates over ⅝-in. thick must be planed at least ⅛ in.

Assembling. 143. Riveted members shall have all parts well pinned up and firmly drawn together with bolts, before riveting is commenced. Contact surfaces to be painted. (See 172.)

Lattice Bars. 144. Lattice bars shall have neatly rounded ends, unless otherwise called for.

Web Stiffeners. 145. Stiffeners shall fit neatly between flanges of girders. Where tight fits are called for, the ends of the stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

SplicePlate and Fillers. 146. Web splice plates and fillers under stiffeners shall fit neatly.

Web Plates. 147. Web plates of girders and stringers which have no cover plates shall be flush with the backs of flange angles or project above not more than ⅛-in. unless otherwise called for. When web plates are spliced not more than ¼-in. clearance between ends of plates will be permitted.

Floor Beams and Stringers. 148. The main sections of floor beams and stringers shall be milled to exact length after riveting and the connection angles accurately set flush and true to the milled ends. In case milling of connection angles is necessary after riveting, the removal of more than 1/16 in. of their thickness will be cause for rejection.

Rivets. 149. Rivets shall have heads of approved shape, full and concentric with shank. Rivets made in worn dies and exhibiting any lips, fins or fillets on head or shank will be rejected.

Riveting. 150. Rivets shall be uniformly heated to a light cherry red heat in a gas or oil furnace so constructed that it can be adjusted to the proper temperature. They shall be driven by pressure tools wherever possible. Pneumatic hammers shall be used in preference to hand driving.

151. Rivets shall look neat and finished, with heads of approved shape, full and of equal size. They shall be central on shank and grip the assembled pieces firmly. Recupping and calking will not be allowed. Loose, burned or otherwise defective rivets shall be cut out and replaced. In cutting out rivets, great care shall be taken not to injure the adjacent metal. If necessary, they shall be drilled out.

Turned Bolts. 152. Wherever bolts are used in place of rivets which transmit shear, the holes shall be reamed parallel and the bolts shall make a driving fit, with the threads entirely outside of the holes. A washer not less than ¼-in. thick shall be used under nut.

Members to be Straight. 153. The several pieces forming one built member shall be straight and fit closely together, and finished members shall be free from twists, bends or open joints.

Finish of Joints. 154. Abutting joints shall be cut or dressed true and straight and fitted close together, especially where open to view. In compression joints, depending on contact bearing, the surfaces shall be truly faced, so as to have even bearings after they are riveted up complete and when perfectly aligned.

Field Connections. 155. Holes for floor beam and stringer connections shall be sub-punched and reamed according to paragraph 140, to a steel templet not less than one inch thick. If required, all other field connections, except those for laterals and sway bracing, shall be assembled in the shop and the unfair holes reamed; and when so reamed, the pieces shall be match-marked before being taken apart.

Eye Bars. 156. Eye-bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by upsetting, rolling or forging.

Welding will not be allowed. The form of heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the Engineer, but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck shall not vary more than 1/16-in. from that specified. (See 182.)

Boring Eye-Bars.

157. Before boring, each eye-bar shall be properly annealed and carefully straightened. Pin-holes shall be in the center line of bars and in the center of heads. Bars of the same length shall

Pin Holes.

be bored so accurately that, when placed together, pins 1/32-in. smaller in diameter than the pin-holes can be passed through the holes at both ends of the bars at the same time without forcing.

158. Pin-holes shall be bored true to gages, smooth and straight; at right angles to the axis of the member and parallel to each other, unless otherwise called for. The borings shall be done after the member is riveted up.

159. The distance center to center of pin-holes shall be correct within 1/32 in., and the diameter of the holes not more than 1/50 in. larger than that of the pin, for pins up to 5-in. diameter and 1/32 in. for larger pins.

Pins and Rollers.

160. Pins and rollers shall be accurately turned to gages and shall be straight and smooth and entirely free from flaws.

Screw Threads.

161. Screw threads shall make tight fits in the nuts and shall be U. S. Standard, except above the diameter of 1⅜-in., when they shall be made with six threads per inch.

Annealing.

162. Steel, except in minor details, which has been partially heated, shall be properly annealed.

Steel Castings.

163. Steel castings shall be free from large or injurious blowholes and shall be annealed.

Welds.

164. Welds in steel will not be allowed.

Bed Plates.

165. Expansion bed plates shall be planed true and smooth. Cast wall plates shall be planed top and bottom. The finishing cut of the planing tool shall be fine and correspond with the direction of expansion.

Pilot Nuts.

166. Pilot and driving nuts shall be furnished for each size of pin, in such numbers as may be ordered.

Field Rivets.

167. Field rivets shall be furnished to the amount of 15 per cent. plus ten rivets in excess of the nominal number required for each size.

Shipping Details.

168. Pins, nuts, bolts, rivets and other small details shall be boxed or crated.

Weight.

169. The scale weight of every piece and box shall be marked on it in plain figures.

Finished Weight.

170. Scale weights of the finished members, inclusive of lead bearing sheets, shall be the basis of payment for pound price contracts provided these weights do not exceed the weights as computed from the detailed drawings by more than 2 per cent.

in which case the computed weights, plus 2 per cent. shall be the basis of payment.

No allowance in weight will be made for paint applied after the member is weighed.

If required, the contractor shall furnish to the Railway Company certificate of accuracy of the scales from some reputable scale manufacturer.

VIII. SHOP PAINTING.

Cleaning.

171. No material shall be painted until accepted by the Inspector.

All metal work, except finished surfaces, before leaving the shop shall be *thoroughly* cleansed with wire brushes, etc., from all loose scale, rust, dirt, etc., and be given one good coating of pure boiled linseed oil, well worked into all joints and open spaces.

Contact Surfaces.

172. In riveted work, all surfaces coming in contact shall each be painted with pure red lead paint, mixed with pure linseed oil, before being riveted together.

Inaccessible Surfaces.

173. Pieces and parts which are not accessible for painting after erection, including tops of stringers, eye-bar heads, ends of posts and chords, etc., shall have an additional coat of pure red lead paint mixed with pure linseed oil before leaving the shop.

Condition of Surfaces.

174. Painting shall be done only when the surface of the metal is perfectly dry. It shall not be done in wet or freezing weather, unless protected under cover.

Machine-Finished Surfaces.

175. Machine-finished surfaces shall be coated with white lead and tallow before shipment or before being put out into the open air.

IX. INSPECTION AND TESTING AT THE SHOPS.

Facilities for Inspection.

176. The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of workmanship at the shop where material is manufactured. He shall furnish a suitable testing machine for testing full-sized members, if required.

Starting Work.

177. The Railway Company shall be notified well in advance of the start of the work in the shop, in order that it may have an inspector on hand to inspect material and workmanship.

Access to Shop.

178. The Railway Company's inspector shall have full access, at all times, to all parts of the shop where material under his inspection is being manufactured.

Accepting Material.

179. The inspector shall stamp each piece accepted with a private mark. Any piece not so marked may be rejected at any time and at any stage of the work. If the inspector, through an oversight or otherwise, has accepted material or work which

is defective or contrary to the specifications, this material, no matter in what stage of completion, may be rejected by the Railway Company.

Shipping Invoices.

180. Three copies of all shipping invoices shall be furnished to the Railway Company with each shipment. These shall show the scale weights of the individual pieces.

X. FULL-SIZED TESTS.

Eye-Bar Tests.

181. Full-sized tests on eye-bars and similar members, to prove the workmanship, shall be made at the manufacturer's expense, and shall be paid for by the Railway Company at contract price, if the tests are satisfactory. If the tests are not satisfactory, the members represented by them will be rejected.

182. In eye-bar tests, the minimum ultimate strength shall be 55,000 lbs. per sq. in. The elongation in 10 ft., including fracture, shall be not less than 15 per cent. Bars shall break in the body and the fracture shall be silky or fine granular, and the elastic limit as indicated by the drop of the mercury shall be recorded.

XI. ERECTION.

Work Included.

183. The work of erection shall include the furnishing of all labor, tools, equipment and materials, other than those which enter into the permanent structure, the removal of the old bridge, if any, and the construction of the new superstructure ready for the floor, all in accordance with the plans and specifications, except painting.

Delivery of Material.

184. Unless stated otherwise, when inviting bids, it is understood that the Railway Company will furnish switching service free of charge from the nearest station to the site of the work for all steel work, erection outfit, etc.

The erector must receive the material, unload same and release cars promptly upon their delivery, or he will be required to pay regular demurrage charges.

Erection Methods.

185. The method of erection, except where local conditions justify a special scheme, will generally be at the discretion of the erector, subject to the approval of the Engineer.

Where conditions justify a special scheme, the requirements will be clearly stated or shown on plans.

Plans.

186. Bridges shall be erected in accordance with approved plans of the falsework and permanent structure. Approval of contractor's plans shall not be considered as relieving the contractor of any responsibility.

Conducting the Work.

187. Erection shall not be started until sufficient material has been delivered to enable the work to proceed continuously,

nor until the erector has been authorized to proceed. It shall be conducted with a force of men and plant sufficient for speedy completion and in such manner as to be at all times subordinate to the unobstructed use of the tracks of the Railway Company, and so as not to interfere with other work in progress, or close any thoroughfare by land or water, except under proper authority.

Traffic and work must be protected by flagmen whenever necessary, and competent watchmen shall guard the work and materials against injury. All laws and ordinances applying to the work shall be complied with, the necessary permits obtained, and lights provided to protect work at night.

Engine Service.

188. When engine or work train service is desired by the contractor, he shall give the proper railway officials at least 24 hours' advance notice, and the Railway Company will furnish the service according to conditions stated as promptly as possible, consistent with railway operations. When derrick cars are used on main tracks, their movements shall be in charge of a regular train crew.

Transportation.

189. No free transportation of equipment, materials or men will be allowed unless stated otherwise.

Masonry Finish.

190. The Railway Company will finish all masonry to correct lines and elevations, and unless otherwise stated will make all changes in old masonry without unnecessarily impeding the operations of erection. The Engineer will establish lines and elevations, but the erector shall compare the elevations, distances, etc., shown on plans, with the masonry as actually constructed, so far as practicable with spirit levels and steel tapes, before he assembles the steel. In case of discrepancy he shall immediately notify the Engineer.

Handling and Storing Materials.

191. Cars containing materials or plant shall be promptly released upon delivery. Material shall be placed on skids above the ground, laid so as not to hold water and stored and handled in such a manner as not to be injured and not interfere with railway operations. The expense of repairing or replacing material injured in handling by contractors shall be charged to the contractors. Material when being unloaded and stored shall be compared with the shipping list, and any shortage or injury discovered shall be promptly reported.

Temporary Structures.

192. The temporary structures for use during erection and for maintaining the traffic shall be properly designed and substantially constructed for the loads which will come upon them. All bents shall be thoroughly braced transversely, and held against longitudinal movement by diagonal bracing or lines of struts extending from face to face of piers or other approved anchorages. The bents shall be well secured against settling, and piles driven wherever firm bottom can not be obtained by wedging down the bents.

Temporary falsework placed by the Railway Company under

an old structure or for carrying traffic over a new opening may be used by the erector during erection, provided it is not unnecessarily cut and wasted.

Maintenance of Traffic.

193. When traffic is maintained by the Railway Company's forces, any changes in structures carrying the traffic, required for the purpose of facilitating erection by contract, shall be made by the contractor, under the supervision of the Engineer.

Old Structures.

194. Metal work in old structures shall be dismantled without any unnecessary damage and loaded on cars or neatly stored at the site, immediately adjacent to the tracks and at a convenient grade for future handling, as may be directed. When a structure is to be used elsewhere, all parts shall be match-marked in accordance with diagram to be furnished by the Engineer, and when the old bridge is composed of several spans, the parts of each shall be kept separate. Any unnecessary damage to old material shall be paid for by the contractor. All trestle work placed under the old bridge for support shall be considered part of the old structure.

Steel Work.

195. All steel work shall be adjusted to correct position and true to lines before being permanently connected, threads of pins protected by pilot and driving nuts, and wherever permanent bolts are used, the nuts effectively locked by checking the threads. Moderate drifting will be permitted in order to draw parts together, but not for the purpose of matching unfair holes. Such holes shall be reamed or drilled.

All splices and field connections shall be securely bolted before riveting, and such important connections as tension splices shall be fully riveted when the parts are required to carry traffic; when not to carry traffic, at least 50 per cent. of the holes shall have bolts. Rivets in splices of compression members with faced ends shall not be driven until the members have been subjected to the full dead load stresses.

Rivets shall be uniformly heated to a light cherry red color, and when driven shall completely fill the holes and be tight. The heads shall be full and uniform in size, concentric, free from fins, in full contact with metal and be painted immediately after inspection and acceptance. Rivets shall be inspected immediately after being driven, and those rejected shall be cut out and replaced without delay.

Shop Errors.

196. Minor misfits which require a reasonable amount of reaming, cutting and chipping in order to permit accurate assembling shall be considered a legitimate part of erection. Errors in general dimensions and misfits or holes so badly matched as to require drilling or cutting apart of metal work cause extra work properly chargeable to the manufacturer. Such errors shall be reported to the Engineer as soon as discovered and corrections made during the presence of the inspector who shall check the time required. All extra work ordered will be paid

for at actual cost to the contractor for labor and materials, plus 15 per cent. for use of tools and supervision.

Anchor Bolts.

197. Holes for anchor bolts, except where bolts are built into the masonry, shall be drilled by the erector and set in Portland cement grout after the span is in place.

Bed Plates.

198. Bed plates shall be set level in exact position and have a full and even bearing over their entire surface, a lead plate being used for this purpose, unless the use of rust joints is indicated on the plans.

Clearing Site.

199. Upon completion of the steel work all surplus material, debris and temporary structures shall be removed and the premises left in a neat condition. The material from temporary structures, if the property of the Railway Company, shall be neatly stored near the site or loaded on cars, as may be directed.

Workmanship.

200. All work done and materials furnished shall be of good quality.

Inspection.

201. The work of erection shall at all times be subject to the inspection and acceptance of the Engineer or his representative on the ground.

Responsibility.

202. When work is done under contract, the contractor shall assume all responsibility for loss or damage to his own work, materials or plant, due to any cause whatsoever; also for all loss or damage to the Railroad Company's materials or property and to the property of other parties caused by the acts or omissions of the contractor, his agents or employees.

The contractor shall assume all risks and bear any losses incident to the work occasioned by flood, accident, fire or other cause, until the structure is completed and accepted by the Railway Company.

He shall assume all responsibility for injury to the workmen or the public or to any individual, and in case of accident or suit he shall defend the suit in person, and relieve the Railway Company from all costs and expenses, and pay any judgments that may be recovered thereon.

He shall comply with the local or Government laws or ordinances controlling or limiting the manner of doing the work and shall take such precautions as may be necessary to protect life and property.

TABLE No. 1.

Maximum Moments M, Endshears S, and Floor Beam Reactions R **per one rail** produced by Cooper's E60 Loading on Spans from 10 to 125 feet.

Span	Max. Mom.	Max. Endshears	Max. Flr. Bm. Reac.	Equivalent Uniform Load.		
L	M	S	R	M	S	R
in ft.	in ft. lbs.	in lbs.	in lbs.			
10	84400	45000	60000	6750	9000	6000
11	98600	49100	65500	6520	8930	5950
12	120000	52500	70000	6670	8750	5830
13	142500	55400	73900	6750	8510	5685
14	165000	57900	78200	6740	8270	5590
15	187500	60000	82000	6670	8000	5470
16	210000	63800	85300	6560	7970	5330
17	232500	67100	88200	6440	7900	5190
18	255000	70100	91000	6300	7780	5055
19	279900	72600	94400	6200	7640	4965
20	309400	75000	98300	6190	7500	4920
21	339000	77100	102000	6150	7340	4860
22	368600	79100	105200	6090	7190	4785
23	398100	80900	108200	6020	7030	4700
24	427800	83100	111000	5940	6920	4630
25	457500	85200	113500	5860	6820	4540
26	487200	87100	116600	5770	6700	4480
27	516900	88900	120100	5670	6580	4450
28	548300	90600	123500	5600	6470	4410
29	581900	92300	126500	5530	6370	4365
30	615800	94600	129400	5475	6310	4310
31	649300	96600	132700	5410	6230	4280
32	683100	98600	136500	5340	6165	4270
33	716700	100400	140000	5265	6080	4245
34	750500	102100	143300	5190	6010	4215
35	784500	103800	146400	5130	5930	4180
36	822800	105800	.....	5080	5880	.....
37	861400	107900	.....	5030	5830	.....
38	900000	109700	.....	4990	5775	.....
39	940100	111500	Viaduct span.	4940	5715	.....
40	983300	113100	30′-60′	4920	5655	.....
42	1070000	117200	179200	4860	5595	.....
44	1157000	120800	Viaduct span.	4780	5490	.....
46	1244000	124200	40′-60′	4710	5400	.....
48	1332000	127200	197200	4630	5300	.....
50	1427000	130700	.....	4570	5230	.....
52	1523000	133900	.....	4510	5150	.....
54	1622000	136800	.....	4450	5070	.....

Span	Max. Mom.	Max. Endshears	Max. Flr. Bm. Reac.	Equivalent Uniform Load.		
L	M	S	R	M	S	R
in ft.	in ft. lbs.	in lbs.	in lbs.			
56	1728000	140000	.....	4410	4980	.....
58	1835000	143100	.....	4365	4935	.....
60	1949000	146400	.....	4335	4880	.....
62	2065000	150200	.....	4300	4845	.....
64	2183000	153900	.....	4270	4810	.....
66	2309000	157500	.....	4245	4770	.....
68	2435000	161700	.....	4210	4755	.....
70	2561000	165800	.....	4185	4730	.....
72	2688000	170000	.....	4155	4725	.....
74	2819000	174500	.....	4120	4720	.....
76	2957000	178600	.....	4100	4700	.....
78	3097000	182600	.....	4070	4680	.....
80	3241000	186300	.....	4050	4660	.....
82	3385000	190400	.....	4030	4640	.....
84	3535000	194300	.....	4000	4640	.....
86	3689000	198200	.....	3990	4610	.....
88	3846000	202100	.....	3975	4590	.....
90	4006000	205900	.....	3960	4575	.....
92	4164000	209700	.....	3940	4560	.....
94	4328000	213500	.....	3920	4545	.....
96	4491000	217200	.....	3900	4520	.....
98	4660000	221300	.....	3885	4515	.....
100	4830000	225000	.....	3860	4500	.....
105	5306000	234200	.....	3860	4460	.....
110	5831000	243000	.....	3855	4420	.....
115	6368000	251900	.....	3855	4380	.....
120	6921000	260600	.....	3850	4340	.....
125	7495000	269100	.....	3840	4300	.....

TABLE No. 2.

COEFFICIENT OF IMPACT.

L	$\frac{300}{L+300}$	L	$\frac{300}{L+300}$	L	$\frac{300}{L+300}$	L	$\frac{300}{L+300}$
5	0.984	38	0.888	70	0.811	110	0.732
6	0.980	39	0.885	71	0.809	115	0.723
7	0.977	40	0.882	72	0.806	120	0.714
8	0.974	41	0.880	73	0.804	125	0.706
9	0.971	42	0.877	74	0.802	130	0.698
10	0.968	43	0.875	75	0.800	135	0.690
11	0.965	44	0.872	76	0.798	140	0.682
12	0.962	45	0.870	77	0.796	145	0.674
13	0.958	46	0.867	78	0.794	150	0.667
14	0.955	47	0.865	79	0.792	155	0.659
15	0.952	48	0.862	80	0.789	160	0.652
16	0.949	49	0.860	81	0.787	165	0.645
17	0.946	50	0.857	82	0.785	170	0.638
18	0.943	51	0.855	83	0.783	175	0.632
19	0.940	52	0.852	84	0.781	180	0.625
20	0.937	53	0.850	85	0.779	185	0.619
21	0.935	54	0.847	86	0.777	190	0.612
22	0.932	55	0.845	87	0.775	195	0.606
23	0.929	56	0.843	88	0.773	200	0.600
24	0.926	57	0.840	89	0.771	210	0.588
25	0.923	58	0.838	90	0.769	220	0.577
26	0.920	59	0.836	91	0.767	230	0.566
27	0.917	60	0.833	92	0.765	240	0.556
28	0.915	61	0.831	93	0.763	250	0.546
29	0.912	62	0.829	94	0.761	260	0.536
30	0.909	63	0.826	95	0.759	270	0.526
31	0.906	64	0.824	96	0.758	280	0.517
32	0.904	65	0.822	97	0.756	290	0.508
33	0.901	66	0.820	98	0.754	300	0.500
34	0.898	67	0.817	99	0.752	400	0.429
35	0.896	68	0.815	100	0.750	500	0.375
36	0.893	69	0.813	105	0.741	600	0.333
37	0.890						

TABLE No. 3.

SHEARING AND BEARING VALUE OF RIVETS.

ALL DIMENSIONS IN INCHES.

Diameter of Rivet.	Single Shear at 12000 lbs. at 10000 lbs.	Dbl. Shear at 12000 lbs. at 10000 lbs.	Bearing Value for Different Thicknesses of Plate at { 24000 Lbs. / 20000 Lbs. } Per Sq. Inch. { Shop Rivets. / Field Rivets. }											
			1/4"	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"
1/2 in.	2360 1960	4720 3920	3000 2500	3756 3130	4500 3750	5256 4380	6000 5000								
5/8 in.	3680 3070	7360 6140	3756 3130	4692 3910	5628 4690	6564 5470	7500 6250	8436 7030	9372 7810						
3/4 in.	5300 4420	10600 8840	4500 3750	5628 4690	6756 5630	7872 6560	9000 7500	10128 8440	11256 9380	12372 10310	13500 11250				
7/8 in.	7220 6010	14440 12020	5256 4380	6564 5470	7884 6570	9192 7660	10500 8750	11808 9840	13128 10940	14436 12030	15756 13130	17064 14220	18372 15310	19692 16410	
1 in.	9430 7850	18860 15700	6000 5000	7500 6250	9000 7500	10500 8750	12000 10000	13500 11250	15000 12500	16500 13750	18000 15000	19500 16250	21000 17500	22500 18750	24000 20000

NOTE.—Upper Figures are for Shop Rivets—Lower Figures for Field Rivets.

TABLE No. 4.

ALLOWABLE UNIT STRESSES IN COLUMNS.

(Pounds per square inch)

For various ratios of length to least radius of gyration.
$16{,}000 - 70 \frac{L}{R}$ (with a maximum of 14,000 lbs. per sq. in.)
L = length in inches.
R = least radius of gyration.

$\frac{L}{R}$		$\frac{L}{R}$		$\frac{L}{R}$		$\frac{L}{R}$	
10	14000	38	13340	66	11380	94	9420
11	14000	39	13270	67	11310	95	9350
12	14000	40	13200	68	11240	96	9280
13	14000	41	13130	69	11170	97	9210
14	14000	42	13060	70	11100	98	9140
15	14000	43	12990	71	11030	99	9070
16	14000	44	12920	72	10960	100	9000
17	14000	45	12850	73	10890	101	8930
18	14000	46	12780	74	10820	102	8860
19	14000	47	12710	75	10750	103	8790
20	14000	48	12640	76	10680	104	8720
21	14000	49	12570	77	10610	105	8650
22	14000	50	12500	78	10540	106	8580
23	14000	51	12430	79	10470	107	8510
24	14000	52	12360	80	10400	108	8440
25	14000	53	12290	81	10330	109	8370
26	14000	54	12220	82	10260	110	8300
27	14000	55	12150	83	10190	111	8230
28	14000	56	12080	84	10120	112	8160
29	13970	57	12010	85	10050	113	8090
30	13900	58	11940	86	9980	114	8020
31	13830	59	11870	87	9910	115	7950
32	13760	60	11800	88	9840	116	7880
33	13690	61	11730	89	9770	117	7810
34	13620	62	11660	90	9700	118	7740
35	13550	63	11590	91	9630	119	7670
36	13480	64	11520	92	9560	120	7600
37	13410	65	11450	93	9490		