(=)

General Specifications for Steel Railroad Bridges and Viaducts

By THEODORE COOPER.

SIXTH EDITIONS

1901.

General Description.

1. All the structures shall be of wrought steel, as specified. (§§ 128-141)

Cast iron or cast steel may be used in the machinery of movable bridges and in special cases for bedplates.

Kind of Girders

2. The following kinds of girders shall preferably be employed:

Spans, up to 20 feet....Rolled beams, or longitudinal trough floors.
„ 20 to 75 „ ....Riveted plate girders.
„ 75 to 120 „ ....Riveted plate or lattice girders.
„ 120 to 150 „ ....Lattice or pin-connected trusses.
„ over 150 „ ....Pin-connected trusses.

Generally "double track through" bridges will have but two trusses, to avoid spreading the tracks at bridges.

Length of Span.

In calculating strains the length of span shall be understood to be the distance between centres of end pins for trusses, and between centres of bearing plates for all beams and girders.

Spacing of Girders.

3. The girders shall be spaced, with reference to the axis of the bridge, as required by local circumstances, and directed by the Engineer of the Railroad Company. (§ 5.) Longitudinal floor girders shall in no case be less than three feet and three inches from centre line of tracks for single track bridges, or one-half standard distance centre to centre of tracks for double track bridges. (§§ 6.)

Head-room

4. For all through bridges and overhead structures there shall be a clear head-room of 21 feet above the base of the rails, for a width of six feet over each track.

Clear Width

5. In all through bridges the clear width from the centre of the track to any part of the trusses shall not be less than seven (7) feet at a height exceeding one foot above the rails where the tracks are straight, and an equivalent clearance, where the tracks are curved.

(The additional clearance required on curves for passenger cars, 54 feet c. to c. of tracks and 75 feet over all, will be as follows:

For curvature, 0.8 D inches on each side;
1.6 D inches between tracks,
where D equals degree of curve.

For elevation, the clearance of top of the car on inside of curve must be increased $2\frac{1}{2}$ inches for each inch of track elevation.

6. The standard distance, centre to centre of tracks on straight lines, will be ..... feet for .... R.R.

Trestle Towers

7. Each trestle bent shall, as a general rule, be composed of two supporting columns, and the bents united in pairs to form towers; each tower thus formed of four columns shall be thoroughly braced in both directions, and have struts between the feet of the columns. Transversely the columns shall have a batter of not less than one horizontal to six vertical for single track, and one horizontal to eight vertical for double track. The feet of the columns must be secured to an anchorage capable of resisting double the specified wind forces. (§§ 25, 27)

8. Each tower shall have sufficient base, longitudinally, to be stable when standing alone, without other support than its anchorage. (§§ 25, 27)

Trestle Spans.

9. Tower spans for high trestles shall not be less than 30 feet.

Form of Trusses.

10. Unless otherwise specified, the form of bridge trusses may be selected by the bidder; for through bridges, the end vertical suspenders and two panels of the lower chord, at each end, will be made rigid members. In general, all spans shall have end floor beams for supporting the stringers; such end floor beams may have one intermediate bearing on the masonry. In through bridges, the floor beams shall be riveted to the posts, above or below the pins.

Lateral Bracing

11. All lateral, sway and portal bracing must be made of shapes capable of resisting compression as well as tension, and must have riveted connections.

Wooden Floor.

12. The wooden floors will consist of transverse ties or floor timbers; their scantling will vary in accordance with the design of the supporting steel floor. (§ 15.) They shall be spaced with openings not exceeding six inches, and shall be notched down $\frac{1}{2}$ inch and be secured to the supporting girders by $\frac{3}{4}$ inch bolts at distances not over six feet apart. For deck bridges the ties will extend the full width of the bridge, and for through bridges at least every other tie shall extend the full width of bridge for a footwalk.

Guard Timbers.

13. There shall be a guard timber (scantling not less than $6\times8''$ on each side of each track, with its inner face parallel to and at .... feet .... inches from centre of track. Guard timbers must be notched one inch over every floor timber, and be spliced over a floor timber with a half-and-half joint of six inches lap. Each guard timber shall be fastened to every third floor timber and at each splice with a three-quarter ($\frac{3}{4}$) inch bolt. All heads or nuts on upper faces of ties or guards must be countersunk below the surface of the wood. (§ 61.)

14. The guard and floor timbers must be continuous over all piers and abutments.

15. The maximum strain allowed upon the extreme fibre of the best yellow pine or white oak floor timbers will be 1,000 pounds per square inch. The weight of a single engine wheel may be assumed as distributed over three ties, spaced as per § 12.

16. The floor timbers from centre to each end of span must be notched down over the longitudinal girders so as to reduce the camber in the track, as directed by the Engineer.

17. All the floor timbers shall have a full and even bearing upon the stringers; no open joints or shims will be allowed.

18. On curves the outer rail must be elevated, as may be directed by the Engineer.

19. In comparing different proposals, the relative cost to the Railroad Company of the required masonry or changes in existing work will be taken into consideration. Proposals.

20. Contractors in submitting proposals shall furnish complete strain sheets, general plans of the proposed structures, and such detail drawings as will clearly show the dimensions of all the parts, modes of construction and the sectional areas.

21. Upon the acceptance of the proposal and the execution of contract, all working drawings required by the Engineer must be furnished free of cost.

22. No work shall be commenced or materials ordered until the working drawings are approved by the Engineer in writing; if such working drawings are detained more than one week for examination, the Contractor will be allowed an equivalent extension of time. Approval of Plans.

Loads.

23. All the structures shall be proportioned to carry the following loads:

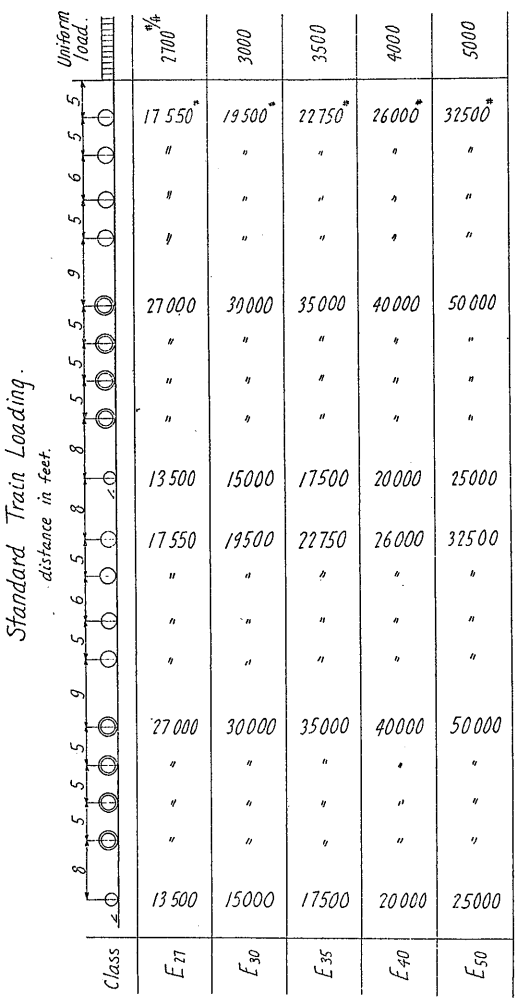
1st. The weight of metal in the structure and floor.

2nd. The weight of rails, fastenings, ties, guards, footwalk and ballast when used. The rails and fastenings being assumed at 100 pounds per foot of track; timber at 4½ pounds per foot B.M.; and ballast at 110 pounds per cubic foot. Minimum will be assumed at 400 pounds per foot of track. Dead Load.

These two items, taken together, shall constitute the "dead load."

3rd. A "live load" on each track, supposed to be moving in either direction, consisting of two "consolidation" engines, coupled and followed by a train load, distributed as shown on diagram E .....; or a special load equally distributed on two pairs of driving wheels, spaced six feet, centre to centre, of 100,000 pounds up to class E40; and of 120,000 pounds for all classes above E40. Live Loads.

Note.—As all the wheel loads in each diagram are made of the same



percentages of the driving wheel loads, the strains due to the different engine diagrams will be proportionate to the numerical classes of the engines.

Any intermediate numbers may be selected, with the understanding that this rule of proportion applies.

The maximum strains due to all positions of either of the above "live loads," of the required class, and of the "dead loads," shall be taken to proportion all the parts of the structure.

Wind Bracing.

24. To provide for wind strains and vibrations from high speed trains, the top lateral bracing in deck bridges, and the bottom lateral bracing in through bridges, shall be proportional to resist a lateral force of 600 pounds for each foot of the span; 450 pounds of this to be treated as a moving load, and as acting on a train of cars, at a line 6 feet above base of rail.

The bottom lateral bracing in deck bridges, and the top lateral bracing in through bridges, shall be proportioned to resist a lateral force of 150 pounds for each lineal foot for spans up to 300 feet, and 10 pounds additional for each additional 30 feet.

25. In trestle towers the bracing and columns shall be proportioned to resist the following lateral forces, in addition to the strains from dead and live loads:

1st. With either one track loaded with cars only, or with both tracks loaded with maximum train load, the lateral forces specified in § 24; and a lateral force of 100 pounds for each vertical lineal foot of the trestle bents; or 2d. With both tracks unloaded, a lateral force of 500 pounds for each longitudinal lineal foot of the structure, acting at the centre line of the girders; and a lateral force of 200 pounds for each vertical lineal foot of the trestle bents.

26. For determining the requisite anchorage for a loaded structure, the train shall be assumed to weigh 800 pounds per lineal foot.

Longitudinal Forces.

27. The strains produced in the bracing of the trestle towers, in any

members of the trusses or in the attachments of the girders or trusses to their bearings, by the greatest tractive force of the engines or by suddenly stopping the maximum trains on any part of the work must be provided for; the coefficient of friction of the wheels on the rails being assumed as 0.20.

28. Variation in temperature, to the extend of 150 degrees, shall be provided for. Temperature.

29. When the structures are on curves, the additional effects due to the centrifugal force of trains shall be considered as a live load. It will be assumed to act 5 feet above base of rail, and will be computed for a speed of 60-3 D miles per hour; D being the degree of curve. Centrifugal Force.

30. All parts shall be so designed that the strains coming upon them can be accurately calculated.

Proportion of Parts.

31. All parts of the structures shall be proportioned in tension by the following allowed unit strains: Tensile Strain.

For Medium Steel	Pound per square inch	
Floor beam hangers, and other similar members liable to sudden loading, net section	6,000	Medium Steel.
Longitudinal, lateral and sway bracing, for wind strains (§§ 8, 24, 25.)	18,000	
Longitudinal, lateral and sway bracing, for live load strains (§§ 27, 29, 105)	12,000	
Solid rolled beams, used as cross floor beams and stringers	10,000	
Bottom flanges of riveted cross girders, net section	10,000	
Bottom flanges of riveted longitudinal plate girders, used as track stringers, net section	10,000	

	For live loads.	For dead loads.
Bottom chords, main diagonals, counters and long verticals	10,000	20,000

For swing bridges and other movable structures, the dead load unit strains, during motion, must not exceed three-fourths of the above allowed unit strains for dead load on stationary structures.

The areas obtained by dividing the live load strains by the live load unit strains will be added algebraically to the areas obtained by dividing the dead load strains by the dead load unit strains to determine the required sectional area of any member. (§ 47.)

Soft Steel may be used in tension with unit strains ten per cent. less than those allowed for Medium Steel. Soft Steel.

32. Angles subject to direct tension must be connected by both legs, or the section of one leg only will be considered as effective.

33. In members subject to tensile strains full allowance shall be made for reduction of section by rivet-holes, screw-threads, etc. (§ 60.) Net Section.

34. Compression members shall be proportioned by the following allowed unit strains. Compressive Strains.

For Medium Steel.

Chord segments	$P=10{,}000-45\frac{1}{r}$	for live load strains.
	$P=20{,}000-90\frac{1}{r}$	for dead load strains.
All posts of through bridges	$P=8{,}500-45\frac{1}{r}$	for live load strains.
	$P=17{,}000-90\frac{1}{r}$	for dead load strains.
All posts of deck bridges and trestles.	$P=9{,}000-40\frac{1}{r}$	for live load strains.
	$P=18{,}000-80\frac{1}{r}$	for dead load strains.

End posts are not to be considered chord segments.

Lateral struts and rigid bracing.	$P=13{,}000-60\frac{1}{r}$	for wind strains;

for live load strains use two-thirds of the above. (§§ 27, 29, 105.)

P=the allowed strain in compression per square inch of cross-section, in pounds.

1=the length of compression member, in inches, C. to C., of connections.

r=the least radius of gyration of the section, in inches.

No compression member, however, shall have a length exceeding 100 times its least radius of gyration for main members, or 120 times for laterals.

Soft Steel may be used in compression with unit strains fifteen per cent. less than those allowed for Medium Steel. Soft Steel.

For swing bridges and other movable structures, the dead load unit strains during motion must not exceed $\frac{3}{4}$ of the above allowed unit strains for dead load on stationary structures.

35. For long span bridges, when the ratio of the length and width of span is such that it makes the top chords acting as a whole, a longer column than the segments of the chord, the chord will be proportioned for this greater length.

36. All members and their connections subject to alternate strains of tension and compression shall be proportioned to resist each kind of strain. Both of the strains shall, however, be considered as increased by an amount equal to $\frac{8}{10}$ of the least of the two strains, for determining the sectional areas by the above-allowed unit strains. (§§ 31, 34.) Alternate Strains.

37. The strains in the truss members or trestle posts from the assumed wind forces need not be considered except as follows: Effect of Wind on Chord Strains.

1st. When the wind strains on any member exceed 30 per cent. of the maximum strains due to the dead and live loads upon the same member.

The section shall then be increased until the total strain per square inch will not exceed by more than 30 per cent. the maximum fixed for dead and live load only.

2d. When the wind strain alone or in combination with a possible temperature strain, can neutralize or reverse the strains in any member.

38. The rivets in all members, other than those of the floor and lateral systems, must be so spaced that the shearing strain per square inch shall not exceed 9,000 pounds; nor the pressure on the bearing surface (diameter x thickness of the piece) of the rivet-hole exceed 15,000 pounds per square inch. Rivets, Bolts and Pins.

The rivets in all members of the floor system, including all hanger connections, must be so spaced that the shearing strains and bearing pressures shall not exceed 80 per cent. of the above limits.

The rivets in the lateral and sway bracing will be allowed 50 per cent. increase upon the above limits for lateral forces as per §§ 24, 25, but not per §§ 27, 29.

In the case of field riveting (and for bolts as per § 61) the above-allowed shearing strains and pressures shall be reduced one-third.

Rivets and bolts must not be used in direct tension.

39. Pins shall be proportioned so that the shearing strain shall not exceed 9,000 pounds per square inch; nor the pressure on the bearing surface of any member (other than forged eye-bars, see § 85) connected to the pin be greater per square inch than 15,000 pounds; nor the bending strain exceed 18,000 pounds, when the applied forces are considered as uniformly distributed over the middle half of the bearing of each member.

40. When any member is subjected to the action of both axial and bending strains, as in the case of end posts of through bridges (§ 37), or of chords carrying distributed floor loads, it must be proportioned so that the greatest fibre strain will not exceed the allowed limits of tension or compression on that member.

If the fibre strain resulting from the weight only, of any member, exceeds ten per cent. of the allowed unit strain on such member, such excess must be considered in proportioning the areas.

41. In beams and plate girders the compression flanges shall be made of same gross section as the tension flanges. Compression Flanges.

42. Riveted longitudinal girders shall have, preferably, a depth not less than $\frac{1}{10}$ of the span. Depth of Girders.

Rolled beams used as longitudinal girders shall have, preferably, a depth

not less than $\frac{1}{12}$ of the span.

Plate Girders, etc.

43. Plate girders shall be proportioned upon the supposition that the bending or chord strains are resisted entirely by the upper and lower flanges, and that the shearing or web strains are resisted entirely by the web-plate; no part of the web-plate shall be estimated as flange area.

The distance between centres of gravity of the flange areas will be considered as the effective depth of all girders.

Web Plates.

44. The webs of plate girders must be stiffened at intervals, not exceeding the depth of the girders or a maximum of 5 feet, wherever the shearing strain per square inch exceeds the strain allowed by the following formula:

$$\text{Allowed shearing strain} = 10{,}000 - 75\,H,$$

where H = ratio of depth of web to its thickness; but no web-plates shall be less than three-eighths of an inch in thickness.

Stiffeners.

45. All stiffeners must be capable of carrying the maximum vertical shear without exceeding the allowed unit strain.

$$P = 10{,}000 - 45\frac{1}{r}$$

Each stiffener must connect to the webs by enough rivets to transfer the maximum shear to or from the webs.

Rolled Beams.

46. Rolled beams shall be proportioned (§§ 31, 41) by their moments of inertia.

Counters.

47. The areas of counters shall be determined by taking the difference in areas due to the live and dead load strains considered separately (§ 31); the counters in any one panel must have a combined sectional area of at least three square inches, or else must be capable of carrying all the counter live load in that panel. (§ 86.)

48. Counters shall be provided and proportioned, so that a future increase of 25 per cent. in the specified live load shall not in any case increase the allowed unit strain more than 25 per cent.

Details of Construction.

Details.

49. All the connections and details of the several parts of the structures shall be of such strength that, upon testing, rupture will occur in the body of the members rather than in any of their details or connections.

50. Preference will be had for such details as shall be most accessible for inspection, cleaning and painting; no closed sections will be allowed.

Riveting.

51. The pitch of Rivets in all classes of work shall never exceed 6 inches, or sixteen times the thinnest outside plate, nor be less than three diameters of the rivet.

52. The rivets used shall generally be $\frac{3}{4}$ and $\frac{1}{8}$ inch diameter.

53. The distance between the edge of any piece and the centre of a rivet-

hole must never be less than $1\frac{1}{4}$ inches, except for bars less than $2\frac{1}{2}$ inches wide; when practicable it shall be at least two diameters of the rivet.

54. For punching, the diameter of the die shall in no case exceed the diameter of the punch by more than $\frac{1}{16}$ of an inch, and all holes must be clean cuts without torn or ragged edges.

55. All rivet holes must be so accurately spaced and punched that when the several parts forming one member are assembled together, a rivet $\frac{1}{16}$ inch less in diameter than the hole can generally be entered, hot, into any hole, without reaming or straining the metal by "drifts"; occasional variations must be corrected by reaming.

56. The rivets when driven must completely fill the holes. The rivet-heads must be round and of a uniform size for the same sized rivets throughout the work. They must be full and neatly made, and be concentric to the rivet-hole, and thoroughly pinch the connected pieces together.

57. Wherever possible, all rivets must be machine driven. The machines must be capable of retaining the applied pressure after the upsetting is completed. No hand-driven rivets exceeding $\frac{1}{8}$ inch diameter will be allowed.

58. Field riveting must be reduced to a minimum or entirely avoided, where possible.

59. All holes for field rivets, except those in connections of the lateral and sway systems, shall be accurately drilled or reamed to an iron template or be reamed true while the parts are temporarily connected together.

60. The effective diameter of a driven rivet will be assumed the same as its diameter before driving. In deducting the rivet-holes to obtain net sections in tension members, the diameter of the rivet-holes will be assumed as $\frac{1}{8}$ inch larger than the undriven rivets. Net Section.

The rupture of a riveted tension members is to be considered as equally probable, either through a transverse line of rivet-holes or through a diagonal line of rivet-holes, where the net section does not exceed by 30 per cent. the net section along the transverse line.

The number of rivet-holes to be deducted for net-section will be determined by this condition.

61. When members are connected by bolts the holes must be reamed parallel and the bolts turned to a driving fit. All bolts must be of neat lengths, and shall have a washer under the heads and nuts where in contact with wood. Bolts must be used in place of rivets, except by special permission. Bolts.

62. All nuts must be of hexagonal shape.

63. All joints in riveted tension members must be fully and symmetrically spliced. Splices.

64. Riveted tension members shall have an effective section through the pin-holes 25 per cent. in excess of the net section of the member, and back of

the pin at least 75 per cent. of the net section through the pin-hole.

65. In continuous compression members, as chords and trestle posts, the abutting joint with planed face must be placed as close to the panel points as is practicable, and the joints must be spliced on all sides with at least two rows of closely pitched rivets on each side of the joint.

Joints in long posts must be fully spliced.

66. In compression members, abutting joints with untooled faces must be fully spliced, as no reliance will be placed on such abutting joints. The abutting ends must, however, be dressed straight and true, as there will be no open joints. Abutting Joints.

67. The web of plate girders must be spliced at all joints by a plate on each side of the web. Web Splices.

68. All web-plates must have stiffeners over bearing points and at points of local concentrated loadings; such stiffeners must be fitted at their ends to the flange angles, at the bearing points. Stiffeners.

69. All other angles, filling and splice plates on the webs of girders and riveted members must fit at their ends to the flange angles, sufficiently close to be sealed, when painted, against admission of water.

70. Web-plates of all girders must be arranged so as not to project beyond the faces of the flange angles, nor on the top be more than $\frac{1}{16}$ inch below the face of these angles, at any point. Web Plates.

71. Wherever there is a tendency for water to collect, the spaces must be filled with a suitable waterproof material.

72. In girders with flange plates, at least one-half of the flange section shall be angles or else the largest sized angles must be used. Flange plates must extend beyond their theoretical length, two rows of rivets at each end. Flange Plates.

73. In lattice girders and trusses the web members must be double and connect symmetrically to the webs of the chords. The use of plates or flats, alone, for tension members must be avoided, where it is possible; in lattice trusses, the counters, suspenders and two panels of the lower chord, of each end, must be latticed; all other tension members must be connected by batten plates or latticed. (see Arts. 90, 91 and 92.)

74. The compression flanges of beams and girders shall be stayed against transverse crippling when their length is more than sixteen times their width. Compression Flanges.

75. The unsupported width (distance between rivets) of plates subject to compression shall not exceed thirty times their thickness; except cover plates of top chords and end posts, which will preferably be limited to forty times their thickness; where a greater relative width is used in chords and end posts, however, only forty times the thickness shall be considered as effective section. Width of Plates.

76. The flange plates of all girders must be limited in width so as not to extend beyond the outer lines of rivets connecting them with the angles, more

than five inches or more than eight times the thickness of the first plate. Where two or more plates are used on the flanges, they shall either be of equal thickness or shall decrease in thickness outward from the angles.

77. Where the floor timbers are supported at their ends on the flange of one angle, such angle must have two rows of rivets in its vertical leg, spaced not over 4 inches apart.

78. For main members and their connections no material shall be used of a less thickness than $\frac{3}{8}$ of an inch; and for laterals and their connections, no material less than $\frac{5}{16}$ of an inch in thickness; except for lining or filling vacant spaces. Thickness of Metal.

79. The heads of eye-bars shall be so proportioned and made, that the bars will preferably break in the body of the original bar rather than at any part of the head or neck. The form of the head and the mode of manufacture shall be subject to the approval of the Engineer of the Railroad Company. (Art. 141) Eye Bars

80. The bars must be free from flaws and of full thickness in the necks. They shall be perfectly straight before boring. The holes shall be in the centre of the head, and on the centre line of the bar.

81. The bars must be bored to lengths not varying from the calculated lengths more than $\frac{1}{64}$ of an inch for each 25 feet of total length.

82. Bars which are to be placed side by side in the structure shall be bored at the same temperature and of such equal length that upon being piled on each other the pins shall pass through the holes at both ends without riving.

83. The lower chord shall be packed as narrow as possible.

84. The pins shall be turned straight and smooth; chord pins shall fit the pin-holes within $\frac{1}{50}$ of an inch, for pins less than $4\frac{1}{2}$ inches diameter; for pins of a larger diameter the clearance may be $\frac{1}{32}$ inch.

85. The diameter of the pin shall not be less than three-quarters the largest dimension of any eye-bar attached to it. The several members attaching to the pin shall be so packed as to produce the least bending moment upon the pin, and all vacant spaces must be filled with wrought filling rings. Pins.

86. All bars with screw ends shall be upset at the ends, so that the diameter at the bottom of the threads shall be $\frac{1}{16}$ inch larger than any part of the body of the bar. Where closed sleeve nuts are used on adjustable members the effective length of the thread shall be legibly stamped at the screw ends of each bar. Adjustable counters to be avoided where practicable. Upset Ends.

87. All threads must be of the United States standard, except at the ends of the pins.

88. Floor beam hangers when permitted shall be made without adjustment and so placed that they can be readily examined at all times (§ 10.) Hangers.

89. All the floor beams must be effectually stayed against end motion or

any tendency to rotate from the action of the lateral system.

Compression Members.

90. Compression members shall be of steel, and of approved forms.

91. The pitch of rivets of the ends of compression members shall not exceed four diameters of the rivets for a length equal to twice the width of the member.

92. The open sides of all compression members shall be stayed by batten plates at the ends and diagonal latticework at intermediate points. The batten plates must be placed as near the ends as practicable, and shall have a length not less than the greatest width of the member or $1\frac{1}{2}$ times its least width. The size and spacing of the lattice bars shall be duly proportioned to the size of the member. They must not be less in width than 2 inches for members 9 inches or less in width, nor $2\frac{1}{4}$ inches for members 12 to 9 inches in width, nor $2\frac{1}{2}$ inches for members 15 to 12 inches in width. Single lattice bars shall have a thickness not less than $\frac{1}{40}$ or double lattice bars connected by a rivet at the intersection, not less than $\frac{1}{60}$ of the distance between the rivets connecting them to the members. They shall be inclined at an angle not less than 60° to the axis of the member for single latticing, nor less than 45° for double latticing with riveted intersections. The pitch of the latticing must not exceed the width of the channel plus nine inches.

93. Where necessary, pin-holes shall be reinforced by plates, some of which must be of the full width of the member, so the allowed pressure on the pins shall not be exceeded, and so the strains shall be properly distributed over the full cross-section of the members. These reinforcing plates must contain enough rivets to transfer their proportion of the bearing pressure, and at least one plate on each side shall extend not less than six inches beyond the edge of the batten plates. (§ 92).

94. Where the ends of compression members are forked to connect to the pins, the aggregate compressive strength of these forked ends must equal the compressive strength of the body of the members.

95. In compression chord sections and end posts, the material must mostly be concentrated at the sides, in the angles and vertical webs. Not more than one plate, and this not exceeding $\frac{1}{2}$ inch in thickness, shall be used as a cover plate, except when necessary to resist bending strains, or to comply with § 75. (§ 40.)

96 The ends of all square-ended members shall be planed smooth, and exactly square to the centre line of strain.

Floor Beams and Stringers.

97. The ends of all floor beams and stringers shall be faced true and square, and to correct lengths. Allowance must be made in the thickness of the end angles to provide for such facing without reducing the required effective strength of such end angles.

98. All members must be free from twists or bends. Portions exposed to

view shall be neatly finished.

99. Pin-holes shall be bored exactly perpendicular to a vertical plane passing through the centre line of each member, when placed in a position similar to that it is to occupy in the finished structure. Pin-Holes.

100. The several pieces forming one built member must fit closely together, and when riveted shall be free from twists, bends or open joints.

101. All through bridges shall have latticed portals, of approved design, at each end of the span, connected rigidly to the end posts and top chords. They shall be as deep as the specified head-room will allow, and provision shall be made in end posts for the bending strains from wind pressure. (§ 24.) (§ 4.) (§ 11.) Transverse Diagonal Bracing.

102. When the height of the trusses exceeds 25 feet, an approved system of overhead diagonal bracings shall be attached to each post and to the top lateral struts.

103. All members of the web, lateral, longitudinal or sway systems must be securely riveted at their intersections to prevent sagging and rattling.

104. Pony trusses and through plate or lattice girders shall be stayed by knee braces or gusset plates attached to the top chords of the ends and at intermediate points, and attached below to the cross floor beams or to the transverse struts.

105. All deck girders shall have transverse braces at the ends. All deck bridges shall have transverse bracing at each panel point. This bracing shall be proportioned to resist the unequal loading of the trusses. Deck Bridges.

106. In double-truck deck bridges, where three trusses are used, all three trusses will be made of equal strength ; the unequal loading being distributed through the transverse diagonal bracing as a live load. (For the purpose of reducing the unequal deflection under single-track loadings.)

107. All bed-plates must be of such dimensions that the greatest pressure upon the pedestal stone shall not exceed 250 pounds per square inch. Bed Plates.

108. All bridges over 80 feet span shall have hinged bolsters on both ends, and one end nests of turned friction rollers running between planed surfaces. These rollers shall not be less than $2\frac{1}{8}$ inches diameter for spans 100 feet or less, and for greater spans this diameter shall be increased in proportion of 1 inch for 100 feet additional. Friction Rollers.

The rollers shall be so proportioned that the pressure per lineal inch of roller shall not exceed the product of the diameter in inches by 300 pounds (300 d.)

The rollers must be of machinery steel and the bearing plates of medium steel.

The rollers and bearings must be so arranged that they can be readily cleaned and so that they will not hold water.

109. Bridges less than 80 feet span shall be secured at one end to the masonry, and the other end shall be free to move longitudinally upon smooth surfaces.

110. Where two spans rest upon the same masonry, a continuous plate, not less than $\frac{3}{8}$ inch thick, shall extend under the two adjacent bearings, or the two bearings must be rigidly tied together.

Pedestals and Bed-Plates.

111. Pedestals shall be made of riveted plates and angles. All bearing surfaces of the base plates and vertical webs must be planed. The vertical webs must be secured to the base by angles having two rows of rivets in the vertical legs. No base plate or web connecting angle shall be less in thickness than $\frac{3}{4}$ inch. The vertical webs shall be of sufficient height and must contain material and rivets enough to practically distribute the loads over the bearings or rollers.

Where the size of the pedestal permits, the vertical webs must be rigidly connected transversely.

112. All the bed-plates and bearings under fixed and movable ends must be fox-bolted to the masonry; for trusses, these bolts must not be less than $1\frac{1}{4}$ inches diameter; for plate and other girders, not less than $\frac{1}{8}$ inch diameter. The contractor must furnish all bolts, drill all holes and set bolts to place with sulphur or Portland cement.

113. While the expansion ends of all trusses must be free to move longitudinally under changes of temperature, they shall be anchored against lifting or moving sideways.

Camber.

114. All bridges shall be cambered by giving the panels of the top chord an excess of length in the proportion of $\frac{1}{8}$ of an inch to every ten feet.

Trestle Towers.

115. The lower struts in trestle towers must be capable of resisting the strains due to changes of temperature or of moving the tower pedestals under the effects of expansion or contraction.

For high or massive towers, these lower struts will be securely anchored to intermediate masonry piers, or the tower pedestals will have suitably placed friction rollers, as may be directed by the Engineer.

116. All joints in the tower columns shall be fully spliced for all possible tension strains, and to hold the parts firmly in position. (§ 65.)

117. Tower footings and bed-plates must be planed on all bearing surfaces; and the holes for anchor bolts slotted to allow for the proper amount of movement. (§ 28.)

Workmanship.

118. All workmanship shall be first-class in every particular.

119. All eye-bars must be made of medium steel.

Eye-Bars

120. Eye-bars, all forgings and any pieces which have been partially heated or bent cold must be wholly annealed. Crimped stiffeners need not be annealed.

121. No reliance will be placed upon the welding of steel.

122. No sharp or unfilleted angles or corners will be allowed in any piece of metal.

123. Medium steel may be used in compression in chords, posts and pedestals without reaming of punched holes, for all thickness of metal, which will stand the drifting test (§ 135.); provided all sheared edges are planed off to a depth of $\frac{1}{8}$ inch. Medium Steel.

In all other cases medium steel over $\frac{5}{8}$ inch thick must have all sheared edges planed off to a depth of $\frac{1}{8}$ inch and all holes drilled or reamed to a diameter $\frac{1}{8}$ inch larger than the punched holes, so as to remove all the sheared surface of the metal.

124. Soft steel need not be reamed if it satisfies the drifting test (§§ 135, 136.)

125. All parts of any tension or compression flange or member, must be of the same kind of steel, but webs of plate girders and the tension members of all girders, plate or lattice, may be made of soft steel in connection with compression members of medium steel.

126. All splices must be of the same kind of steel as the parts to be joined.

127. Pilot nuts must be used during the erection to protect the threads of the pins. Pilot-Nuts.

Quality of Material.

Steel.

128. All steel must be made by the Open Hearth process. The phosphorus must not exceed 0.06 of one per cent. for steel made by the acid method, or 0.04 for steel by the basic method.

129. The steel must be uniform in character for each specified kind. The finished bars, plates and shapes must be free from cracks on the faces or corners, and have a clean, smooth finish. No work shall be put upon any steel at or near the blue temperature or between that of boiling water and of ignition of hard wood saw dust.

130. The tensile strength, elastic limit* and ductility shall be determined by samples cut from the finished material after rolling. The samples to be at least 12 inches long, and to have a uniform sectional area not less than $\frac{1}{2}$ square inch.

131. Material which is to be used without annealing or further treatment

*) For the purpose of these specifications, the Elastic Limit will be considered the least strain producing a visible permanent elongation in a length of 8 inches, as shown by scribe marks of a pair of finely pointed dividers. If the yield point or drop of the beam can be calibrated for any machine and its speed to represent the elastic limit within 5 per cent., it may be used for general cases. Test reports must state by which method the elastic limit was determined.

is to be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material is to be similarly treated before testing, for tensile strength.

The elongation shall be measured on an original length of 8 inches. Two test pieces shall be taken from each melt or blow of finished material, one for tension and one for bending. (Art. 147.)

132. All samples or full-sized pieces must show uniform fine grained fractures of a blue steel-gray color, entirely free from fiery lustre or a blackish cast.

Medium Steel.

133. Medium steel shall have an ultimate strength, when tested in samples of the dimensions above stated, of 60,000 to 68,000 pounds per square inch, an elastic limit of not less than one-half of the ultimate strength, and a minimum elongation of 22 per cent. in 8 inches. Steel for pins may have a minimum elongation of 15 per cent.

135. Before or after heating to a low cherry red and cooling in water at 82 degrees Fah, this steel must stand bending to a curve whose inner radius is one and a half times the thickness of the sample, without cracking.

135. For all medium steel, $\frac{5}{8}$ inch or less in thickness, rivet holes punched as in ordinary practice (§ 52, 53, 54), must stand drifting to a diameter one-third greater than the original holes, without cracking either in the periphery of the holes or on the external edges of the piece, whether they be sheared or rolled.

Soft Steel.

136. Soft steel shall have an ultimate strength, on same sized samples, of 54,000 to 62,000 pounds per square inch, an elastic limit not less than one-half the ultimate strength, and a minimum elongation of 25 per cent. in 8 inches.

For soft steel the above drifting test (§ 135) shall apply to all material to be riveted.

137. Before or after heating to a light yellow heat and quenching in cold water, this steel must stand bending 180 degrees, to a curve whose inner radius is equal to the thickness of the sample, without sign of fracture.

Rivet-Steel.

138. Rivet steel shall have an ultimate strength of 50,000 to 58,000 pounds per square inch, an elastic limit not less than one-half the ultimate strength and an elongation of 26 per cent.

139. The steel for rivets must, under the above bending test (137), stand closing solidly together without sign of fracture.

140. Eye-bar material, $1\frac{1}{2}$ inches and less in thickness, shall, on test pieces cut from finished material, fill the above requirements. For thicknesses greater than $1\frac{1}{2}$ inches, there will be allowed a reduction in the percentage of elongation of 1 per cent. for each $\frac{1}{8}$ of an inch increase of thickness, to a minimum of 20 per cent. (Art. 119).

141. Full sized eye-bar shall show not less than 10 per cent. elongation

in the body of the bar, and an ultimate strength not less than 56,000 pounds per square inch. Should a bar break in head, but develop 10 per cent. elongation and the ultimate strength specified, it shall not be cause for rejection, provided not more than one-third of the total number of bars tested break in the head.

142. Pins over 7 inches in diameter shall be forged. Blooms for pins shall have at least three times the sectional area of the finished pins.

143. A variation of cross-section or weight in the finished members of $2\frac{1}{2}$ per cent. from the specified size may be cause for rejection.

Steel Castings.

144. Steel castings will be used for drawbridge wheels, track segments and gearing (Art. 1.) Steel Castings.

They must be true to form and dimensions, of a workmanlike finish and free from injurious blowholes and defects. All castings must be annealed.

When tested in specimens of uniform sectional area of at least $\frac{1}{2}$ square inch for a distance of 2 inches, they must show an ultimate strength of not less than 67,000 pounds per square inch, an elastic limit of one-half the ultimate, and an elongation in 2 inches of not less than 10 per cent.

The metal must be uniform in character, free from hard or soft spots, and be capable of being properly tool finished.

Cast Iron.

145. Except where cast steel or chilled iron is required, all castings must be of tough, gray iron, free from cold shuts or injurious blowholes, true to form and thickness, and of a workmanlike finish. Sample pieces, 1 inch square, cast from the same heat of metal in sand moulds, shall be capable of sustaining, on a clear span of 12 inches, a central load of 2,400 pounds, when tested in the rough bar. A blow from a hammer shall produce an indentation on a rectangular edge of the casting without flaking the metal. Cast Iron.

Timber.

146. The timber, unless otherwise specified, shall be strictly first-class southern yellow pine or white oak bridge timber, sawed true, and out of wind, full size, free from wind shakes, large or loose knots, decayed or sap wood, worm holes, or other defects impairing its strength or durability. It will be subject to the inspection and acceptance of the Engineer. Timber

Inspection.

147. All facilities for inspection of the materials and workmanship shall be furnished by the contractor. He shall furnish without charge such specimens Inspection

(prepared) of the several kinds of steel to be used, as may be required to determine their character.

148. The contractor must furnish the use of a testing machine capable of testing the above specimens at all mills where the steel may be manufactured, free of cost.

149. Full sized parts of the structure may be tested at the option of the Engineer of the Railroad Company, but if tested to destruction, such material shall be paid for at cost, less its scrap value to the contractor, if it proves satisfactory. If it does not stand the specified tests, it will be considered rejected material, and be solely at the cost of the contractor.

Painting.

150. All metal work before leaving the shop shall be thoroughly cleaned from all loose scale and rust, and be given one good coating of pure raw linseed oil, well worked into all joints and open spaces. Painting.

151. In riveted work the surfaces coming in contact shall each be painted before being riveted together. Bottoms of bed-plates, bearing-plates, and any parts which are not accessible for painting after erection, shall have two coats of paint; the paint shall be a good quality of iron ore paint, mixed with pure linseed oil, unless otherwise directed. It will be subject to approval of the Engineer.

152. After the structure is erected, the metal work shall be thoroughly and evenly painted with two additional coats of paint, mixed with pure linseed oil. All recesses which will retain water, or through which water can enter, must be filled with thick paint or some waterproof cement before receiving the final painting.

153. Pins, bored pin-holes, screw threads and turned friction rollers shall be coated with white lead and tallow before being shipped from the shop.

Erection.

154. The contractor, unless it be otherwise specified, shall furnish all staging and false work, shall erect and adjust all the metal work, and put in place all floor timbers, guards, etc., complete, ready for the rails. Erection

155. The contractor shall so conduct all his operations as not to impede the operations of the road, interfere with the work of other contractors, or close any thoroughfare by land or water.

156. The contractor shall assume all risks of accidents to men or material prior to the acceptance of the finished structure by the Railroad Company.

The contractor must also remove all false work, piling and other obstructions, or unsightly material produced by his operations.

Final Test.

157. Before the final acceptance the Engineer may make a thorough test by passing over each structure the specified loads, or their equivalent, at a speed not exceeding 60 miles an hour, and bringing them to a stop at any point by means of the air or other brakes, or by resting the maximum load upon the structure for twelve hours. Final Test.

After such tests the structures must return to their original positions without showing any permanent change in any of their parts.

Export Work.

All plans, including working drawing, must be submitted for the examination and approval of the Consulting Engineer before the material is ordered or any work done. Export Work.

Any proposed modification of accepted plans, to adapt them to the plant end mothods of the manufacturer or to facilitate the prompt delivery of the work, must also be submitted to and approved by the Consulting Engineer, before such changes can be allowed.

In all designs, the length and size of parts must be so arranged that they can be readily handled and stored during transportation to the site.

Length of bars, posts, chords and pieces of small section must not exceed....feet.

Length of girders or girder sections over....feet in width must not exceed.... feet.

Weight of any single piece must not exceed....pounds.

Pins, roller-nests, bolts, rivets and all small pieces must be packed in strong, iron-bound boxes, with the detailed contents of each box legibly marked on the outside. Boxes to be consecutively lettered or numbered.

The screw-ends of all bars to be securely protected by canvass wrapped and wired about the same.

Every piece must not only be legibly marked by paint, but also by letters stamped on the metal, showing its location in the structure.

All necessary rivets for the field connections, with an extra allowance of 25 per cent. for each kind, shall be sent with each shipment.

The customary pilot-nuts (§ 127) for all pins shall be sent with the pins.

Proposals for building and erecting complete, ready for the...., a bridge over.....near.....on the..... Division, ...Railroad, in accordance with the attached specifications and accompanying profile, will be received up to..... The live load to be adopted for this bridge will be Class E....., paragraph 23.