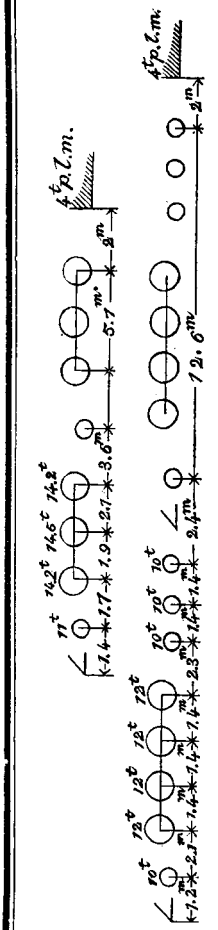
SPECIFICATIONS

FOR

DESIGNS OF RAILWAY BRIDGES AND VIADUCTS

Structures shall be designed to sustain either of the following live load systems in every possible position.



Further they must sustain in addition to the above, the following *dead loads* :—

At the panel points of the *loaded* chord :—

1. The weight of the track consisting of sleepers, rails, rail joint materials, spikes, guards and planking, weighing in all 400 kg. p. l. m.
2. The weight of the floor system.
3. Half the weight of trusses.
4. The weight of the lateral system.
5. Half the weight of sway bracing.

At the panel points of the *unloaded* chord :—

1. Half the weight of trusses.
2. The weight of the lateral system.
3. Half the weight of sway bracing.

In order to provide against *impact*, the following increase of stresses due to the live load shall be made on those determined by loadings above specified :—

For Floorbeam and stringer connections 35%

For stringers, Floorbeams and for girders $\frac{600}{L+16}$%.

L, denoting span length in metres.

The *types of construction* shall be for spans above 25m, trusses, and for those under 25m plate girders.

The *allowable unit stress* for each member or part shall be determined according to the following formulas :

For members subject to *Compressoin or Tension only*

$$a = c\left(1 + \frac{3}{4}\ \frac{\min S}{\max S}\right)$$

For members subject to *alternate Tension and Compression*:

$$a = c\left(1 - \frac{1}{2}\ \frac{\text{max. lesser } S}{\text{max. greater } S}\right)$$

c being for Soft Steel 650 kg. p. sq. cm., for Wrought Iron 10% less and for Medium Steel 10% more than that for Soft Steel.

The *allowable extreme fibre stress* in pins may be taken at $1.2a$

The *allowable shearing stress* shall not exceed $0.8a$.

The *allowable pressure* on *pin* or *rivet* may be taken at $1.5a$, the area being measured on the diametrical section of the pin or rivet in contact.

To obtain the *actual allowable compression in columns* a must be reduced by the following formula:

$$k = \frac{a}{1 + \frac{l^2}{15000\, r^2}}$$

k = allowable compression in kg. p. sq. cm., l = column length,

r = least radius of gyration.

In *posts* with rigid floor-beam connections, the secondary stress arising from bending of the beam shall be taken into account in calculating the necessary sectional areas.

No *post* shall have a length exceeding 100 times its least radius of gyration, nor least width less than 20 cm.

Only in members subject to *tension*, rivet holes in line of a right section need be deducted in calculating the necessary sectional area.

All *splices* shall be made as direct as possible.

Chords shall be thoroughly *spliced* in webs.

Angles shall be spliced with cover-angles.

Whenever practicable every member shall be so made up, that the centre of gravity of its section will coincide with the geometrical centre of the same.

In no part of the structure shall plates *thinner than* 6^{mm}. be used except as fillers.

Rivets shall be so *spaced* that the maximum distance apart in the direction of stress will not exceed 15 times the thickness of the thinnest plate connected and that laterally 30 times.

Rivets shall not be *spaced* closer than 3 diameters from centre to centre, and $1\frac{1}{2}$ diam. from edges of the piece.

Plate girder web shall not be thinner than 1 cm. and wherever spliced the connection shall be made with plates on both sides.

Stiffners shall be put in, at least, wherever web taken as a column inclined at 45° between upper and lower rows of rivets will not be able to withstand a pressure equal to max. shearing stress existing at the section taken.

Top flange of a plate girder shall be fixed laterally at intervals not exceeding 12 times its width.

Wind Pressure—In addition to the foregoing requirements, structures shall be designed to withstand wind pressure, for which the following provisions shall be made: *Lateral and Sway braces* shall be proportioned to resist a pressure of 150 *kg. p. sq. m. on the exposed surfaces of trusses and flooring as well as the train surface*, the latter being considered as a *moving load*. They shall also be proportioned to withstand a wind pressure of 250 *kg. p. sq. m. on the exposed surfaces of trusses and floor-system*. The *allowable stress* may be increased 75% above those specified for normal loading.

Main truss members shall have their sections increased in case stresses per sq. cm. due to loading and wind taken together exceed the limiting stress allowed for lateral and sway bracing until they are brought within these limits.

Members with adjustments shall be calculated to sustain an initial stress of 4000 kg. in addition to the stress produced by loading or by wind pressure.

When bridge is *on curve*, the *centrifugal force* of the moving load shall be taken into consideration in calculating the stress.

Girder longer than 25^{m} shall be provided with a nest of steel *rollers* at one end. The diameter of such rollers shall be determined by the formula:

$$p = 70\sqrt{D}$$

p=allowable pressure in kg. p. l. cm. D=diam. in cm.

Bed plates shall be of such dimensions as to be capable of transmitting a pressure not exceeding 15 kg. p. sq. cm. on the masonry.

SPECIFICATIONS

for

Designs of Highway Bridges.

Stresses shall be calculated for the following assumed loads:

Dead:

At the panel points of the *loaded chord*,

(1) The weight of the floor system iucluding railings.
(2) Half the wt. of trusses.
(3) The wt. of the lateral system.
(4) Half the wt. of sway braces.

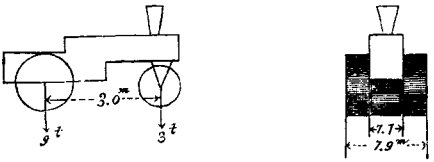
At the panel points of the *unloaded chord*,

(1) Half the wt. of trusses.
(2) The wt. of the lateral system.
(3) Half the wt. of sway braces.

Live:

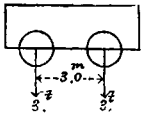
For *I class. bridges*,

Generally a uniform load of $440+\frac{1400}{l}$ kg. per sq. metre (l=span length in metres). For short spans and floor system, a 12-ton steam roller.



For *II class bridges*,

Generally a uniform load of $360+\frac{1200}{l}$ kg. p. sq. m. (l=span length in m.) and for short spans and floor system, a 6-ton wagon besides.



When a highway bridge is to carry an electric tramway not using locomotive, a continuous train consisting of cars with 6 tons per axle spaced 2.0m and 6.0m alternately and occupying a width of 2.5m for every line, together with the above specified uniform load on the remaining portion of the floor shall be assumed as live load.

In order to provide against *impact*, increase stresses due to live load by $\frac{2500}{l+50}$ %, l being span length in metres.

The *allowable stresses* shall be for *soft steel*, not more than 1200 *kg. p. sq. cm.* For *wrought iron* 10% less and for *medium steel* 10% more than for soft steel.

The *allowable shearing stress* shall not exceed 1000 kg. p. sq. cm. for soft steel.

The *allowable pressure on pin or rivet* may be taken at 1800 kg. p. sq. cm. for soft steel, the area being meassured on the diametrical section of the pin or rivet in contact.

The *allowable compression in Columns* shall be deduced from the following formula:

$$k=\frac{a}{1+\frac{l^2}{15000r^2}}$$

a=allowable stress above specified
l=length of column.
r=least radius of gyration
k=allowable compression in column (kg. p. sq. cm.)

In *posts* with rigid floor-beam connections, the secondary stress arising from

bending of the beam shall be taken into account in calculating the necessary sectional areas.

No *post* shall have a length exceeding 100 times its least radius of gyration.

For *alternating stresses* make the total sectional area equal to the sum of areas required for each stress.

Whenever practicable every member shall be so made up that the centre of gravity of its section will coincide with the geometrical centre of the same.

Chords shall be thoroughly specified in webs.

Angles shall be spliced with cover-angles.

In no part of the structure shall plates thinner than 5^{mm} be used except as fillers.

Floor metals (*Buckle-plates*, *corrugated iron*, &) shall have thickness not less than 7^{mm} for the roadway.

Rivets shall be so spaced that the max. distance apart in the direction of stress shall not exceed 15 times the thickness of the thinnest plate connected and that laterally 30 times.

Rivets shall not be spaced closer than 3 diameters from centre to centre and $1\frac{1}{2}$ diam. from edges of the piece.

Plate girder web shall not be thinner than 8^{mm} and wherever spliced the connection shall be made with plates on both sides.

Stiffners shall be put in, at least, wherever the web taken as a column inclined at 45°, between upper and lower rows of rivets will not be able to withstand a pressure equal to max. shearing stress existing at the section taken.

Wind pressure. Lateral & sway braces shall be proportioned to withstand a wind pressure of 250 kg. p. sq. metre on the exposed surfaces of trusses and floor system using the same allowable stresses as specified for normal loading.

Main truss members shall have their sections increased in case the stresses per sq. cm. due to dead load and wind taken together exceed the allowable stresses.

Members with adjustments shall be calculated to sustain an initial stress of 4000 kg. in addition to the stress produced by loading or by wind pressure.

Girder longer than 25^{m} shall be provided with a nest of steel rollers at one end. The diameter of such rollers shall be determined by the formula:

$$p = 80\sqrt{D}$$

p = allowable pressure in kg. p. l. cm.

D = diameter in cm.

Bed plates shall be of such dimensions as to be capable of transmitting a pressure not exceeding 16 kg. p. sq. cm. on the masonry.

SPECIFICATIONS

for material and workmanship for bridges and viaducts.

MATERIAL.

Wrought Iron.—All wrought iron shall be tough, fibrous, uniform in quality and, when tested, falling under no circumstance short of the following results:—

Bar iron: Ultimate tensile strength 3600 kg. per sq. cm.

Elastic limit, not less than ½ ultimate strength.

Elongation before rupture, 20% in 20 cm.

Reduction of sectional area at the point of rupture, not less than 25% of the original section.

Bending 180 degrees around a cylinder with a diameter equal to the length of the shortest side, without showing any sign of fracture.

Plate and shape iron: Ultimate tensile strength determined from test piece shall be for:—

Shapes .....3,400 kg. per. sq. cm.

Plates .....3,300 " " " "

Elastic limit, not less than ½ ult strength.

Elongation in 20 cm. 15%.

Steel.—All steel shall be tough, ductile and uniform in quality. In determining the quality of steel, test pieces should be cut from a finished piece from every heat. They should, when tested, give the following results:—

Ultimate tensile strength: Soft Steel 3600 to 4200 kg. per sq. cm.

Medium Steel 4000 to 4800 " " " "

Elastic limit, not less than ½ ultimate strength.

Elongation in 20 cm.: Soft Steel not less than 22%

Medium Steel, not less than 20%

Reduction of area at the point of rupture: Soft Steel, not less than 45%

Medium Steel, not less than 40%.

The test piece must be capable of being bent flat on itself in the case of soft steel and 180 degrees around a cylinder with a diameter 1½ times the length of the shortest side of the piece for medium steel without showing in either case, signs of fracture on the bent portions.

All Test pieces should have a section not less than 3 square centimeters. They are to be planed to size, but whenever practicable two flat faces shall be, left as they come from the rolls.

All Rolled steel or iron must be free from seams, blisters, cinderspots, imperfect edges, and must be first class in every respect.

Variation of more than 2% in cross sectional area from that specified may

be a cause for rejection.

Cast Iron—All cast iron shall be good, tough gray iron, of such a quality that a bar 2½ cm square on a clear span of 1½ m. will sustain a load of 220 kg. at its middle point without breaking.

Whenever full sized pieces are tested to destruction and proved to give the required results, they will be paid for at the same rate per kilogram as the rest; but in case the results are not satisfactory they will not be paid for and all the pieces made from the same material shall be rejected.

Full sized eye-bars tested to destruction shall break in the body and the intensity of ultimate strength, shall not be less than 90% of the test-piece strength of the material with which they are made.

WORKMANSHIP.

All workmanship shall be strictly first class.

Every piece shall be finished in strict accordance with the drawing furnished by the Engineer.

All measurements in laying out work shall be made with steel standards o the same temperature as the piece measured.

Neither steel nor iron shall be struck with hammer at black heat.

Pin Holes shall be bored exactly perpendicular to the axis of the piece.

The Diameter of pin-hole shall not exceed that of the pin by more than ½ mm. except for lateral connections, where the difference of up to 1 mm. will be allowed.

Eye Bars shall be carefully straightened, and those of the same class piled, clamped, and bored in one operation and at the same temperature.

Eye Bars which are to be so packed in the truss that they deviate from its axis at the rate of more than 1 : 100 shall be gently bent till their heads stand at right angle to the axis of the pin.

Pins shall be carefully turned.

In rivetting, machine is to be prefered to hand.

Rivets shall completely fill their holes and on any indication to the contrary they shall be cut and rivetted anew.

Rivets having heads either imperfectly formed, or not formed centrally on the body, shall be cut out.

Rivets in steel members shall be of steel.

Rivets holes shall be carefully spaced, and any inaccuracy either in punching or drilling shall be reamed so that holes shall be exactly opposite without the use of drift pins.

All rivet-holes in steel shall be drilled, or reamed to a diameter 3 mm larger

than the punched holes.

Drilled or reamed rivet-holes shall have their sharp edges coming under rivet heads trimmed.

Holes for field-rivets shall be accurately matched before leaving the shops and all unmatched holes reamed to fit.

All abutting surfaces, except in flanges of plate girders, shall be carefully planed.

Rollers shall be carefully turned and roller beds planed.

All turned surfaces shall be coated with whitelead and tallow.

All finished pieces shall be lettered to correspond to those on the erection plan.

Every piece shall receive one coat of boiled linseed oil before being assembled, and another coat when finished, after which the whole surface shall receive two coats of metallic paint approved by the Engineer.

On drawings, figures shall always be relied on and not the measurements by scale

The maker will be held responsible for errors in lengths and fittings, whatever may be the cause thereof.

No alteration will be allowed unless authorized by the Engineer.

Every facility for inspection of material and workmanship and the necessary means for testing, as well as testpieces shall be furnished, free of charge, by the maker whenever called for by the engineer or his representative.