Britannia Iron Works, Derby.

11 Oct 1883

Proposed Bridge over River Glen at Surfleet

Memo of Loads & Strains &c

The bridge is to be 90.0" span centre to centre of bearings with a clear width of 21.0" between handrails; Skew 8.2" no overhead bracing permitted.

Dead load, 90 lbs per foot super, for 9" thick of concrete & macadam.

Live load, Two traction engines of 20 tons weight each passing each other at any part of the bridge, together with a crowd load of 3/4 cwt per foot super on all parts of the bridge not occupied by the traction engines, & a side wind pressure of 40 lbs per foot super.

Unit strains, allowed for under such loading are as follows

Main girders;	top booms,	3½	tons per square inch of	gross	section
"	bottom "	5	" " "	net	"
"	struts	2½	" " "	gross	"
"	ties	5	" " "	net	"
Cross girders;	top flange	4	" " "	gross	"
"	bottom "	5	" " "	net	"
Longitudinals;	top flange	4½	" " "	gross	"
"	bottom "	4½	" " "	net	"
Shearing on webs		3	" " "	gross	"

The ~~type~~ of bridge adopted is with 2 Main girders of Braced Bowstring ~~is~~ form, with vertical struts; working depth 1/8th of span, top boom curved to an ellipse; Plate cross girders 2.0" deep, placed 8.2" apart suspended to Main girders, & carried out beyond main girders at intervals, with raking struts up to top boom; Longitudinals of rolled joist iron 4.3" apart; and decking of W.I. arched plates;

L 2170

Maximum loads upon each bay of 8.2" in length of each main girder under these conditions will be as follows.

Dead load,	by concrete & macadam 8.2 × 10.6 × 90 lbs =		69 cwt
	add for floor plates 3/8 thick, 8.2 × 11.0 × 15 lbs =		12
	" " longitudinals, 2/8.2 × say 35 lbs =		5
	" " railing & gravel plate, 8.2 × 1/2 cwt =		4
	" " cross girder & bracing, say		14
	" " main girder "		36
		140 =	7 tons

Rolling Load, by two 20 ton traction engines passing, each cross girder is taken as transmitting half the weight of one engine to each main girder = 10 tons

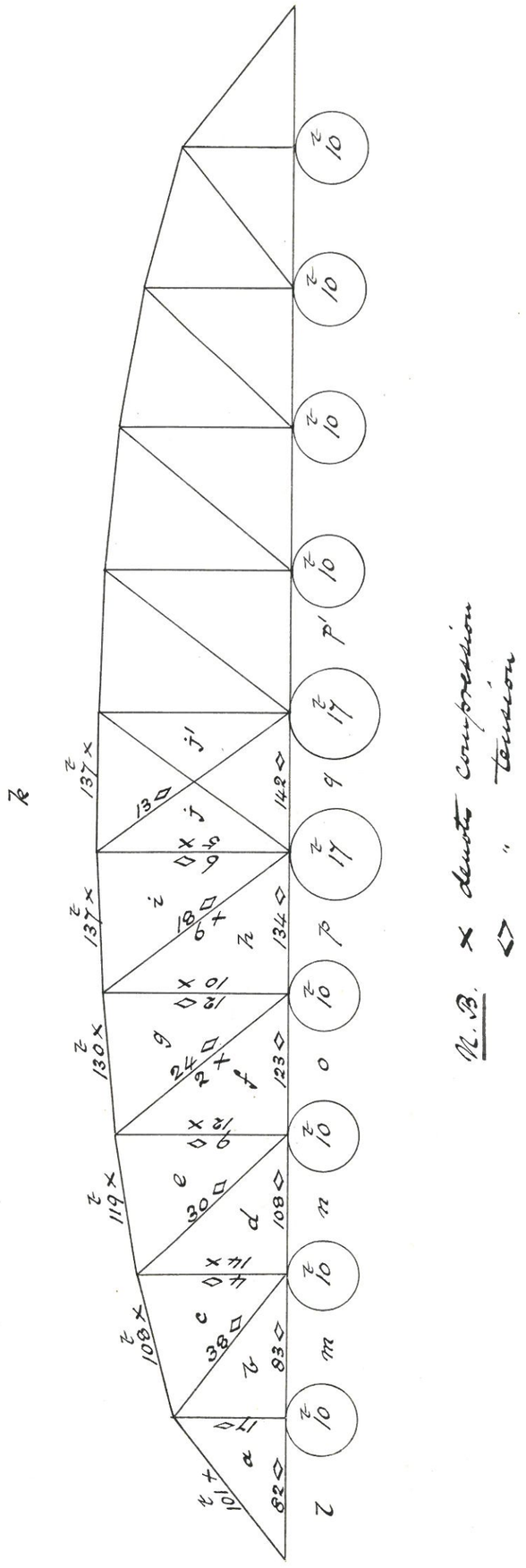
Crowd Load taken upon cross girders not occupied by the engines. 8.2 × 10.6 × 3/4 cwt = 3 tons

The maximum loads will therefore be 7t + 10t = 17 tons upon any 2 contiguous cross girders; and 7 + 3 = 10 tons on others.

Wind pressure, in consideration of the open character of the main girders & the small obstruction they oppose to the wind it will be sufficient to allow a vertical resisting surface of 6.0" in height for structure & traffic.

90.0" × 6.0" × 40 lbs = say 10 tons dist. over girder

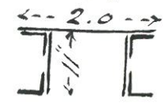
The maximum strains upon the various members of main girders by these loads is shown upon the following diagram:



Areas & Sections of Main girders

Top boom

a. k. 101 tons ÷ 3½ = 28·8 sq ins required area }
c. k. 108 ÷ " = 30·8 " " " }



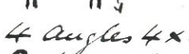
Section, 1 plate 24" × 3/8" = 9
2 bars 11 × ½ = 11
4 angles 3 × 3 × ½ = 11
} 31 sq. ins.

e. k. 119 ÷ 3½ = 34 sq ins required area; Section 1 plate 24 × ½ = 12
2 bars 11 × ½ = 11
4 angles 3 × 3 × ½ = 11
} 34 sq. ins.

g. k. 130 ÷ 3½ = 37 sq ins required area; Section 1 plate 24 × 5/8 = 15
2 bars 11 × ½ = 11
4 angles 3 × 3 × ½ = 11
} 37 sq. ins.

i. k. & j. k. 137 ÷ 3½ = 39 sq ins required area; Section 1 plate 24 × ¾ = 18
2 bars 11 × ½ = 11
4 angles 3 × 3 × ½ = 11
} 40 sq ins

Bottom boom

a. l. 82 ÷ 5 = 16·4 sq ins required area; }
b. m. 83 " = 16·6 " " } Section  4 angles 4 × 3 × ½ = 11
2 bars 8 × ½ = 6
} 17 nett sq ins

d. n. 108 ÷ 5 = 21·6 required area }
f. o. 123 " = 24·5 " " } Section 4 angles 4 × 3 × ½ = 11
2 bars 8 × ½ = 6
2 " 8 × 5/8 = 7½
} 24½ sq ins

h. p. 134 ÷ 5 = 26·8 required area }
j. q. 142 " = 28·4 " " } Section 4 angles 4 × 3 × ½ = 11
2 bars 8 × ½ = 6
2 " 8 × 5/8 = 7½
2 " 8 × 3/8 = 4½
} 29 sq. ins.

Vertical struts

c. d. 14 ÷ 2½ = 5·6 sq ins required area; Section ⊢⊣ 2 Tees 6 × 3 × ½ = 8½ sq. ins.

Diagonal ties

b. c. 38 ÷ 5 = 7·6 sq ins required area; Section 2 angles 4 × 4 × 5/8 = 7·8 sq. ins. nett
d. e. 30 " = 6·0 " " " 2 " 4 × 4 × ½ = 6·5 "
f. g. 24 " = 4·8 " " " 2 " 4 × 3 × ½ = 5·5 "
h. i. 18 " = 3·6 " " " 2 " 4 × 3 × 3/8 = 4·1 "
j. j' 13 " = 2·6 " " " 2 " 4 × 3 × ¼ = 3·0 "

Cross girder

made 2'.0" deep over web; working depth = 1'.10"

" length = 23'.3"

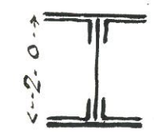
Max. load with one pair of wheels from each engine.

Road metal & floor plates	21'.0" × 8'.0" × 1 cwt =	8½ tons	
add for longitudinals	say	½	"
" " own weight	"	1	"
rolling load		20	"
		30 tons	distributed

Strain on flanges at centre $\frac{30 \times 23\frac{1}{4}}{8 \times 1.83}$ = 48 tons

Top flange 48 ÷ 4 = 12 sq ins required area

bottom " 48 ÷ 5 = 9.6 " " "

Section 

1 bar 9" × 5/8" = 5½ } 12 sq ins. gross.
2 angles 4 × 3 × ½ = 6½ }

2 angles 4 × 3 × ½ = 5.6 } 10.1 sq ins nett.
1 bar 9 × 5/8 = 4.5 }

Longitudinal girder

made of rolled joist 10" deep, working depth = 9"

" length = 7'.6"

Max. load with one wheel of engine at centre.

Road metal & floor plate	7'-6" × 4'.3" × 1 cwt =	33 cwt	
add own weight	say	2	} 1¾ tons distributed
Rolling load 5 tons at centre =		10	"
		11¾	"
		(say 12 tons)	

Strain on flanges at centre $\frac{12 \times 7\frac{1}{2}}{8 \times \frac{3}{4}}$ = 15 tons

15 ÷ 4½ = 3⅓ sq ins required areas

Section I 10" × 5" × 35 lbs joist with flange area of 3.6 sq ins