

HBR3/124 BE4 Assessment and Inspection Report

Little Smeaton, North Yorkshire

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National Highways – Historical Railways Estate
HBR3/124

HRE Assessment Programme
28 September 2023



HBR3/124 BE4 Assessment and Inspection Report

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Executive summary

Structure Type: Skewed single span overbridge

Superstructure Form: Longitudinal edge girders supporting transverse girders and jack arches

Substructure Form: Brick abutments and wingwalls

Span: Skew Span: 17.33m (56' – 10") Square Span: 11.84m (38' – 10")

Assessment Code: BE4

Live Load Capacity: Full C&U Loading

Capacity Critical Element: Edge Girder in bending at IG10

Carriageway Restriction: None

Condition: Poor

Local Authority: North Yorkshire

OS Reference: SE 532 165

This report presents the load carrying capacity for the bridge and identifies the data used to derive the assessment. The load carrying capacity of the bridge is based only on the assessment of visible spans that were amenable to inspection. It has been prepared by Jacobs for the exclusive use by HRE and should not be relied on by third parties. It has been based on site measurements and investigation by Jacobs or historical information provided by HRE, as appropriate.

The description of condition does not represent a principal inspection, nor should it be relied on for the development of maintenance works. Close inspection of members was limited by the constraints of safe access possible within the site visit described.

Identification of defects is principally based on ground level observation of visible members. The structural arrangement of the bridge meant that the following elements were not examined as part of the inspection for assessment:

- Edge girders – The buried sections of the internal face of the web panel, connecting angles and internal outstands of the flanges were considered as built-in parts and therefore not amenable to inspection. Unexposed surfaces were assumed to be competent owing to their protection by the deck construction.
- Internal girders – due to the jack arch construction, only the undersides of the bottom flanges were visible. The webs, connecting angles and top flanges of the internal girders were considered built-in parts protected by the deck construction and not amenable for inspection.

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1. General Description and Structural Details

1.1 Introduction

Jacobs was appointed by National Highways – Historical Railways Estate (HRE) to undertake a BE4 assessment of structure HBR3/124.

1.2 Location and General Description

Structure HBR3/124 carries 'Stubbs Road' over the former Hull and Barnsley railway line on the edge of Little Smeaton, Pontefract.

The structure carries a single lane carriageway with no markings 3.83m (12' – 7") wide. Grass verges line both sides of the road 1.96m (6' – 5") and 1.83m (6' – 0") on the north and south sides respectively. The overall width between the parapets is 7.62m (25' – 0").

Traffic flow across the bridge is low. No HGV use was observed during the survey though agricultural vehicle use is expected due to the nature of the surrounding land and presence of entrances to crop fields adjacent to the east end of the structure.

The OS Grid reference is SE 532 165.

The Hull and Barnsley railway line was opened circa 1885 and it is probable that the bridge was constructed at this time.

1.3 Construction Type

The structure is a skewed, single span overbridge. The clear skew span is 17.32m (56' – 10") and the clear square span is 11.84m (38' – 10") giving an angle of skew of 47°.

The superstructure comprises two longitudinal wrought iron edge girders supporting 18no. girders spanning transversely which in turn support brick jack arches. The central six internal girders span between the edge girders, all remaining transverse girders span between the edge girders and their adjacent abutment.

The edge girders comprise 20" x 5/8" flange plates attached to a 60" x 3/8" web plate via 3" x 3" x 1/2" angles. The rivets are 7/8" diameter at 3" pitch. There are three additional curtailment plates and a cover plate on both top and bottom flanges. The curtailment plates are all 5/8" thick and the cover plate is 1/2". The lengths of the curtailment plates are 47' – 10", 39' – 4", 26' – 0 1/2". The cover plate is 8' – 6 1/2" long. The overall length of the edge girders is 65' – 4". The flange plates are spliced but identification of all joint locations was not possible. The curtailment plates have additional lines of 7/8" diameter rivets at 3" pitch set 2" from the edges of the plates in line with the rivets connecting to the angles, refer to Figure 2 below. The edge girders are placed at 26' – 8" centre to centre.

There are stiffeners at 4' – 8" centres along the girder with bearing stiffeners at 2' – 4" from the end plates. Six of the stiffeners, including the ones at the bearings, comprise a gusset plate 1/2" thick attached to the web via 3" x 3" x 1/2" angles. The remaining stiffeners are formed from 6" x 3" x 1/2" T's. Refer to figure 3 below.

There are splice plates on the web at 2' – 4" centres, located at each of the stiffeners and mid-way between, apart from at midspan. Here, there are two bays where the web plates are assumed to be 4' – 8" long terminating at the stiffener locations. Refer to figure 3 below. The splice plates at the stiffeners are attached by an additional line of rivets each side of the stiffener except for three locations at midspan where there are only packer plates between the web and stiffener.

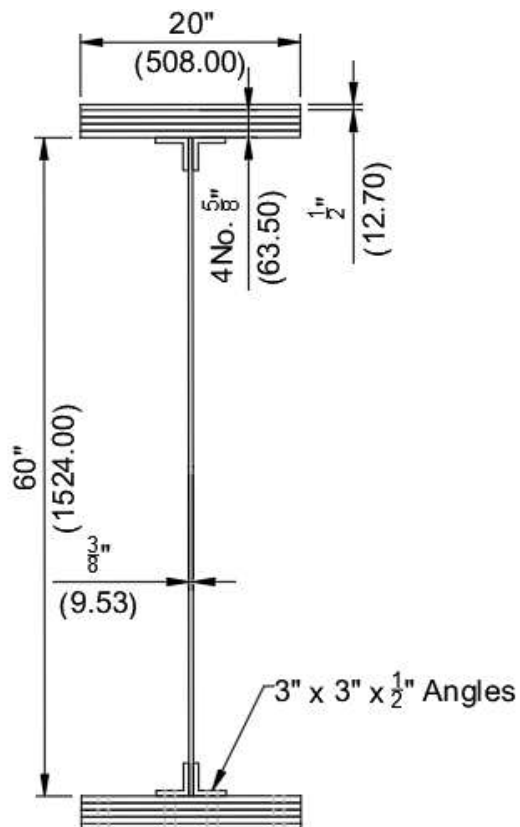


Figure 1. Edge Girder Cross Section (midspan)

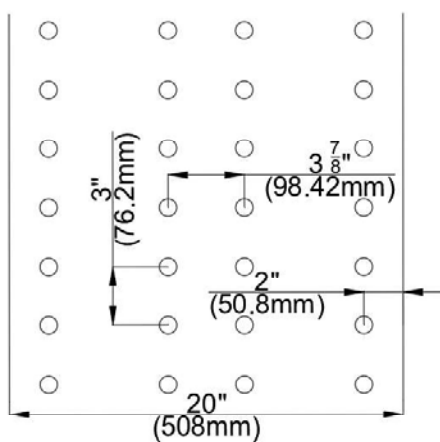


Figure 2. Edge girder rivet layout

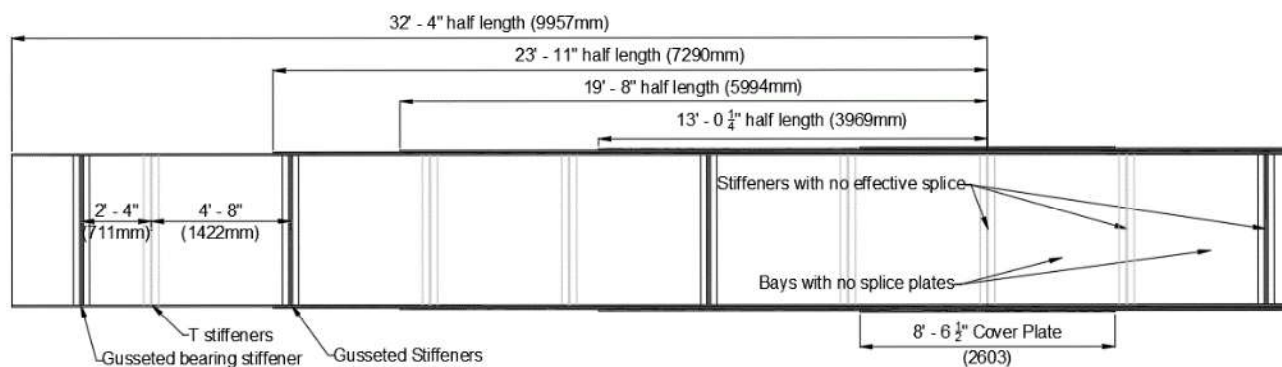


Figure 3. Edge Girder Half Elevation

The transverse girders comprise a $22\frac{1}{2}" \times \frac{3}{8}"$ web with $3" \times 3" \times \frac{1}{2}"$ angles. The shortest spanning transverse girders in the north east and south west corners do not have flange plates, only the angles (IG1 and IG18, transverse girders labelled 1 to 18 from north east to south west). The remaining girders have $12" \times \frac{1}{2}"$ flange plates. Internal girders IG4 to IG16 all have an additional $12" \times \frac{1}{2}"$ curtailment plate and IG6 to IG13 each have $12" \times \frac{1}{2}"$ cover plates. The lengths of the curtailment plates are $19' - 9"$ and the cover plates are $6' - 4\frac{3}{4}"$. The rivets are $\frac{7}{8}"$ diameter at $3\frac{3}{4}"$ pitch.

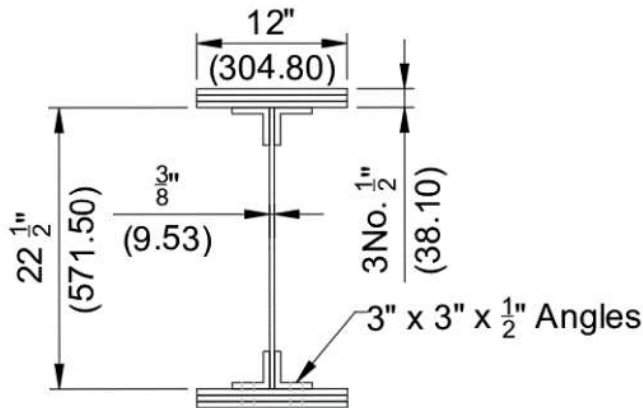


Figure 4. Internal Girder Cross Section

The transverse girders are connected to the edge girders via the stiffeners and angles at the end of the girders between the flanges. Refer to figure 5 below.

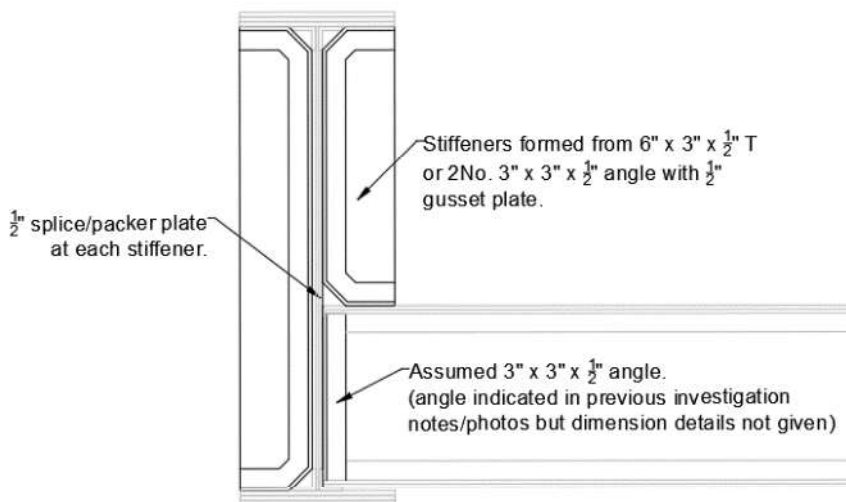


Figure 5. Internal girder to edge girder connection

Brick jack arches span between the angles of the transverse girders. The jack arches have a span of $4' - 1\frac{5}{8}"$ and a rise of $9\frac{1}{2}"$. Previous assessments have shown them as concrete backed with concrete up to the level of the internal girder top flanges.

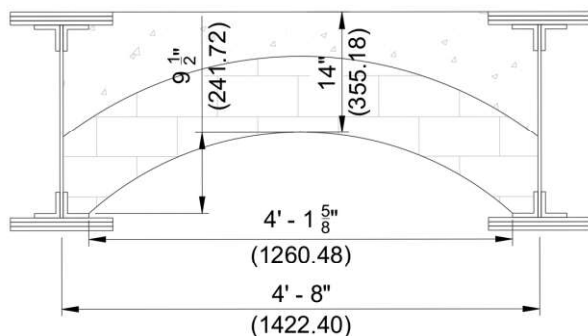


Figure 6. Jack Arch arrangement

Substructure

The substructure comprises gravity type abutments and wingwalls constructed from brick. The edge girders bear onto thick sandstone blocks.

Parapets

The parapets are constructed from plates attached to the top flanges of the edge girders.

Sketches of the plan at road level, section of the deck and elevation are included in Appendix F.

2. Information Search

2.1 Services Search

A services search was undertaken in 2021 as part of previous design works. No intrusive investigations were required as part of the survey, accordingly, an updated services search was not carried out by Jacobs. Refer to Appendix D.

2.2 Site Investigation Description and Results

A tower scaffold was erected to allow close tactile inspection of the structure soffit.

2.3 Existing Drawings

Sketches from a previous Jacobs BE4 assessment showing the connection between the edge and internal girders. Assessment drawing completed by British Rail in 1981. Refer to Appendix E.

3. Structure Condition

3.1 General

Jacobs undertook survey for inspection for BE4 assessment on Wednesday 19th October 2022. Weather conditions were overcast. Parking was available west of the structure on a wide verge. Access to the formation was gained via the embankment at the north east corner of the structure.

3.2 Structure Condition

3.2.1 Edge Girders

Both edge girders are in poor condition. Throughout the webs there are holes both below the jack arch soffits and at the level of the fill on the inside faces (Photographs 1, 2, 16 and 20). One of the holes beneath the crown of a jack arch at midspan of the north girder had been repaired with an additional plate welded on but this has also since corroded through (Photograph 21). Across the soffit of the girders there is up to 50% section loss of the exposed plate. The exposed sections of the internal angles have up to 75% section loss to each of the faces. There is total loss of the flange plate on the inside edge between the end of the angles and the edge of the curtailment plates. Refer to Figure 7 below.

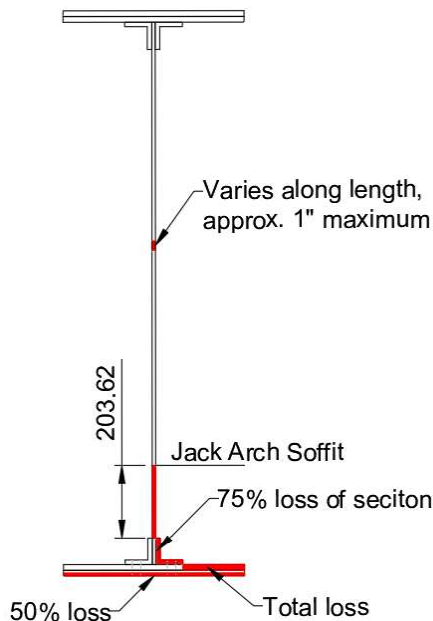


Figure 7. Edge girder – typical along length (one curtailment plate shown)

At the supports the edge girders are in fair condition apart from the underside of the bottom flange and the exposed inside faces of the webs and angles. There is up to 2mm section loss on the inside face of the web and inside angle. On the bottom flange there is 1mm loss between the outside edge and rivet line, 2mm between the rivet lines and the inside edge of the flange is severely corroded to 1mm thick. Refer to Figure 8 below.

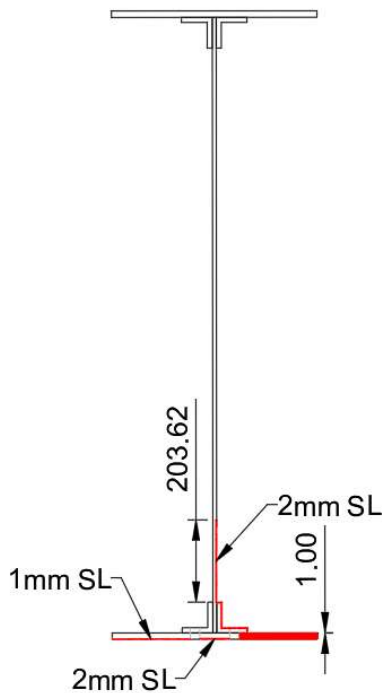


Figure 8. Edge girder at support condition

3.2.2 Internal Girders

Internal girders have been numbered IG1 to IG18 from the north east corner to the south west corner. Refer to sketch provided in Appendix F.

All of the girders are in fair to poor condition with varying degrees of corrosion and section loss.

IG1 is in poor condition. The horizontal legs of the angles that form the bottom flange of the girder have completely corroded away along the length of the girder leaving the jack arches unsupported. (Photograph 13)

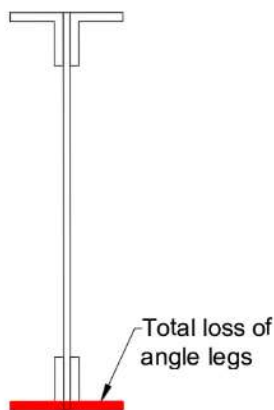


Figure 9. IG1 corrosion

IG2 is in poor condition. The bottom flange has 50% loss of the thickness with up to ½" on each end that has corroded to knife edge (1mm). (Photograph 14)

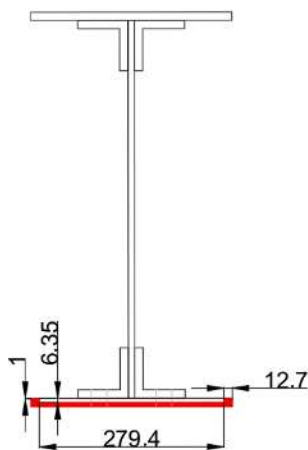


Figure 10. IG2 corrosion

IG3 is missing the full flange at the support. At midspan the residual width of the flange is 11" reducing from full thickness at the rivets to knife edge at the outer edges. (Photograph 15)

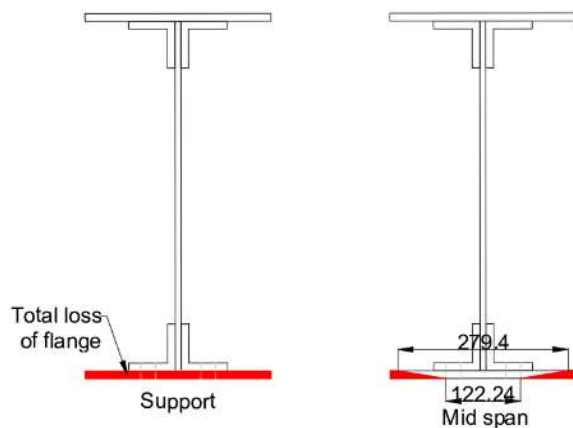


Figure 11. IG3 corrosion

IG8 is the typical case for the internal girders spanning between the edge girders. At the support there is $\frac{1}{2}$ " loss from the ends of the flange with the thickness of the flange reducing from full thickness between the rivets to knife edge. At third span (1No. additional plate) there is full loss of the end of the flange plates up to the ends of the connecting angles giving a residual width of $6\frac{3}{8}$ ". The residual thickness of the remaining plate is 3mm. At midspan the flange plate has corroded back to the end of the connecting angles. On the curtailment plate and cover plate there is only up to 1mm loss from the ends and only minor paint loss on the girder soffit. (Photographs 17 – 19)

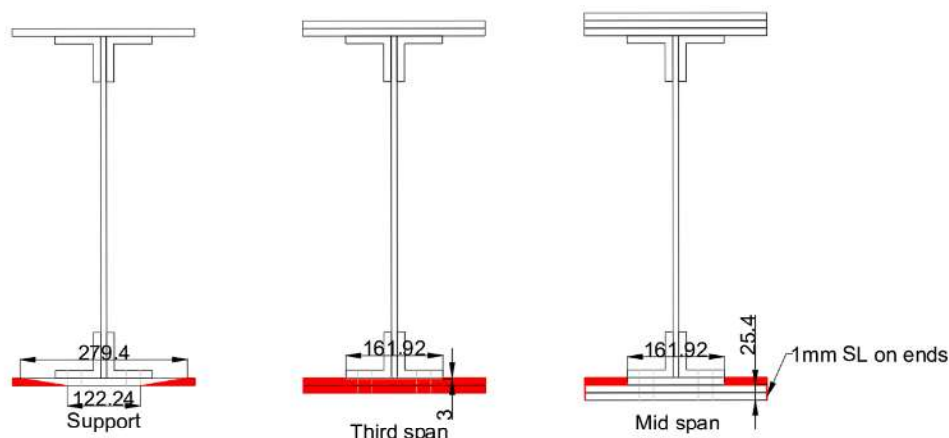


Figure 12. IG8 corrosion

3.2.3 Jack Arches

All the jack arches are in fair condition (Photograph 22). There are isolated missing bricks at the springing points (Photograph 23).

3.2.4 Abutments

Both abutments are in fair condition. There is minor algal and leachate staining throughout with some heavier staining towards the top corners on both ends. The west abutment has some ivy encroaching from ground level at the south end. (Photographs 7 and 8)

3.2.5 Wingwalls

The wingwalls are all in fair condition. There are isolated bricks with spalling up to 25mm deep. (Photographs 9 – 12)

The north east pilaster has a hairline fracture which extends from level with the top of the edge girder to 1.0m above ground level. (Photograph 24)

The south east wingwall was obscured by nettle growth during the survey and therefore inspection was limited. (Photograph 12)

The south west wingwall has spalling present across the face below the stringcourse an average depth of 15mm. There are also open joints throughout the areas with spalling. (Photographs 11)

3.2.6 Formation

The formation to both north and south is flanked by cutting slopes and overgrown with trees. (Photographs 28 and 29)

3.2.7 Parapet Screens

The parapet screens are in fair condition. The paint system has completely failed and there is surface corrosion covering the parapets. There are missing sections along the bottoms of the plates below the line of rivets where the plates meet the girder flanges. (Photographs 26 and 27)

3.2.8 Road Surface and Traffic Flow

The road surface over the structure is in fair condition with no signs of settlement or tracking over the bridge deck (Photograph 5). There are cracks in the surface at the ends of the deck with settlement across the road resulting in a minor dip just before the bridge (Photograph 25). There is some degradation to the surface over the structure.

No HGV use was observed during the survey. National speed limit of 60mph applies over the structure but practical speeds are limited by the 30mph speed limit immediately after the bridge at the west end.

4. Assessment to BE4

4.1 Methodology

Capacities of the elements were calculated using estimates of reduced section sizes where corrosion is present. A general condition factor was not applied.

The girders are wrought iron. The locations of all joints within the web plate are not known and it is suspected the plates are limited in length between stiffeners where there are no obvious splices. Where the splices are formed from a flat plate and at the stiffeners with a single line of rivets each side, they may not be effective. Therefore the girders were checked including the web plate and excluding the web plate between the ends of the connecting angles when determining properties about x-x. At each location considered for the section properties, one curtailment plate was ignored, i.e. at midspan with three additional plates, only two were included, as it is suspected that the flange plates will have multiple joint locations but exact locations are not known.

U-frame and L-frame action restraining the edge girders against lateral torsional buckling was considered. A flexibility coefficient, f , was added as a third term for calculating the virtual lateral displacement of the compression flange, in BS 153: Part 2: Clause 21c. A coefficient appropriate to the type of connection obtained from NR/GN/GN/CIV025 Fig. A42. At the gusseted stiffeners a coefficient of 0.2×10^{-4} rad/kNm was deemed appropriate.

The capacities of the wrought iron girders were checked using the permissible stress as stated in BE4 Part I Clause 304(b).

The internal girders were considered to be fully restrained by the concrete backing to the jack arches. The effective length was therefore taken as zero.

Loading was applied to the edge girders by simple statics with the load trains applied transversely for maximum effect within the carriageway positioning limits as indicated in BE4 Pt1 302. Longitudinal position of the vehicle trains was adjusted for maximum load effects at the positions under consideration.

Determination of the adequacy of the jack arches was based upon the empirical method described in Bridgeguard 3 Current Information Sheet No. 22 (Pro-forma for the empirical assessment of brick, masonry and concrete jack arches and associated ties).

The substructure was assessed qualitatively.

4.2 Results

Element: Edge Girders

Action	Location	DL & SDL Effect	Live Load Effect	Total Load Effect	Assessed Resistance	Live Load Capacity
Bending	Midspan	782.2 ton.ft	222.1 ton.ft	1,004.3 ton.ft	1,414.6 ton.ft (web incl.)	Full C&U loading
					1,349.7 ton.ft (web excl.)	Full C&U loading
Bending	IG10	659.4 ton.ft	187.2 ton.ft	846.6 ton.ft	987.7 ton.ft (web incl.)	Full C&U loading
					922.5 ton.ft (web excl.)	Full C&U loading

Action	Location	DL & SDL Effect	Live Load Effect	Total Load Effect	Assessed Resistance	Live Load Capacity
Bending	IG8	354.0 ton.ft	101.2 ton.ft	455.2 ton.ft	571.6 ton.ft (web incl.)	Full C&U* loading
					496.5 ton.ft (web excl.)	Full C&U loading
Shear	Support	57.2 ton	18.4 ton	75.6 ton	101.6 ton	Full C&U loading
Axial compression	Bearing Stiffener	57.2 ton	18.4 ton	75.6 ton	88.2 ton	Full C&U loading

**C&U loading in accordance with 'The Motor Vehicles (C&U) Regulations 1963 as amended up to 1969' This includes any 4 axle vehicles to 24 tons and specific 4 axle 28 ton vehicles and specific 4 axle articulated vehicles to 32 tons.'*

Element: Transverse Girders IG1 and IG18

Action	Location	DL & SDL Effect	Live Load Effect	Total Load Effect	Assessed Resistance	Live Load Capacity
Bending	Midspan	1.5 ton.ft	0 ton.ft	1.5 ton.ft	44.5 ton.ft	Sufficient for imposed loads
Shear	Support	1.4 ton	0 ton	1.4 ton	41.6 ton	Sufficient for imposed loads

Element: Transverse Girders IG2 and IG17

Action	Location	DL & SDL Effect	Live Load Effect	Total Load Effect	Assessed Resistance	Live Load Capacity
Bending	Midspan	5.4 ton.ft	2.3 ton.ft	7.7 ton.ft	161.6 ton.ft	Full C&U loading
	Live loads Mmax	1.6 ton.ft	4.6 ton.ft	6.2 ton.ft	161.6 ton.ft	Full C&U loading
Shear	Support	2.6 ton	6.9 ton	9.5 ton	42.5 ton	Full C&U loading

Element: Transverse Girders IG3 and IG16

Action	Location	DL & SDL Effect	Live Load Effect	Total Load Effect	Assessed Resistance	Live Load Capacity
Bending	Midspan	11.6 ton.ft	23.3 ton.ft	34.9 ton.ft	111.4 ton.ft	Full C&U loading
	Live loads Mmax	10.8 ton.ft	29.4 ton.ft	40.1 ton.ft	111.4 ton.ft	Full C&U loading
Shear	Support	3.9 ton	4.9 ton	8.8 ton	42.5 ton	Full C&U loading

Element: Transverse Girders IG4 and IG15

Action	Location	DL & SDL Effect	Live Load Effect	Total Load Effect	Assessed Resistance	Live Load Capacity
Bending	Midspan	20.5 ton.ft	23.3 ton.ft	43.8 ton.ft	107.6 ton.ft	Full C&U loading
	Live loads Mmax	20.5 ton.ft	23.8 ton.ft	44.3 ton.ft	107.6 ton.ft	Full C&U loading
Shear	Support	5.2 ton	7.6 ton	12.8 ton	42.5 ton	Full C&U loading

Element: Transverse Girders IG5 and IG14

Action	Location	DL & SDL Effect	Live Load Effect	Total Load Effect	Assessed Resistance	Live Load Capacity
Bending	Midspan	31.6 ton.ft	31.2 ton.ft	62.8 ton.ft	107.6 ton.ft	Full C&U loading
	Live loads Mmax	30.0 ton.ft	31.9 ton.ft	61.9 ton.ft	107.6 ton.ft	Full C&U loading
Shear	Support	6.5 ton	7.2 ton	13.7 ton	42.5 ton	Full C&U loading

Element: Transverse Girders IG6 and IG13

Action	Location	DL & SDL Effect	Live Load Effect	Total Load Effect	Assessed Resistance	Live Load Capacity
Bending	Midspan	45.0 ton.ft	40.5 ton.ft	85.5 ton.ft	199.8 ton.ft	Full C&U loading
Shear	Support	7.7 ton	4.9 ton	12.6 ton	42.5 ton	Full C&U loading

Element: Transverse Girders IG7 to IG12

Action	Location	DL & SDL Effect	Live Load Effect	Total Load Effect	Assessed Resistance	Live Load Capacity
Bending	Midspan	58.4 ton.ft	46.3 ton.ft	104.7 ton.ft	199.8 ton.ft	Full C&U loading
Shear	Support	8.7 ton	5.3 ton	14.0 ton	42.5 ton	Full C&U loading

Element: Jack Arches

The jack arches are compliant with Bridgeguard 3 Current Information Sheet No. 22 apart from in the corners of the structure where the bottom flanges of IG1 and IG18 have completely corroded away and the jack arches are no longer supported.

Element: Substructure

By qualitative assessment, the substructure appears to be satisfactory for full C&U loading. The defects described in Section 3.2 of this report are not considered to be detrimental to the load bearing capacity.

5. Conclusions and Recommendations

As determined by this assessment, the transverse girders supporting the carriageway and the edge girders are sufficient for full C&U loading in accordance with 'The Motor Vehicles (C&U) Regulations 1963 as amended up to 1969'. This includes any 4 axle vehicles to 24 tons and specific 4 axle 28 ton vehicles and specific 4 axle articulated vehicles to 32 tons.

The condition of the substructure is considered to be sufficient for full C&U loading.

The jack arches supporting the carriageway are suitable for full C&U loading but the jack arches springing from IG1 and IG18 are no longer adequately supported.

Though the section of the structure under the carriageway is unrestricted for full C&U loading, the unsupported jack arches beneath the verges are at risk of collapse. It is recommended that works to support the jack arches are completed as a priority.

There is minimal surplus capacity in the edge girders (between 70% and 90% utilisation) and the assessment is reliant upon judgement of the extent of corrosion, therefore should there be any deterioration in the condition of the girders it may result in a reduction in the capacity of the structure. The assessment is also reliant on the assumption of single lane loading over the bridge with no vehicle loading on areas outside of the surfaced carriageway considered. It is therefore recommended that works to repair the edge girders and prevent further deterioration are considered.

Appendix A. Photographs



1. North Elevation



2. South Elevation



3. Road approach looking east



4. Road approach looking west



5. Road over structure looking west



6. General soffit view looking west



7. East abutment



8. West abutment



9. Northeast wingwall



10. Northwest wingwall



11. Southwest wingwall



12. Southeast wingwall



13. Condition of IG1 showing missing angle legs and stained jack arch mortar



14. Condition of IG2



15. Condition of IG3 also showing curtailment of flange plate severely corroded



16. Typical edge girder condition below jack arch crowns



17. Typical condition of internal girders at support



18. Typical condition of internal girders at third span (IG8 shown)



19. Typical condition at midspan (IG8 shown)



20. Example of sever corrosion on edge girders



21. Previous repair which has since corroded though



22. Typical jack arch condition



23. Missing brick



24. Hairline fracture in north east buttress



25. Crack and settlement in road surface at west end



26. North parapet



27. South parapet



28. Formation looking north



29. Formation looking south (2021 site visit)

Appendix B. Form AA

FORM 'AA' (BRIDGES)

GC/TP0356

ELR/ Bridge No HBR3/124

Appendix: 4

Issue: 1

Revision: B (Nov 2000)

APPROVAL IN PRINCIPLE FOR ASSESSMENT

Bridge/Line Name: Little Smeaton / Hull and Barnsley

ELR/Bridge No. HBR3/124

Brief Description of Existing Bridge:

Dimensions and condition are obtained from site measurements and inspection. (See Jacobs report "HBR3/124 Assessment and Inspection Report – March 2023).

(a) Span Arrangement

The structure is a skewed single span overbridge. The clear skew span is 17.32m (56' - 10") and the clear square span is 11.84m (38' - 10") giving an angle of skew of 47°.

(b) Superstructure Type

The superstructure comprises two longitudinal wrought iron edge girders supporting 18 No girders spanning transversely which in turn support brick jack arches. The central six girders span between the edge girders, all remaining transverse girders span between the edge girders and their adjacent abutment.

The edge girders comprise 20" x $\frac{5}{8}$ " flanges plates attached to a 60" x $\frac{3}{8}$ " web plate via 3" x 3" x $\frac{1}{2}$ " angles. The rivets are $\frac{7}{8}$ " diameter at 3" pitch. There are three additional curtailment plates and a cover plate on both top and bottom flanges. The curtailment plates are all $\frac{5}{8}$ " thick and the cover plate is $\frac{1}{2}$ ". The lengths of the curtailment plates are 47' - 10", 39' - 4" and 26' - 0 $\frac{1}{2}$ ". The cover plate is 8' - 6 $\frac{1}{2}$ ". The overall length of the girders is 65' - 4". The flange plates are spliced but identification of all joint locations was not possible. The curtailment plates are also connected via additional lines of $\frac{7}{8}$ " diameter rivets at 3" pitch set 2" from the edges of the plates in line with the rivets connecting to the angles. The edge girders are placed at 26' - 8" centre to centre.

There are stiffeners placed at 4' - 8" centres along the girder with bearing stiffeners placed at 2' - 4" from the end plates. Six of the stiffeners, including the ones at the bearings, comprise a gusset plate $\frac{1}{2}$ " thick attached to the girder via 3" x 3" x $\frac{1}{2}$ " angles. The remaining stiffeners are formed from 6" x 3" x $\frac{1}{2}$ " T's.

There are splice plates on the web at 2' - 4" centres located at each stiffener and midway between, apart from across the girders at midspan. Here, there are two bays at midspan where the web plates are assumed

FORM 'AA' (BRIDGES)

GC/TP0356

ELR/ Bridge No HBR3/124

Appendix: 4

Issue: 1

Revision: B (Nov 2000)

APPROVAL IN PRINCIPLE FOR ASSESSMENT

to be 4' – 8" long terminating at the stiffener locations. The splice plates at the stiffeners are attached by an additional line of rivets each side of the stiffener except for three locations at midspan where there are only packer plates between the web and stiffener.

The transverse girders comprise 22 ½" x ¾" web with 3" x 3" x ½" angles. The shortest spanning transverse girders in the north east and south west corners do not have flange plates, only the angles IG1 and IG18, (transverse girders labelled 1 to 18 from north east to south west). The remaining girders have 12" x ½" flange plates. Internal girders IG4 to IG16 all have an additional 12" x ½" curtailment plate and IG6 to IG13 each have cover plates at midspan. The lengths of the curtailment plates are 19' – 9" and the cover plate is 6' – 4 ¾". The rivets ⅞" diameter at 3 ¾" pitch.

The transverse girders are connected to the edge girders via the stiffeners and angles at the end of the girders between the flanges.

Brick jack arches span between the angles of the transverse girder. The jack arches have a span of 4' – 1 ⅝" and a rise of 9 ½". Previous assessments show them as concrete backed with concrete up to the level of the internal girder top flanges.

(c) Substructure Type

The substructure comprises gravity type abutments and wingwalls constructed from brick. The parapets are constructed from plates attached to the top flanges of the edge girders.

(d) Planned highway works/modifications at this site

None.

(e) Road designation class and whether classed as a heavy load route

The structure carries a single lane carriageway with no markings 3.83m (12' – 7") wide. Grass verges line both sides of the road 1.96m (6' – 5") and 1.83m (6' – 0") on the north and south sides respectively. The overall width between the parapets is 7.62m (25' – 0").

Traffic flow across the bridge is low. No HGV use was observed during the survey though some agricultural vehicle use is expected due to the nature of the surrounding land and presence of entrances to crop fields adjacent to the east end of the structure.

FORM 'AA' (BRIDGES)**GC/TP0356**

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APPROVAL IN PRINCIPLE FOR ASSESSMENT

National speed limit of 60mph applies over the structure but practical speeds are limited by the 30mph speed limit immediately after the bridge at the west end.

Assessment Criteria**(a) Loadings and Speed**

The bridge is to be assessed for standard BE4 loading representative of 24 ton vehicles, with reduced loading being determined where this capacity is not reached.

(b) Codes to be used

BE4 – The Assessment of Highways Bridges for Construction and Use Vehicles, Ministry of Transport 1967 (with amendments to 1969)

BS 153: Parts 3B & 4: 1958 – Steel Girder Bridges, British Standards Institution (with amendments to 12 Sept. 1968)

(c) Proposed Method of Structural Analysis

Capacities of the elements will be calculated using estimates of reduced section sizes where corrosion is present. A general condition factor will not be applied.

The girders are wrought iron. The locations of all joints within the web plates are not known and it is suspected the plates are limited in length between stiffeners where there are no obvious splices. Where the splices are formed from a flat plate and at the stiffeners with a single line of rivets each side, they may not be effective. Therefore, initially the webs of the edge girders between the ends of the connecting angles will be ignored when determining the section properties about x-x. Should the girder be found to be deficient, a check with the web included will also be completed. At each location considered for the section properties, one curtailment plate will be ignored, i.e. at midspan with three additional plates only two will be included, as it is suspected that the flange plates will have multiple joint locations but the exact locations are not known.

There will be U-frame or L-frame action restraining the edge girders against lateral torsional buckling. A flexibility coefficient, f , will be added as a third term for calculating the virtual lateral displacement of the compression flange, in BS 153: Part 2: clause 21b. A coefficient

FORM 'AA' (BRIDGES)**GC/TP0356**

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APPROVAL IN PRINCIPLE FOR ASSESSMENT

appropriate to the type of connection will be obtained from NR/GN/CIV/025 Fig. A42. At the gusseted stiffeners a coefficient of 0.2×10^{-4} rad/kNm is appropriate and at the remaining stiffeners a coefficient of 0.5×10^{-4} rad/kNm is appropriate.

The capacities of the wrought iron girders will be checked using the permissible stress proscribed in BE4 Part I Clause 304(b).

The internal girders are considered to be fully restrained by the concrete backing to the jack arches. The effective length will therefore be taken as zero.

Loading will be applied to the edge girders by simple statics with the load train applied transversely for maximum effect within the carriageway positioning limits as indicated in BE4 Pt1 302. Longitudinal position of the vehicle trains will be adjusted to maximise load effects at the positions under consideration.

The transverse girders will be assessed for axle loads applied in accordance with BE4 Part I Clause 202 (b) using the simple distribution method in BE4 Part II Clause 302.

Determination of the adequacy of the jack arches will be based upon the empirical method described in Bridgeguard 3 Current Information Sheet No. 22 (Pro-forma for the empirical assessment of brick, masonry and concrete jack arches and associated ties).

The substructure will be assessed qualitatively.

FORM 'AA' (BRIDGES)

GC/TP0356

ELR/ Bridge No HBR3/124

Appendix: 4

Issue: 1

Revision: B (Nov 2000)

APPROVAL IN PRINCIPLE FOR ASSESSMENT

Senior Civil Engineer's Comments

None

.....

.....

.....

.....

.....

Proposed Category for Independent Check 1

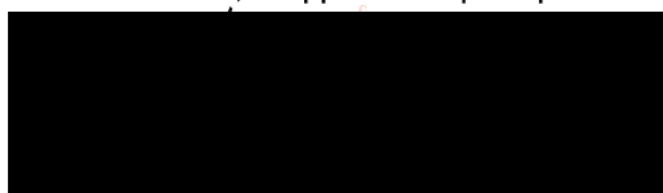
Superstructure 1

Substructure 1

Name of Checker suggested if Cat 2 or 3 Not applicable

Category 1

The above assessment, with amendments shown, is approved in principle:



Category 2 and 3

The above assessment, with amendments shown, is approved in principle:

Signed

Title

Date

Signed

Title

Date

Appendix C. Form BA

FORM 'BA' (BRIDGES)

GC/TP0356

ELR/ Bridge No HBR3/124

Appendix: 4

Issue: 1

Revision: A (Dec 2005)

CERTIFICATION FOR ASSESSMENT CHECK

Assessment Group: Jacobs UK Ltd

Bridge/Line Name: Little Smeaton / Hull and Barnsley

Category of Check: 1

ELR/ Bridge No: HBR3/124

We certify that reasonable professional skill and care have been used in the assessment of the above structure with a view to securing that:

(1) It has been assessed in accordance with the Approval in Principle as recorded on the Form AA approved on 17th March 2023.

(2) It has been checked for compliance with the following principal British Standards, Codes of Practice, BRB (Residuary) Limited technical notes and Assessment standards:

- BE4 – The Assessment of Highway Bridges for Construction and Use Vehicles 1967 (with amendments to 1969)
- BS153: Parts 3B and 4 – Steel Girder Bridges (with amendments to 12th September 1968)

List any departures from the above and additional methods or criteria adopted, with reference and justification for their acceptance.

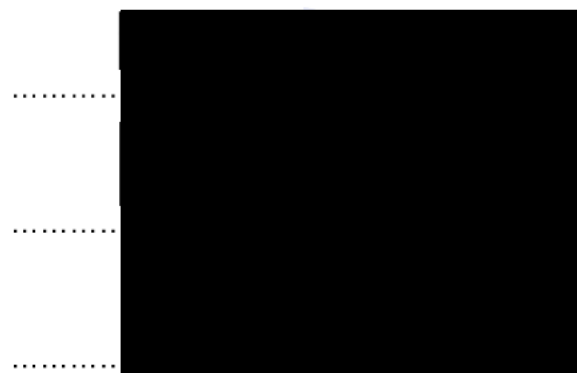
None

Category 1

Name

Signature

Date



..... Assessor

..... Assessment Checker

..... Authorised signatory of the firm of Consulting Engineers to whom Assessor/Checker is responsible.

FORM 'BA' (BRIDGES)

GC/TP0356

ELR/ Bridge No HBR3/124

Appendix: 4

Issue: 1

Revision: A (Dec 2005)

CERTIFICATION FOR ASSESSMENT CHECK

Category 2 and 3 (Note: Category 1 check must also be signed)

(a) Assessment

Name

Signature

Date

.....

Assessor

.....

Assessment Checker

.....

Authorised signatory of the
firm of Consulting
Engineers to whom
Assessor/Checker is
responsible.

(b) Check

Name

Signature

Date

.....

Assessor

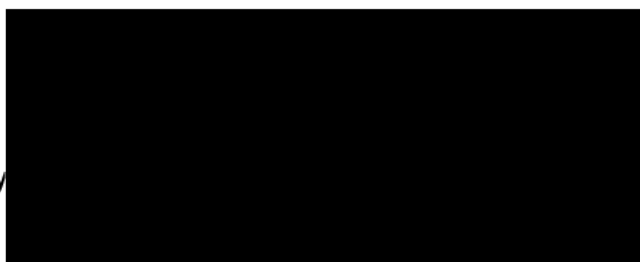
.....

Assessment Checker

.....

Authorised signatory of the
firm of Consulting
Engineers to whom
Assessor/Checker is

This Certificate is accepted by



FORM 'BAA' (BRIDGES)

GC/TP0356

ELR/ Bridge No HBR3/124

Appendix: 4

Issue: 1

Revision: A (Dec 2005)

CERTIFICATION FOR ASSESSMENT CHECK

Notification of Assessment Check

Assessment Group	Jacobs UK Ltd
Bridge Name/Road No.	Little Smeaton / unclassified
Line Name	Hull and Barnsley
ELR Code/Structure No.	HBR3/124

The above structure has been assessed and checked in accordance with Standards which are listed on the appended Form BA. A summary of the results of the assessment in terms of capacity and restrictions are as follows:-

STATEMENT OF CAPACITY

Edge Girders	Full C&U Loading* 24 tons GVW
Internal Girders	Full C&U Loading* 24 tons GVW
Jack Arches (carriageway)	Full C&U Loading* 24 tons GVW
Jack Arches (verges)	Non-compliant
Masonry Substructure	Full C&U Loading* (by qualitative assessment)

*The Motor Vehicles (Construction and Use) Regulations 1969

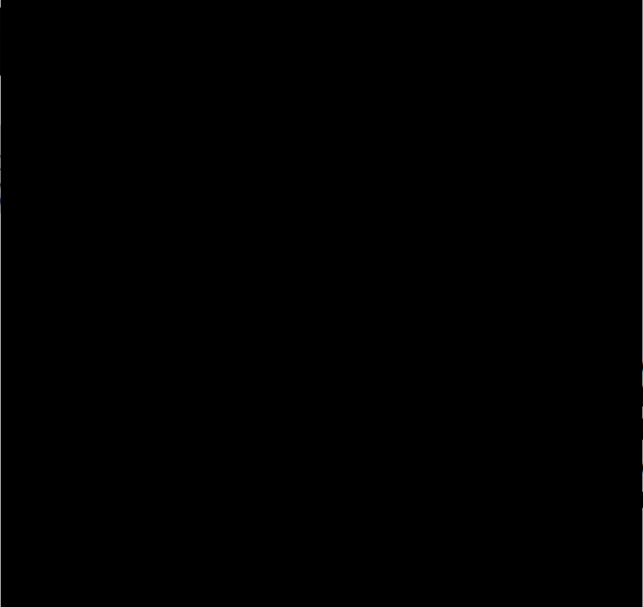
Recommended Loading Restrictions

None

Description of Structural Deficiencies and Recommended Strengthening

The jack arches springing from IG1 and IG18 no longer have adequate springing points due to severe corrosion of the girders. They are therefore at risk of collapse and measures to support the jack arches should be considered a priority.

<u>Name</u>	<u>Signature</u>	<u>Date</u>
-------------	------------------	-------------

..... 		Assessor Assessment Checker Authorised signatory of the firm of Consulting Engineers to whom Assessor/Checker is responsible.
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This Cer

Appendix D. Services Search Results



National One Call

Protecting People and Services in the UK

Online: www.national-one-call.co.uk

Call us: 0800 0853 865 (Mon-Fri, 9am-5pm)

Retriever Planning Pack

Jacobs UK Ltd

Enquiry Date	14/06/21	Enquiry	NOC/ADLYV755
Contact		Service	Retriever
Asset Owners		Enquiry Status	Complete
Price Status	Actual	Payment Status	Unpaid

Enquiry Specification

Option	What is it?	Selected
Enquiry Type	Enquiry by National One Call	✓
Express	Emailing of Plans as they arrive	✗
Fusion Plan	Compile Plans into 1 Drawing	✗
Delivery	Delivery of Completed Pack by Email	✓

Enquiry Documentation

Document	What is it?	Included
PlanToDig Enquiry	Details of Enquiry	✓
Asset Owner Contacts	List of Selected Asset Owners	✓
Text Responses	Instructions from Asset Owners	✓
CoRE	Certificate of Registered Enquiry	✓

Appendix A: Asset Owner Plans

See Plans section Cover Page for Details

Appendix B: Enquiry Accounting

Invoice	Invoice for Enquiry	✓
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For Guidance on PlanToDig

[View / download our PlanToDig Guide](#)



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Call us: 0800 0853 865 (Mon-Fri, 9am-5pm)

PlanToDig Enquiry

Jacobs UK Ltd

Date	14/06/21	Enquiry	NOC/ADLYV755
Contact		Status	Complete



Enquiry Site

Stubbs Rd, Womersley, Doncaster DN6 9BT

2 Disused Railway bridges (**Public Street / Road**)

OS Centre(Approx):453677,416756 (@137167 sq.mtrs)

Work Intentions

Intention	Start	Duration
Works Intended	2021-06-24	1 Day

Please send client waiver letter to all known service providers

Enquiry is Complete

Status: This Enquiry has Completed; you should now have all Responses from Asset Owners.

Asset Owners: Charges from 19 Asset Owners have been Confirmed

Timing: As Asset Owner Areas of Interest and Plans change frequently, please do not rely on Enquiries or Responses that are more than 30 days old.

Content: Asset Owner responses should be considered 'indicative only' until physically verified. Follow guidance in HSG(47)/NRSWA/CDM etc relating to services verification and excavation methods.



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Summary of Asset Owner Contacts for NOC/ADLYV755

Enquiry Date	14/06/21	Enquiry	NOC/ADLYV755
Selected Contacts	19	Closed	19
Est. Charges	£228.2	Act. Charges	£70

Contact List

Asset Owner	Status	Txt	Est.	Act.
Affected by Enquiry				
Electricity				
Northern Power Grid	Closed		-	-
Telecommunications				
BT Openreach	Closed		-	-
Water / Sewerage				
Yorkshire Water	Closed		£27.00	£27.00
See Response Text				
Electricity				
UTILITY ASSETS LIMITED	Closed	T	-	-
Not Affected				
Electricity				
National Grid Transmission Electricity	Closed		-	-
SSE Networks (Electricity)	Closed		£15.00	-
Gas				
Cadent (National Grid Gas)	Closed	T	-	-
National Grid Transmission (Gas)	Closed		-	-
Multi-utility				
Brookfield Utilities UK (was GTC	Closed	T	-	-
Pipeline				
Linesearch (Pipeline search service)	Closed		-	-
Telecommunications				
BSkyB Telecommunications Services Ltd	Closed	T	-	-
CityFibre	Closed	T	-	-
Colt Telecoms	Closed	T	-	-
Instalcom	Closed	T	-	-
Trafficmaster Ltd	Closed	T	-	-
Verizon Business	Closed	T	-	-
Virgin Media	Closed		£43.00	£43.00
Vodafone Limited	Closed	T	£53.20	-
Water / Sewerage				
Severn Trent Plc	Closed	T	£90.00	-



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Contact Comments

Some Asset Owners provide guidance / notes when making their Response - in the interests of safety, these should be provided to any Site Operatives along with any Plans.

Asset Owner	Comments
See Response Text	
Electricity	
UTILITY ASSETS LIMITED	If we do not reply, we do not have any apparatus in the area of your works. However, PLEASE TAKE CARE when excavating around electricity cables in the event that not all cables present may be accurately shown. We recommend you use detecting equipment to map the site before excavating and fully comply with HSG47. DO NOT assume that a cable is dead if you don't have a record of its presence. The cable must be treated as live unless PROVEN DEAD by the cable owner.  In case of emergency please contact your local electricity distribution company.
Not Affected	
Gas	
Cadent (National Grid Gas)	Searches based on your enquiry have identified that there is no record of apparatus in the vicinity of your enquiry.
Multi-utility	
Brookfield Utilities UK (was GTC)	GTC Apparatus Not Found In Search Area Our Plant Enquiry Service Ref: 1892384 Your Enquiry Ref: NOC/ADLYV755 Thank you for your enquiry concerning apparatus in the vicinity of your proposed work. GTC can confirm that we have no apparatus in the vicinity but please note that other asset owners may have and ensure all utility owners have been consulted.
Telecommunications	
BSkyB Telecommunications Services Ltd	Please be advised that Sky Telecommunications Services Ltd will not be affected by your proposal.
CityFibre	Title: NOC/ADLYV755 Comment: Please find attached a plan of the area of your interest that may contain plant which may be affected by your proposed works. The validity of this response is 6 weeks, after such time a new enquiry would need to be made.
Colt Telecoms	The negative response will be for all enquiries that the network is 50 metres or more away from the place of enquiry, We can confirm that Colt Technology Services do not have apparatus near the above location as presented on your submitted plan, if any development or scheme amendments



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	fall outside the 50 metre perimeter new plans must be submitted for review.
Instalcom	We can confirm that Lumen Technologies (formerly CenturyLink Communications UK Limited, Level 3, Global Crossing (Uk) Ltd, Global Crossing PEC, Fibernet UK Ltd and Fibrespan Ltd) do not have any apparatus within the indicated works area.
Trafficmaster Ltd	I can confirm that Trafficmaster does not have equipment installed within the boundary of the works.
Verizon Business	We have reviewed your plans and have determined that Verizon (Formally known as MCI WorldCom, MFS) has no apparatus in the areas concerned.
Vodafone Limited	Please accept this email as confirmation that Vodafone: Fixed does not have apparatus within the vicinity of your proposed works detailed below.
Water / Sewerage	
Severn Trent Plc	Not STW supply area - refer to Yorkshire Water plans / info



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Asset Owner Plans Cover

Plans received from Asset Owners will be sent to you by email; these may require specialist printers, sometimes up to A0.

Plans may be accompanied by Disclaimers / Instructions etc. which will be contained in the Asset Owner Comments document. These Comments are often as important as the plans themselves as they give direction and context to the plan.

Treat All Plans as 'Indicative' until physically verified.

Sometimes an Asset Owner may have provided a Plan even if they considered that they are 'Not Affected'.

It is also possible that an Asset Owner has responded as 'Affected' but is unable to provide a Plan of their services; this will be stated in the Asset Owner Comments.

Ensure that Asset Owner Comments accompany Plans



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Online: www.national-one-call.co.uk

Call us: 0800 0853 865 (Mon-Fri, 9am-5pm)

Certificate of Registered Enquiry (CoRE)

Enquiry Date	14/06/21	Enquiry	NOC/ADLYV755
Work Intention	Works Intended	Site Type	Public Street / Road

Asset Owners Contacted

A CoRE is issued on completion of a PlanToDig Enquiry, when all Responses have been received from the selected Asset Owners. Due to risk of changes to Asset Owner presences / their Area of Interest (AoI), and the probability of changes to plans and service presences, an Enquiry should only be considered 'good' for 30 days following Enquiry Date.

Asset Owner	Comments
Affected by Enquiry	
Electricity	
Northern Power Grid	
Telecommunications	
BT Openreach	
Water / Sewerage	
Yorkshire Water	
See Response Text	
Electricity	
UTILITY ASSETS LIMITED	✓
Not Affected	
Electricity	
National Grid Transmission Electricity	
SSE Networks (Electricity)	
Gas	
Cadent (National Grid Gas)	✓
National Grid Transmission (Gas)	
Multi-utility	
Brookfield Utilities UK (was GTC)	✓
Pipeline	
Linesearch (Pipeline search service)	
Telecommunications	
BSkyB Telecommunications Services Ltd	✓
CityFibre	✓
Colt Telecoms	✓
Instalcom	✓
Trafficmaster Ltd	✓
Verizon Business	✓



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Online: www.national-one-call.co.uk

Call us: 0800 0853 865 (Mon-Fri, 9am-5pm)

Virgin Media	
Vodafone Limited	✓
Water / Sewerage	
Severn Trent Plc	✓

**National One Call**

Protecting People and Services in the UK

Online: www.national-one-call.co.uk

Call us: 0800 0853 865 (Mon-Fri, 9am-5pm)

Jacobs UK Ltd
20 George Hudson Street
York
YO1 6WR

Invoice

NOC/ADLYV755

National One Call
1 Mill Place
Mill Road Ind.Est.
Linlithgow
EH49 7TL

A service provided by CLAIVER LIMITED T/A PlanToDig.com

Order Code: NOC/ADLYV755

Ordered by	Order Date	Your Ref
Karon Archdale	14/06/21	B38380DE B.PN.GEN.DN.EXP
Enquiry Type	Invoice Date	Payment
Multi	29/06/21	Unpaid

Enquiry Site

Stubbs Rd, Womersley, Doncaster DN6 9BT

Enquiry Price Items

Item	What is it?	Price
Enquiry Fee	Our Administration Fee	£99.00
Express	Emailing Plans as they arrive	-
E-Plan	Scanning plans to USB	-
Fusion Plan	All Plans overlaid on 1 Drawing	-
Extra Packs	Planning Pack Copies	-
Postage and Packing	Sending of Planning Pack in Post	-
ENQUIRY FEES	Total Fees for Enquiry	£99.00
Disbursements	Asset Owner Charges (Actual)	£70.00

Order

Enquiry	£169.00
VAT (20%)	£33.80
Total	£202.80

Payment

Prepayment	£0.00
Payment	£0.00
Total Paid	£0.00
Balance Payable	£202.80

Balance Invoice

Make Cheques out to PlanToDig.com To Pay by BACS Sort:83-24-25 Acc.00226099 Royal Bank of Scotland Linlithgow Ref:NOC/ADLYV755	National One Call 1 Mill Place Mill Road Ind.Estate Linlithgow EH49 7TL Tel:0800 0853 865 enquiries@national-one- call.co.uk VAT Registration: 895 5652 66	Credit Terms are 30 Days from Invoice Date (Account Holders Only) To Pay by Phone Call us on 0800 0853 865 (Mon-Fri, 9am-5pm)
--	---	---

Our Ref: Ref shown on map

Date of issue: shown on map

email: nnhc@openreach.co.uk

Dear Customer,

NR & SW ACT 1991 – PROPOSED WORKS AT: Stubbs Rd, Womersley.

Prior to commencement of work: For free onsite guidance and accurate up to date location of BT Apparatus please contact our Plant Protection Service by the following methods:-

Email the Click Before You Dig Team CBYD@openreach.co.uk

Visit the Click Before You Dig Website www.openreach.co.uk/cbyd

Thank you for your request of **NOC/ADLYV755** describing the above proposals.

Enclosed are copies of our drawings marked up to show the approximate locations of BT apparatus in the immediate vicinity of your works. It is intended for general guidance only. No guarantee is given of its accuracy.

The drawings are valid for 90 days from the date of issue and should not be relied upon after this time period has expired.

When planning excavation work or other works near to BT apparatus, please be mindful our apparatus may exist at various depths and may deviate from the marked route.

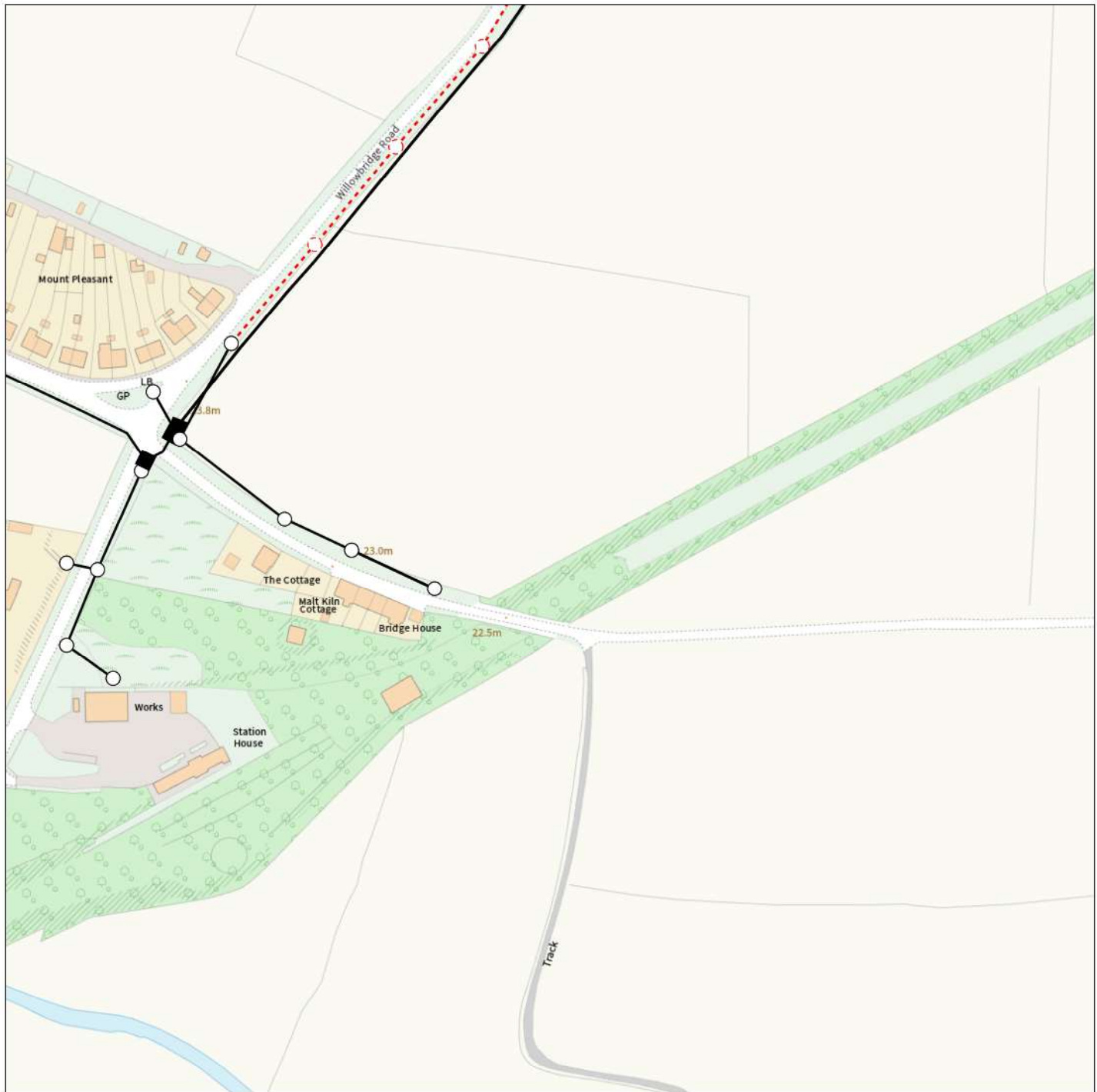
To avoid damage it is recommended that mechanical excavators or borers are not used within 600mm of BT apparatus. If scaffolding is erected, please ensure that our equipment is not enclosed, blocked, covered or otherwise obstructed by the scaffolding.

In the event of BT apparatus being in the area of your works we recommend that your plant/vehicle crossing is either resited, or apply for a budget estimate by submitting detailed plans to our Network Relocation Team at <https://www.ournetwork.openreach.co.uk/altering-our-network.aspx>

Yours faithfully,



Maps by email Plant Information Reply



IMPORTANT WARNING

Information regarding the location of BT apparatus is given for your assistance and is intended for general guidance only. No guarantee is given of its accuracy. It should not be relied upon in the event of excavations or other works being made near to BT apparatus which may exist at various depths and may deviate from the marked route.



openreach

CLICK BEFORE YOU DIG

FOR PROFESSIONAL FREE ON SITE ASSISTANCE PRIOR TO COMMENCEMENT OF EXCAVATION WORKS INCLUDING LOCATE AND MARKING SERVICE

email cbyd@openreach.co.uk

ADVANCE NOTICE REQUIRED
(Office hours: Monday - Friday 08.00 to 17.00)
www.openreach.co.uk/cbyd

Accidents happen

If you do damage any Openreach equipment please let us know by calling 0800 023 2023 (opt 1 + opt 1) and we can get it fixed ASAP

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by permission of Ordnance Survey on behalf of the
Controller of Her Majesty's Stationary Office
(C) Crown Copyright British Telecommunications plc 100028040

KEY TO BT SYMBOLS

	Planned	Live	Change Of State	+	Hatchings	
PCP			Split Coupling		Built	
Pole			Duct Tee		Planned	
Box			Building		Inferred	
Manhole			Kiosk		Duct	
Cabinet			Other proposed plant is shown using dashed lines. BT Symbols not listed above may be disregarded. Existing BT Plant may not be recorded. Information valid at time of preparation. Maps are only valid for 90 days after the date of publication.			
	Pending Add	In Place	Pending Remove	Not In Use		
Power Cable						
Power Duct				N/A		

BT Ref : BAP12248B

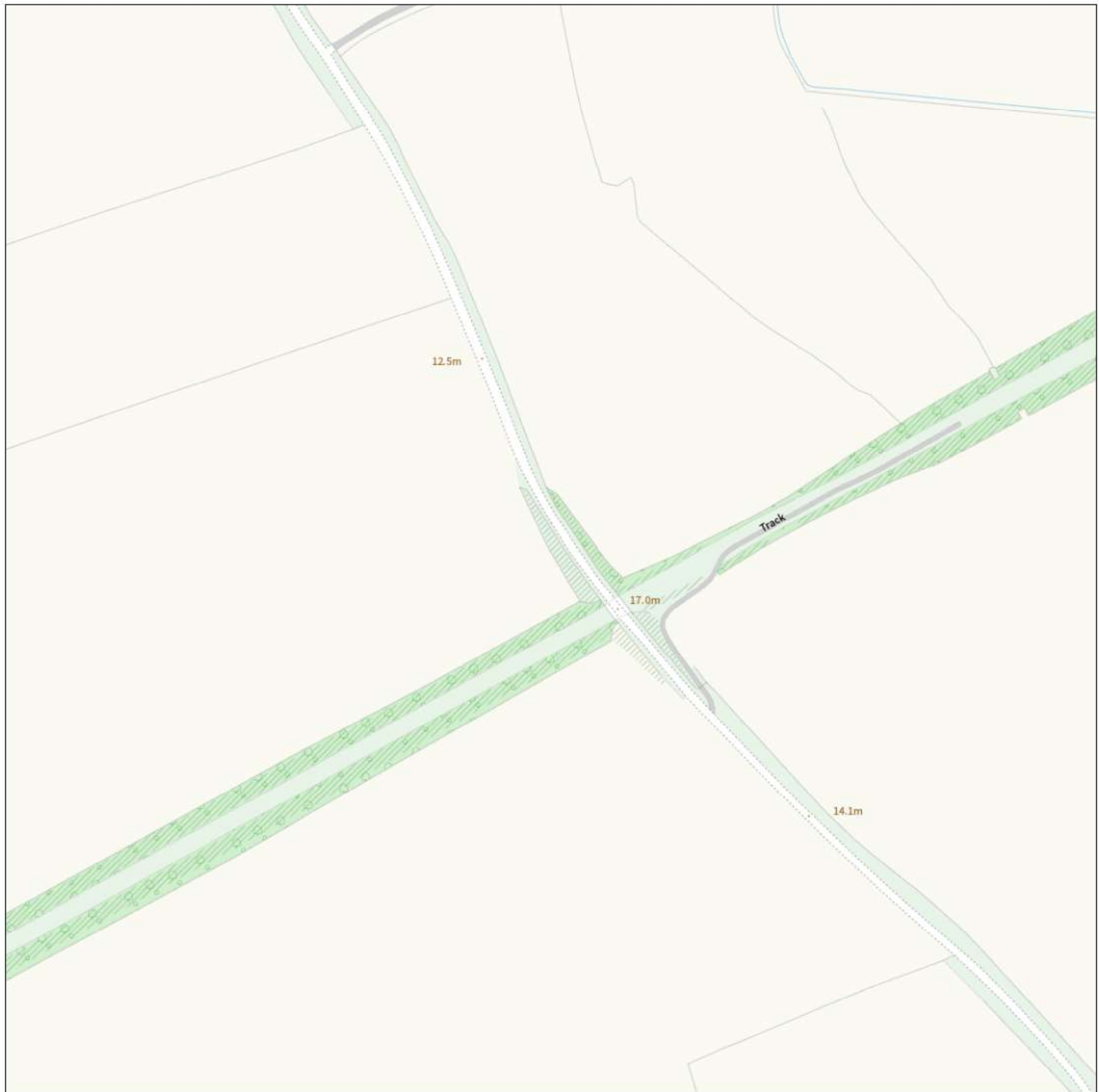
Map Reference : (centre) SE5324916504

Easting/Northing : (centre) 453249,416504

Issued : 15/06/2021 12:24:30

WARNING: IF PLANNED WORKS FALL INSIDE HATCHED AREA IT IS ESSENTIAL BEFORE PROCEEDING THAT YOU CONTACT THE NATIONAL NOTICE HANDLING CENTRE. PLEASE SEND E-MAIL TO: nnhc@openreach.co.uk

Maps by email Plant Information Reply



IMPORTANT WARNING

Information regarding the location of BT apparatus is given for your assistance and is intended for general guidance only. No guarantee is given of its accuracy. It should not be relied upon in the event of excavations or other works being made near to BT apparatus which may exist at various depths and may deviate from the marked route.



openreach

CLICK BEFORE YOU DIG

FOR PROFESSIONAL FREE ON SITE ASSISTANCE PRIOR TO COMMENCEMENT OF EXCAVATION WORKS INCLUDING LOCATE AND MARKING SERVICE

email cbyd@openreach.co.uk

ADVANCE NOTICE REQUIRED
(Office hours: Monday - Friday 08.00 to 17.00)
www.openreach.co.uk/cbyd

Accidents happen

If you do damage any Openreach equipment please let us know by calling 0800 023 2023 (opt 1 + opt 1) and we can get it fixed ASAP

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KEY TO BT SYMBOLS

	Planned	Live	Change Of State	+	Hatchings	
PCP			Split Coupling		Built	
Pole			Duct Tee		Planned	
Box			Building		Inferred	
Manhole			Kiosk		Duct	
Cabinet			Other proposed plant is shown using dashed lines. BT Symbols not listed above may be disregarded. Existing BT Plant may not be recorded. Information valid at time of preparation. Maps are only valid for 90 days after the date of publication.			
	Pending Add	In Place	Pending Remove	Not In Use		
Power Cable						
Power Duct				N/A		

BT Ref : BT112258M

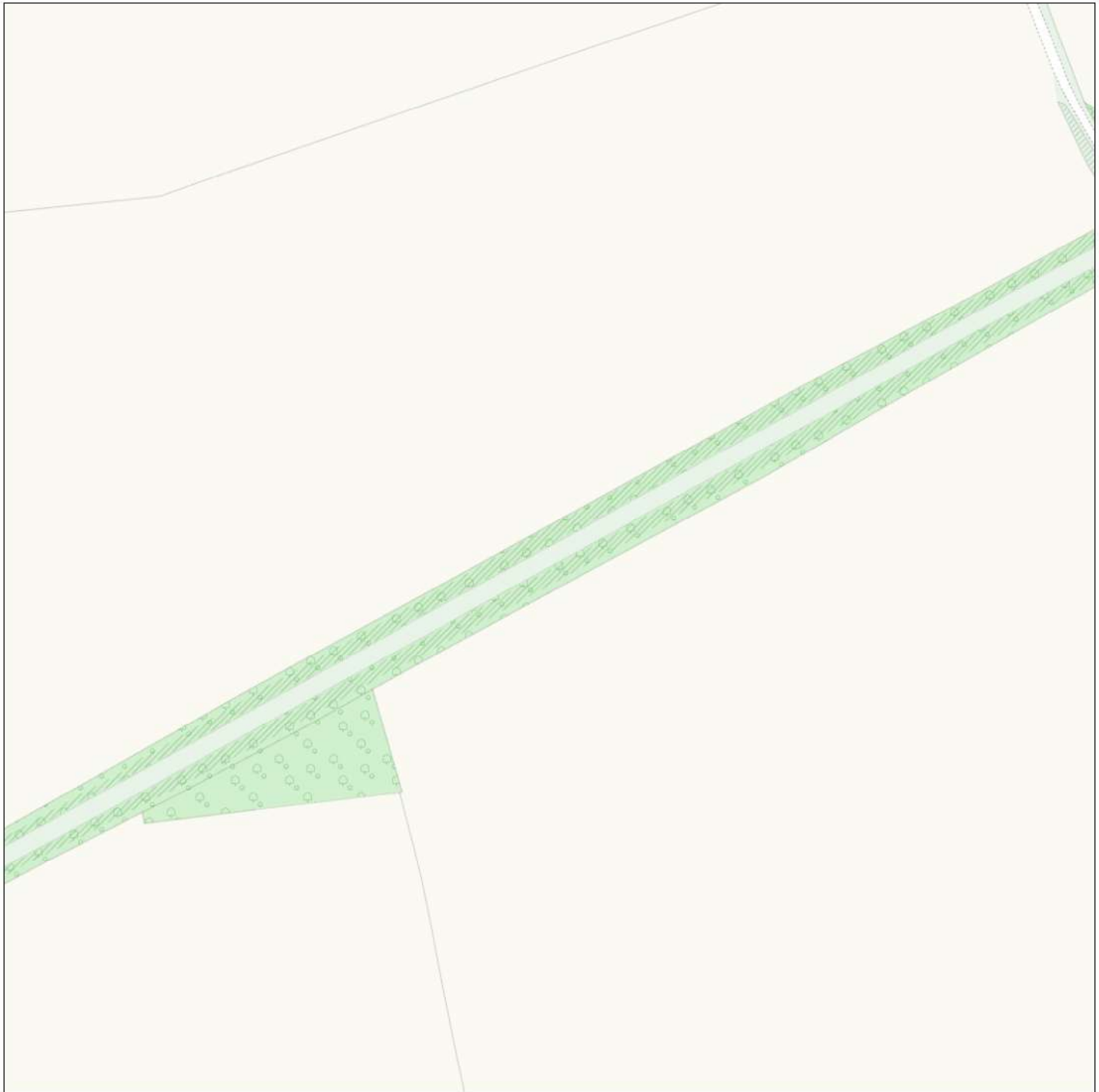
Map Reference : (centre) SE5411616999

Easting/Northing : (centre) 454116,416999

Issued : 15/06/2021 12:25:49

WARNING: IF PLANNED WORKS FALL INSIDE HATCHED AREA IT IS ESSENTIAL BEFORE PROCEEDING THAT YOU CONTACT THE NATIONAL NOTICE HANDLING CENTRE. PLEASE SEND E-MAIL TO: nnhc@openreach.co.uk

Maps by email Plant Information Reply



IMPORTANT WARNING

Information regarding the location of BT apparatus is given for your assistance and is intended for general guidance only. No guarantee is given of its accuracy. It should not be relied upon in the event of excavations or other works being made near to BT apparatus which may exist at various depths and may deviate from the marked route.



openreach

CLICK BEFORE YOU DIG

FOR PROFESSIONAL FREE ON SITE ASSISTANCE PRIOR TO COMMENCEMENT OF EXCAVATION WORKS INCLUDING LOCATE AND MARKING SERVICE

email cbyd@openreach.co.uk

ADVANCE NOTICE REQUIRED
(Office hours: Monday - Friday 08.00 to 17.00)
www.openreach.co.uk/cbyd

Accidents happen

If you do damage any Openreach equipment please let us know by calling 0800 023 2023 (opt 1 + opt 1) and we can get it fixed ASAP

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Controller of Her Majesty's Stationary Office
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KEY TO BT SYMBOLS

	Planned	Live	Change Of State	+	Hatchings	
PCP			Split Coupling		Built	
Pole			Duct Tee		Planned	
Box			Building		Inferred	
Manhole			Kiosk		Duct	
Cabinet			Other proposed plant is shown using dashed lines. BT Symbols not listed above may be disregarded. Existing BT Plant may not be recorded. Information valid at time of preparation. Maps are only valid for 90 days after the date of publication.			
	Pending Add	In Place	Pending Remove	Not In Use		
Power Cable						
Power Duct				N/A		

BT Ref : DHZ12257X

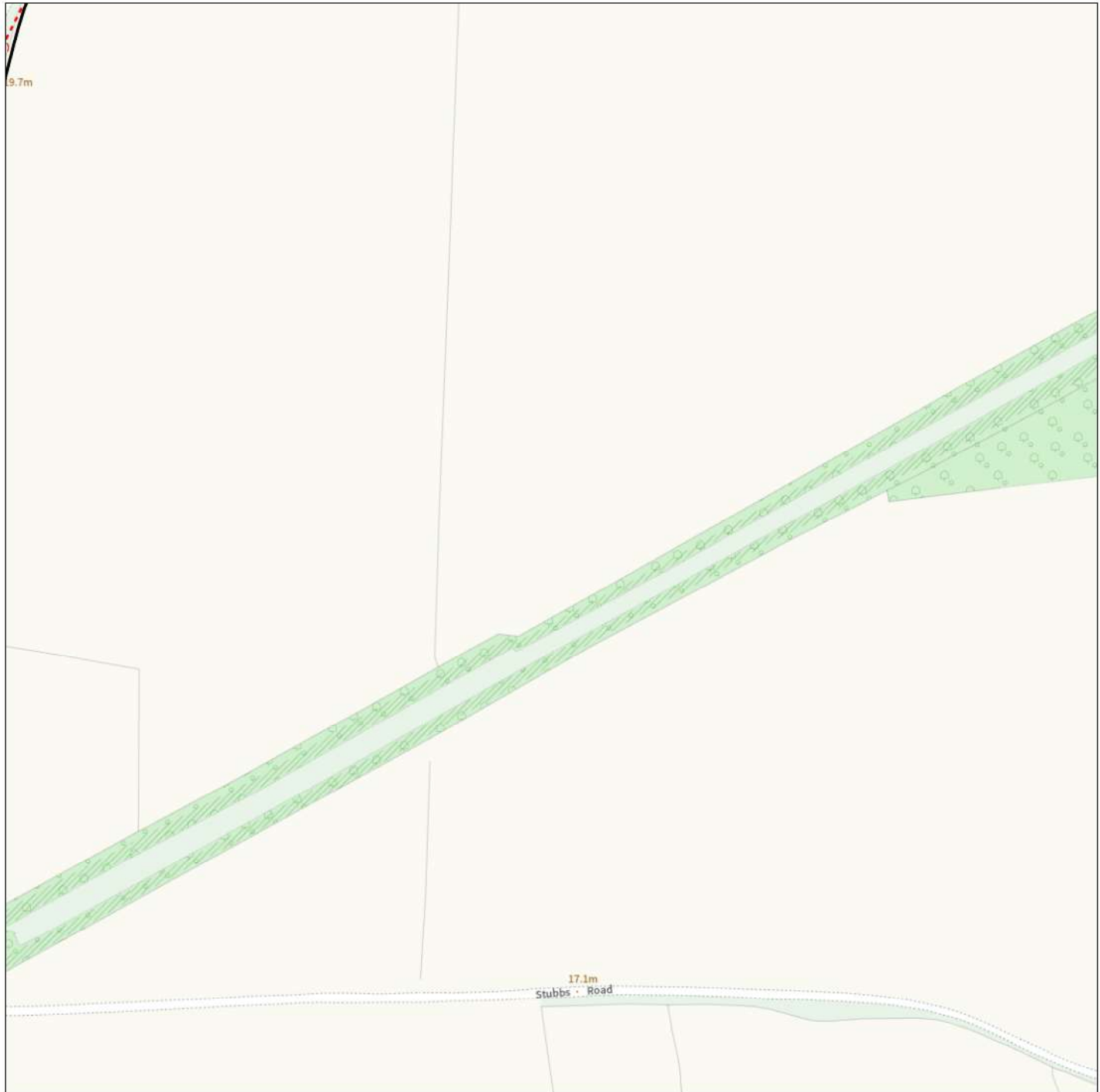
Map Reference : (centre) SE5386916823

Easting/Northing : (centre) 453869,416823

Issued : 15/06/2021 12:25:22

WARNING: IF PLANNED WORKS FALL INSIDE HATCHED AREA IT IS ESSENTIAL BEFORE PROCEEDING THAT YOU CONTACT THE NATIONAL NOTICE HANDLING CENTRE. PLEASE SEND E-MAIL TO: nnhc@openreach.co.uk

Maps by email Plant Information Reply



IMPORTANT WARNING

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openreach

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FOR PROFESSIONAL FREE ON SITE ASSISTANCE PRIOR TO COMMENCEMENT OF EXCAVATION WORKS INCLUDING LOCATE AND MARKING SERVICE

email cbyd@openreach.co.uk

ADVANCE NOTICE REQUIRED
(Office hours: Monday - Friday 08.00 to 17.00)
www.openreach.co.uk/cbyd

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KEY TO BT SYMBOLS

	Planned	Live	Change Of State	+	Hatchings	
PCP			Split Coupling		Built	
Pole			Duct Tee		Planned	
Box			Building		Inferred	
Manhole			Kiosk		Duct	
Cabinet			Other proposed plant is shown using dashed lines. BT Symbols not listed above may be disregarded. Existing BT Plant may not be recorded. Information valid at time of preparation. Maps are only valid for 90 days after the date of publication.			
	Pending Add	In Place	Pending Remove	Not In Use		
Power Cable						
Power Duct				N/A		

BT Ref : LPS12244I

Map Reference : (centre) SE5352916675

Easting/Northing : (centre) 453529,416675

Issued : 15/06/2021 12:25:04

WARNING: IF PLANNED WORKS FALL INSIDE HATCHED AREA IT IS ESSENTIAL BEFORE PROCEEDING THAT YOU CONTACT THE NATIONAL NOTICE HANDLING CENTRE. PLEASE SEND E-MAIL TO: nnhc@openreach.co.uk

National OneCall
National One Call
National One Call
1 Mill Place
Mill Road Industrial Estate
Linlithgow Bridge
West Lothian
EH49 7TL

Plant Protection
Cadent
Block 1; Floor 1
Brick Kiln Street
Hinckley
LE10 0NA
E-mail: plantprotection@cadentgas.com
Telephone: +44 (0)800 688588

National Gas Emergency Number:
0800 111 999*

National Grid Electricity Emergency Number:
0800 40 40 90*

* Available 24 hours, 7 days/week.
Calls may be recorded and monitored.

www.cadentgas.com

Date: 17/06/2021

Our Ref: XX_XX_3SWP_839286

Your Ref: NOC/ADLYV755

RE: Proposed Works, Stubbs Road, Womersley, Doncaster DN6 9BT

Thank you for your enquiry which was received on 14/06/2021.

An assessment has been carried out with respect to Cadent Gas Limited, National Grid Electricity Transmission plc's and National Grid Gas Transmission plc's apparatus. Please note it does not cover the items listed in the section "Your Responsibilities and Obligations", including gas service pipes and related apparatus.

For details of Network areas please see the Cadent website (<http://cadentgas.com/Digging-safely/Dial-before-you-dig>) or the enclosed documentation.

Searches based on your enquiry have identified that there is no record of apparatus in the vicinity of your enquiry.

As your works are at a "proposed" stage, any maps and guidance provided are for information purposes only. This is not approval to commence work. You must submit a "Scheduled Works" enquiry at the earliest opportunity and failure to do this may lead to disruption to your plans and works. Plant Protection will endeavour to provide an initial assessment within 14 days of receipt of a Scheduled Works enquiry and dependent on the outcome of this, further consultation may be required.

In any event, for safety and legal reasons, works must not be carried out until a Scheduled Works enquiry has been completed and final response received.

Your Responsibilities and Obligations

The "Assessment" Section below outlines the detailed requirements that must be followed when planning or undertaking your scheduled activities at this location.

It is your responsibility to ensure that the information you have submitted is accurate and that all relevant documents including links are provided to all persons (either direct labour or contractors) working for you near Cadent and/or National Grid's apparatus, e.g. as contained within the Construction (Design and Management) Regulations.

This assessment solely relates to Cadent Gas Limited, National Grid Electricity Transmission plc (NGET) and National Grid Gas Transmission plc (NGGT) and apparatus. This assessment does **NOT** include:

- Cadent and/or National Grid's legal interest (easements or wayleaves) in the land which restricts activity in proximity to Cadent and/or National Grid's assets in private land. You must obtain details of any such restrictions from the landowner in the first instance and if in doubt contact Plant Protection.
- Gas service pipes and related apparatus
- Recently installed apparatus
- Apparatus owned by other organisations, e.g. other gas distribution operators, local electricity companies, other utilities, etc.

It is **YOUR** responsibility to take into account whether the items listed above may be present and if they could be affected by your proposed activities. Further "Essential Guidance" in respect of these items can be found on either the [National Grid](#) or [Cadent](#) website.

This communication does not constitute any formal agreement or consent for any proposed development work; either generally or with regard to Cadent and/or National Grid's easements or wayleaves nor any planning or building regulations applications.

Cadent Gas Limited, NGGT and NGET or their agents, servants or contractors do not accept any liability for any losses arising under or in connection with this information. This limit on liability applies to all and any claims in contract, tort (including negligence), misrepresentation (excluding fraudulent misrepresentation), breach of statutory duty or otherwise. This limit on liability does not exclude or restrict liability where prohibited by the law nor does it supersede the express terms of any related agreements.

If you require further assistance please contact the Plant Protection team via e-mail ([click here](#)) or via the contact details at the top of this response.

Yours faithfully

Plant Protection Team

GUIDANCE

Standard Guidance

Essential Guidance document:

<http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=8589934982>

General Guidance document:

<http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=35103>

Excavating Safely in the vicinity of gas pipes guidance (Credit card):

<http://www.nationalgrid.com/NR/rdonlyres/A3D37677-6641-476C-9DDA-E89949052829/44257/ExcavatingSafelyCreditCard.pdf>

Excavating Safely in the vicinity of electricity cables guidance (Credit card):

<http://www.nationalgrid.com/NR/rdonlyres/35DDEC6D-D754-4BA5-AF3C-D607D05A25C2/44858/ExcavatingSafelyCreditCardelectricitycables.pdf>

Copies of all the Guidance Documents can also be downloaded from the [National Grid](#) and [Cadent](#) websites.

ENQUIRY SUMMARY

Received Date

14/06/2021

Your Reference

NOC/ADLYV755

Location

Centre Point: 453676, 416732

X Extent: 952

Y Extent: 542

Postcode: DN6 9BT

Location Description: Stubbs Road, Womersley, Doncaster DN6 9BT

Map Options

Paper Size: A3

Orientation: LANDSCAPE

Requested Scale: 2500

Actual Scale: N/A

Real World Extents: N/A

Recipients

pprsteam@cadentgas.com

Enquirer Details

Organisation Name: National One Call

Contact Name: National OneCall

Email Address: retriever@national-one-call.co.uk

Telephone: 08000853865

Address: National One Call, 1 Mill Place, Mill Road Industrial Estate, Linlithgow Bridge, West Lothian, EH49 7TL

Description of Works

plans

Enquiry Type

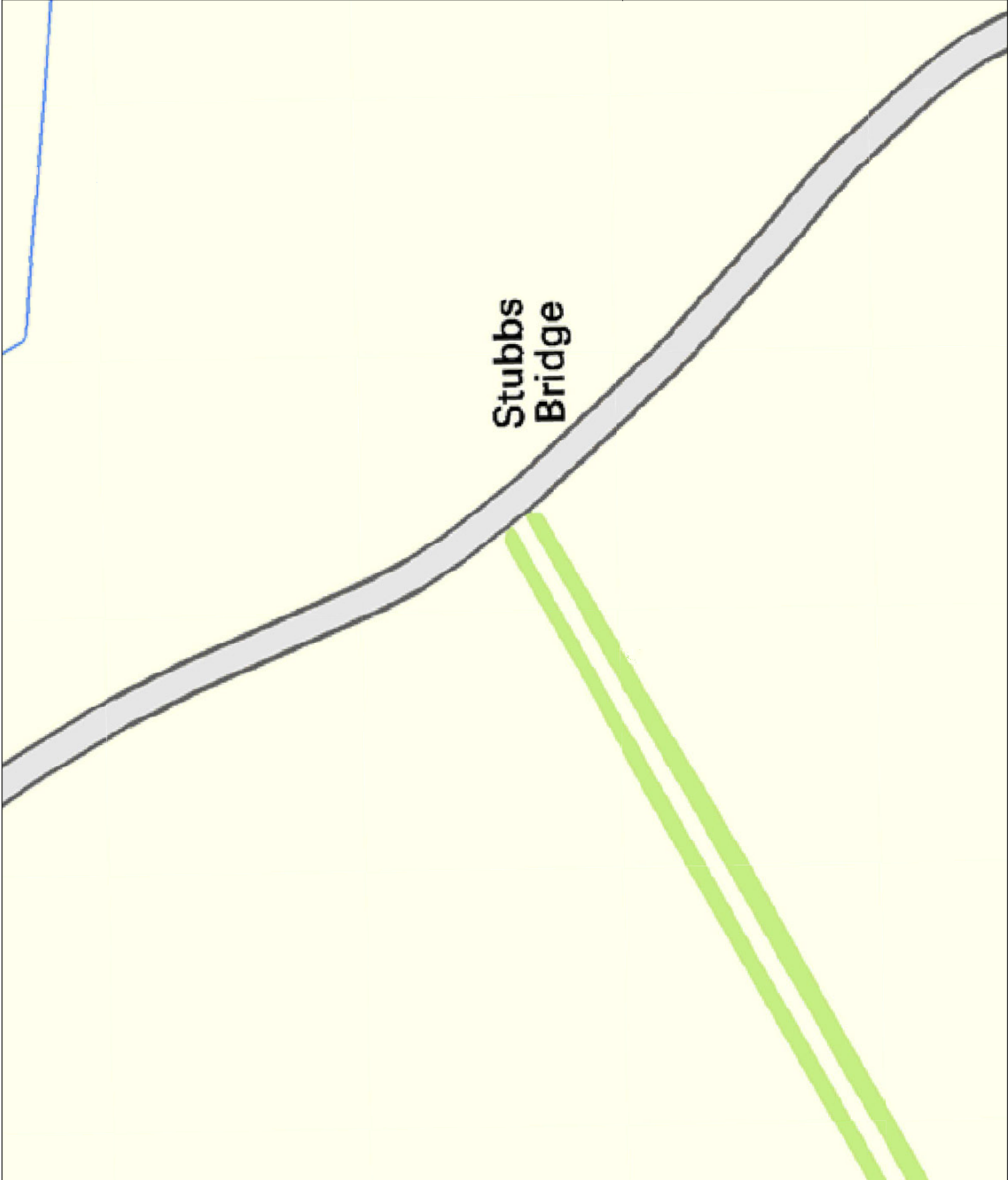
Proposed Works

Activity Type

General Excavation

Work Types

Work Type: Plans Only



bitmap_layout_select_raster

LEGEND

- EXISTING PLANT
- EXISTING PLANT

bitmap_layout_select_raster

Head Office	Asset Office
CityFibre Holdings Ltd	CityFibre Holdings Ltd,
15 Bedford Street,	Rutherford House,
London,	Birchwood,
WC2E 9HE	Warrington,
	WA3 6ZH
Tel: 0845 293 0774	
Web: www.cityfibre.com	Email: asset.team@cityfibre.com

Disclaimer:

Information shown on this plan is for general guidance only. No warranty is made as to its accuracy. This plan must not be solely relied upon in the event of excavation or other works being carried out in the vicinity of Cityfibre plant. No liability of any kind is accepted by Cityfibre, its agents or servants for any error, omission, discrepancy or deviation. This information is valid for the date printed.

Project
Plant Enquiry

Drawing
Existing Plant

Drawn by:

smallworld

Date: 15/06/2021

Drawing No.

CFH_EP_000001

Revision

001

Scale: 1:2500

A4



LEGEND

- EXISTING PLANT
- EXISTING PLANT

Head Office
CityFibre Holdings Ltd
15 Bedford Street,
London
WC2E 9HE
Tel: 0845 293 0774
Web: www.cityfibre.com

Asset Office
CityFibre Holdings Ltd,
Rutheford House,
Birchwood,
Warrington,
WAS 6ZH
Email: asset.team@cityfibre.com

Disclaimer:

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Project
Plant Enquiry

Drawing
Existing Plant

Drawn by:
smallworld

Date: 15/06/2021

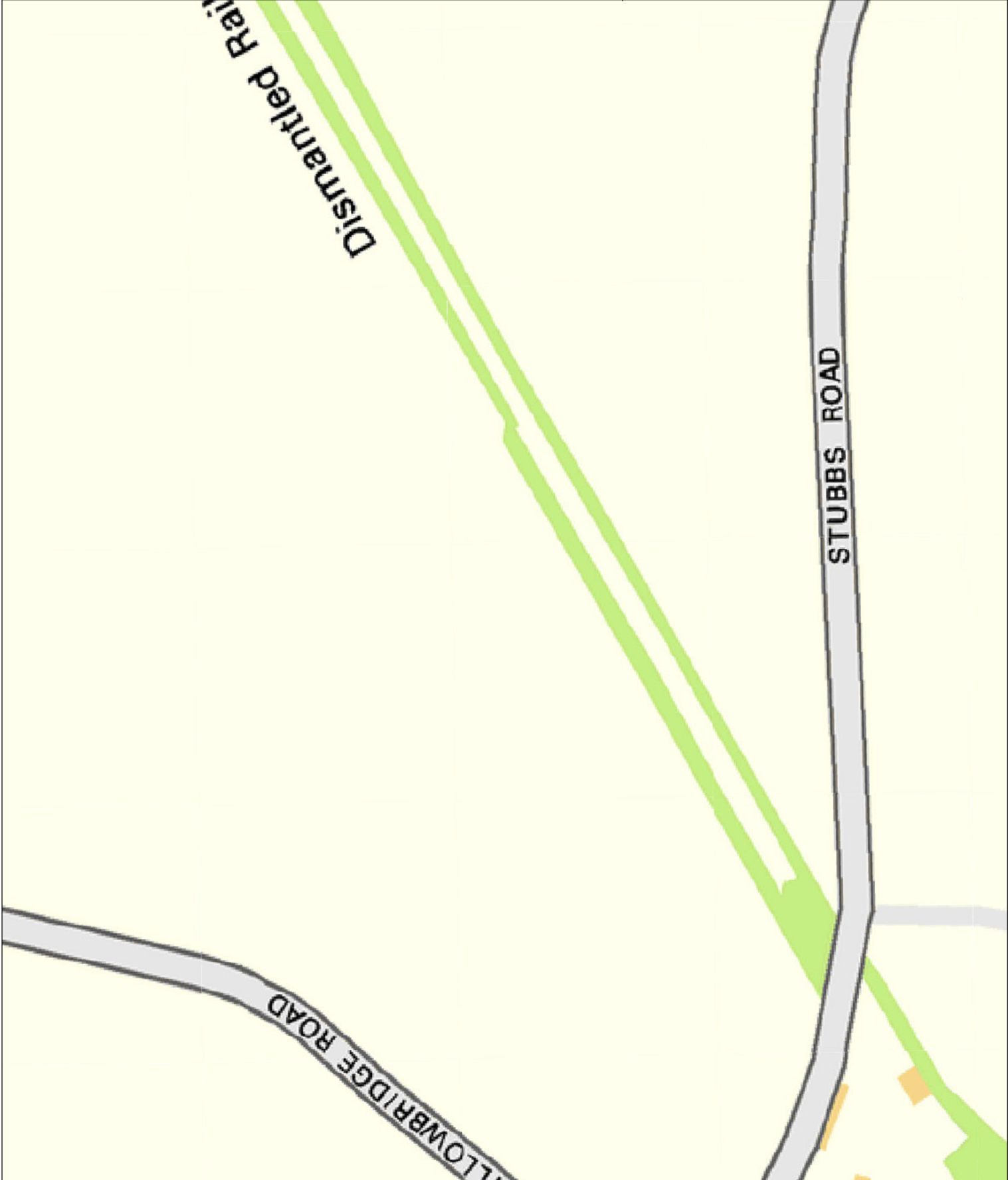
Drawing No.
CFH_EP_000001

Revision
001

Scale: 1:2500

A4





LEGEND

EXISTING PLANT

EXISTING PLANT

Head Office

CityFibre Holdings Ltd

15 Bedford Street,

London

WC2E 9HE

WC2E 9HE

WAS 6ZH

Tel: 0845 293 0774

Web: www.cityfibre.com

Asset Office

CityFibre Holdings Ltd

Rutherford House,

Birchwood,

Warrington,

WAS 6ZH

Email: asset.team@cityfibre.com

Disclaimer:

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Project

Plant Enquiry

Drawing

Existing Plant

Drawn by:

smallworld

Date: 15/06/2021

Drawing No.

CFH_EP_000001

Revision

001

LEGEND



EXISTING PLANT



EXISTING PLANT

Head Office
CityFibre Holdings Ltd
15 Bedford Street,
London,
WC2E 9HE

Tel: 0845 293 0774
Web: www.cityfibre.com

Asset Office
CityFibre Holdings Ltd.
Rutherford House,
Birchwood,
Warrington,
WA3 6ZH
Email: asset.team@cityfibre.co.uk

Disclaimer:

Information shown on this plan is for general guidance only. No warranty is made as to its accuracy. This plan must not be solely relied upon in the event of excavation or other works being carried out in the vicinity of Cylfryne plant.

No liability of any kind is accepted by Cylfryne, its agents or servants for any error, omission, discrepancy or deviation. This information is valid for the date printed.

Project

Plant Enquiry

Drawing

Existing Plant

Drawn by:

smallworld

Date: 15/06/2021

Drawing No.

CFH EP 000001

Revision

001

Scale: 1:2500

A4





Date: 16/06/2021

Tel: 0191 229 4294
Northern Powergrid Records Information Centre
New York Road
Shiremoor
Newcastle Upon Tyne
NE27 0LP

Enquiry No: SD542917
Scheme Reference: NOC/ADLYV755

Thank you for using Northern Powergrid's online Safedig service for your planned works.

Your plan has been generated using our most up to date information. Due to the nature of the information we hold and how often works on the network are carried out, we can only guarantee this plan at the time of generation. We will do our best to notify you if we update the information in your indicated area, but you should endeavour to obtain an up to date plan whenever you commence your works.

The map that has been provided to you will show all the relevant Northern Powergrid electricity cables that are in your indicated dig site, we have included some of the surrounding area as well in case your dig extends further than you previously thought. At any point you may re-apply for your plan to increase the indicated area using the previously submitted details. This plan will be valid for 30 days from the point at which it became available to you.

The enclosed mains records only give the approximate location of known Northern Powergrid apparatus in the area. Great care is therefore needed and all cables and overhead lines must be assumed to be live.

Please note that while all efforts are made to ensure the accuracy of the data, no guarantee can be given. We would refer you to the Health & Safety Executive's publication HS(G)47 "Avoiding Danger From Underground Services" which emphasises that:

- Plans must only be used as a guide in the location of underground cables. The use of a suitable cable-tracing device is essential and careful hand digging of trial holes must be carried out to positively identify and mark the exact route of the cable. You should also bear in mind that a cable is unmistakably located only when it has been safely exposed.
- Cable depths are not generally indicated on our records and can vary considerably even when shown.
- Great caution must be exercised at all times when using mechanical plant. Careful trial digging should always be carried out on the whole route of the planned excavation to ascertain if cables exist.

The Health & Safety executive have another publication, GS6 "Avoidance of Danger from Overhead Electric Lines" that you should be aware of if your work is near overhead powerlines. Both of these documents provide comprehensive guidance for observance of statutory duties under the Electricity at Work Regulations 1989 and the Health & Safety at Work Act 1974. Our provision of these records is based upon the assumption that people using them will have sufficient competence to interpret the information given. Any damage or injury caused will be the responsibility of the organization concerned who will be charged for any repairs.

Please note ground cover must not be altered either above our cables or below overhead lines, in addition no trees should be planted within 3 metres of existing underground cables or 10 metres of overheadlines. All our apparatus is legally covered by a wayleaves agreement, lease or deed or alternatively protected under

the Electricity Act 1989. Should any alteration/diversion of our Company's apparatus be necessary to allow your work to be carried out, budget costs can be provided by writing to Network Connections, Alix House, Falcon Court, Stockton On Tees, TS18 3TU.

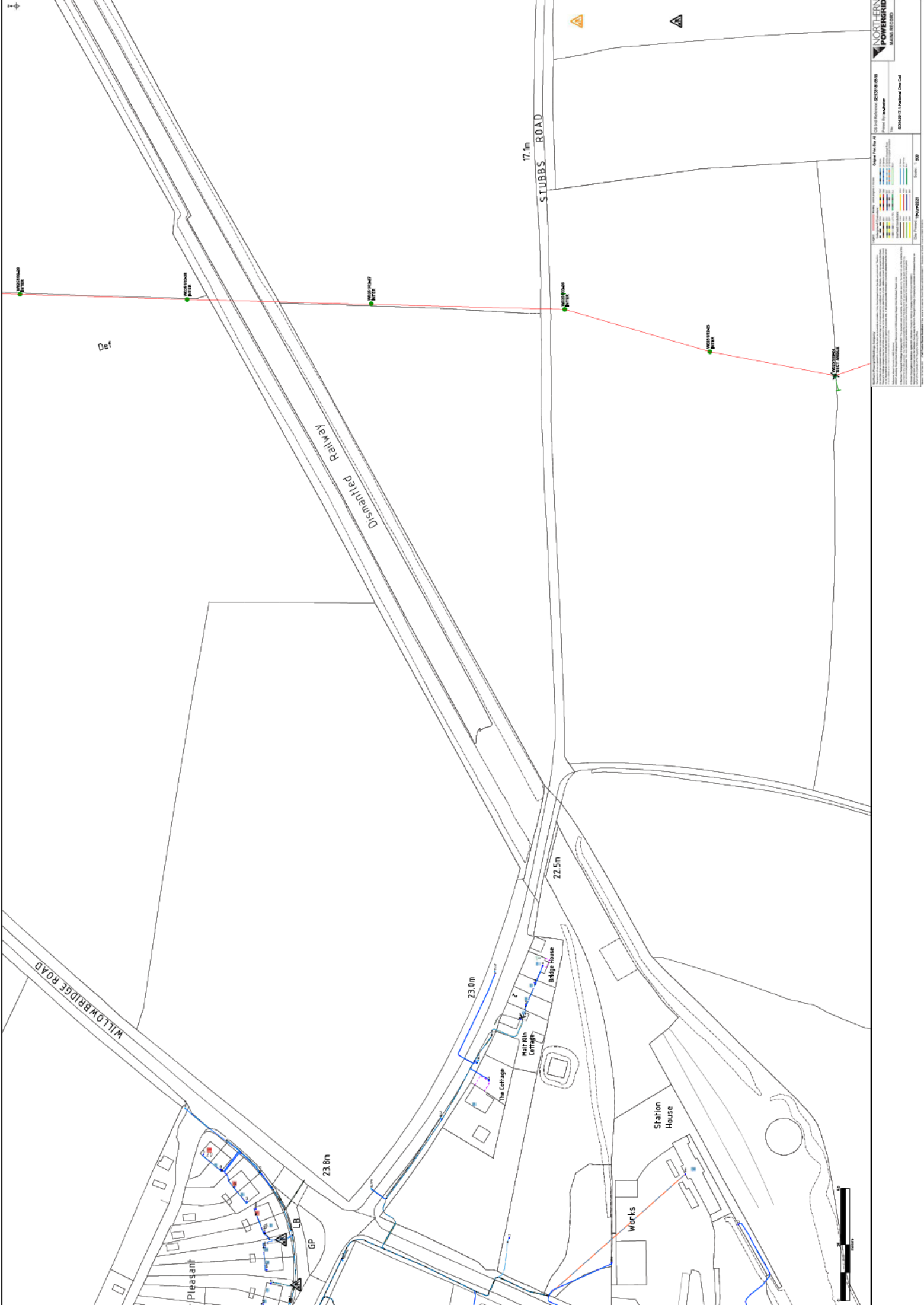
Tel:0800 0113433

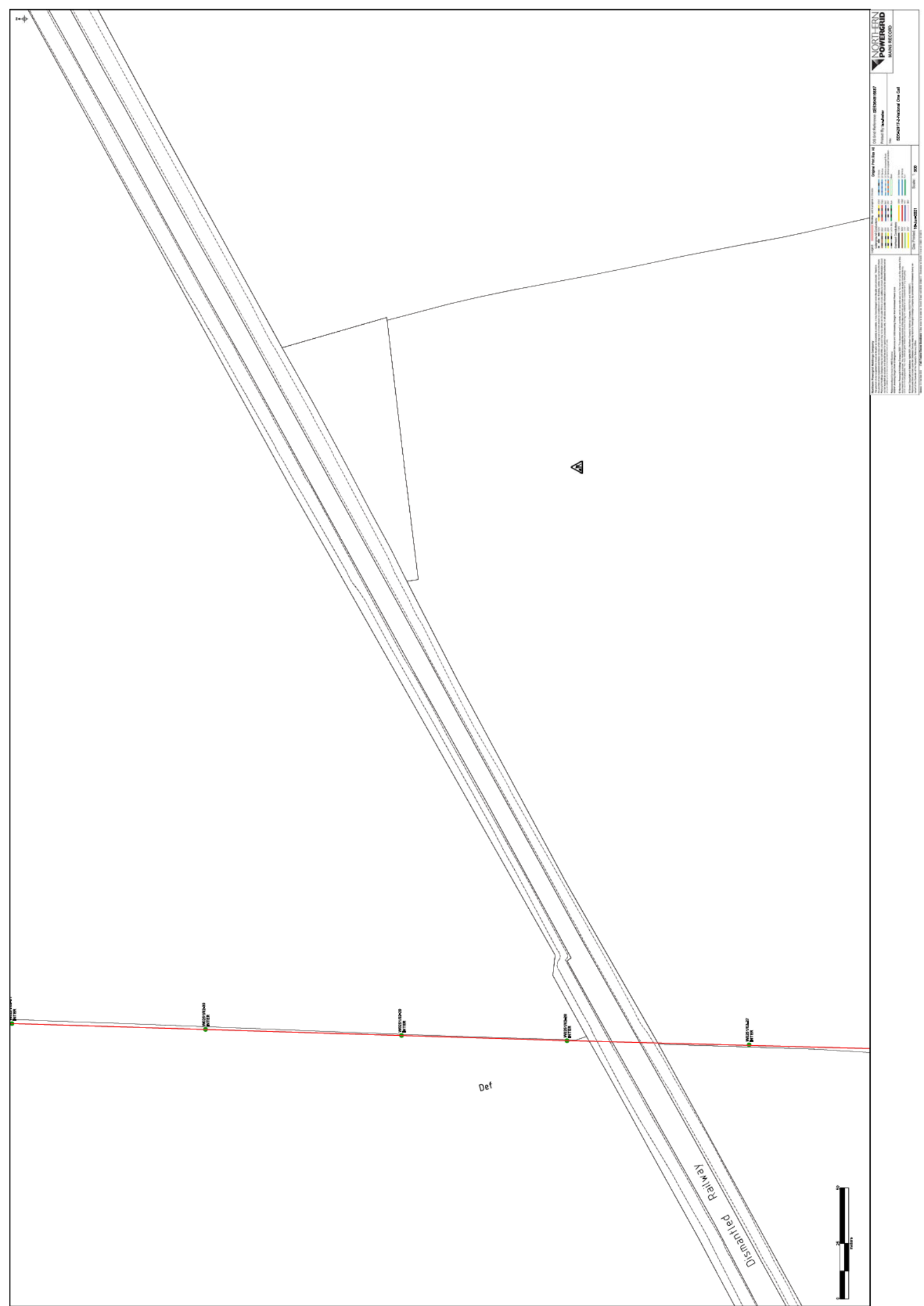
Yours faithfully,

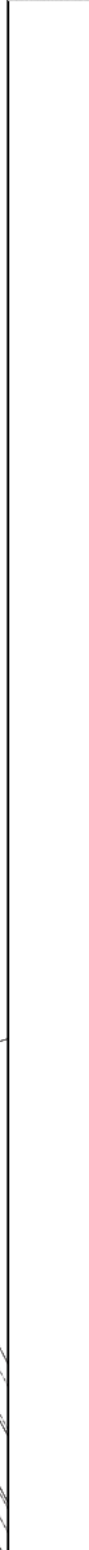
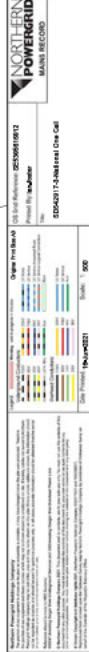
Safedig Team
Northern Powergrid

NORTHERNPOWERGRID

is the trading name of Northern Powergrid(Northeast) limited(RegisteredNo:2906593) and Northern Powergrid(Yorkshire) pic(Registered No:4112320) Registered Office: LloydsCourt, 78 Grey Street, Newcastle upon Tyne NE1 6AF.Registered in England and Wales.









YORKSHIRE WATER PROTECTION OF MAINS AND SERVICES

1. The position of Yorkshire Water Services Ltd (YWS) apparatus shown on the existing mains record drawing(s) indicates the **general** position and nature of our apparatus and the accuracy of this information cannot be guaranteed. Any damage to YWS apparatus as a result of your works may have serious consequences and you will be held responsible for all costs incurred. Prior to commencing major works, the exact location of apparatus must be determined on site, if necessary by excavating trial holes. The actual position of such apparatus and that of service pipes which have not been indicated must be established on site by contacting the Customer Helpline on 0845 124 24 24 for both water and sewerage.
2. The public sewer and water network is lawfully retained in its existing position and the sewerage and water undertaker is entitled to have it remain so without any disturbance. The provisions of section 159 of the Water Industry Act 1991 provides that the undertaker may "inspect, maintain, adjust, repair or alter" the network. Those rights are given to enable the undertaker to perform its statutory duties. Any development of the land or any other action that unacceptably hindered the exercise of those rights would be unlawful. The provisions contained in Section 185 of the Water Industry Act 1991 state that where it is reasonable to do so, a person may require the water supply undertaker to alter or remove a pipe where it is necessary to enable that person to carry out a proposed change of use of the land. The provisions contained in Section 185 also require the person making the request to pay the full cost of carrying out the necessary works.
3. Ground levels over existing YWS apparatus are to be maintained. Sewers in highways will **generally** be laid to give 1200mm of cover from finished ground level working to kerb races, other permanent identification of the limits of the road or to an agreed line and level. Substantial increases or decreases to this 1200mm depth of cover will result in the sewer being re-laid at your expense. Water mains and services will **generally** be laid with a minimum of 750mm depth of cover however some mains and services usually those installed over 50 years ago may have less ground cover.
4. If surface levels are to be decreased / increased significantly the effects on existing water supply apparatus will be carefully considered and if any alterations are necessary, the costs of the alterations will be recharged to you in full. Outlets on fire hydrants must be no more than 300mm below the new levels and all surface boxes must be adjusted as part of the scheme.
5. To enable future repair works to be carried out without hindrance; any pipe, cable, duct, etc. installed parallel to a water main or service pipe should not be installed directly over or within 300mm of a water main or service pipe or 1000mm of a waste water asset. Where a pipe, cable, duct, etc. crosses a main or service it should preferably cross perpendicular or at an angle of no less than 45° and with a minimum clearance of 150mm. These requirements apply to activities within an existing highway and are relevant to the installation of pipes, cables, ducts, etc. up to and including 250mm in diameter (*see illustration below*). Necessary protection measures for installations greater than 250mm in diameter and/or in private land will need to be agreed on an individual basis. Installations within a new development site must comply with the National Joint Utilities Group publication Volume 2: NJUG Guidelines On The Positioning Of Underground Utilities Apparatus For New Development Sites.
6. All excavation works near to YW apparatus should be by hand digging only.
7. Backfilling with a suitable material to a minimum 300mm above YW apparatus is required.
8. Adequate support must be provided where any works pass under YW apparatus.
9. Jointing chambers, lighting columns and other structures must be installed in such a way that future repair or maintenance works to YW apparatus will not be hindered.
10. Apparatus such as; railings, sign posts, etc. must not be placed in such a way that they prevent access to or full operation of controlling valves, hydrants or similar apparatus. YWS surface boxes must not be covered or buried. Any adjustment, alteration or replacement of manhole covers must be agreed on site prior to the commencement of the works with a YWS Inspector who may be contacted via our Call Centre on 0845 124 24 24.
11. Explosives shall not be used within 100 metres of any Yorkshire Water Services apparatus or installations.
12. Vibrating plant should not be used directly over any apparatus. Movement or operation by vehicles or heavy plant is not to be permitted in the immediate vicinity of YWS plant or apparatus unless there has been prior consultation and, if necessary, adequate protection provided without cost to YWS.
13. **Under no circumstances** should thrust boring or similar trenchless techniques commence until the actual position of the Company's mains/services along the proposed route have been confirmed by trial holes.
14. Any alterations to the highway should be notified following the procedures outlined in the New Road and Street Works Act 1991 Code of Practice; Measures Necessary Where Apparatus Is Affected By Major Works (Diversiary Works).
15. You will be held responsible for any damage or loss to YWS apparatus during and after completion of work, caused by yourselves, your servant or agent. Any damage caused or observed to YWS plant or apparatus should be immediately reported to YWS. Should YW incur any costs as a result of non-compliance with the above, all costs will be rechargeable in full.
16. You should ensure that nothing is done on the site to prejudice the safety or operation of YWS employees, plant or apparatus.
17. In accordance with the New Roads and Street Works Act 1991, Chapter 22, Part 3, Section 80. The location of any identified YW asset "which is not marked, or is wrongly marked, on the records made available" should be communicated back to Yorkshire Water. The location of the apparatus should be identified on copies of the supplied plans which should be returned to Yorkshire Water (Asset Records Team) with photographic supporting evidence where possible.
18. The Government has decided that responsibility for private sewers serving two or more properties and lateral drains (the section of pipe beyond the boundary of a single property, connecting it to the public sewer) will be transferred to the water companies on Oct 1 2011.

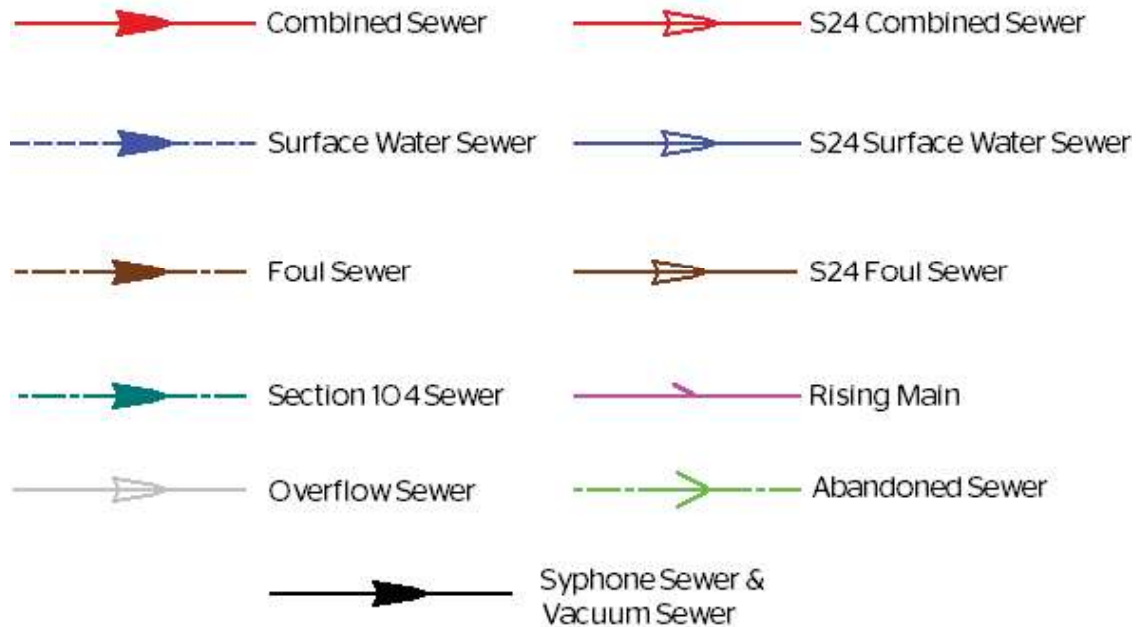
Private pumping stations will also transfer during the period 1 October 2011 – 1 Oct 2016. Records of these assets may not yet be shown on the existing mains record drawing(s). If you encounter any of these assets you must inform Yorkshire Water Services Ltd (YWS).

19. Please note that the information supplied on the enclosed plans is reproduced from Ordnance Survey material with the permission of the Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office, © Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Licence Number 1000019559.
20. This information is for guidance only and the position and depth of any YW apparatus is approximate only. Likewise, the nature and condition of any YW apparatus cannot be guaranteed. YW has no responsibility for recording the locations of privately owned apparatus. As of 1 October 2011, there may be some lateral drains and/or public sewers which are not documented on YW records but may still be present. For the avoidance of doubt, this information is not a substitute for appropriate professional and/or legal advice. YW accepts no responsibility for any inaccuracy or omissions in this information. The actual position of YW apparatus must be determined on site by excavating trial holes by hand. YW requires a minimum of two working days' written notice of the intention to excavate any trial holes before any excavation can be undertaken. If there are any queries in this respect please contact Yorkshire Water on 0845 124 24 24.

Property Identifier



Sewer Legend



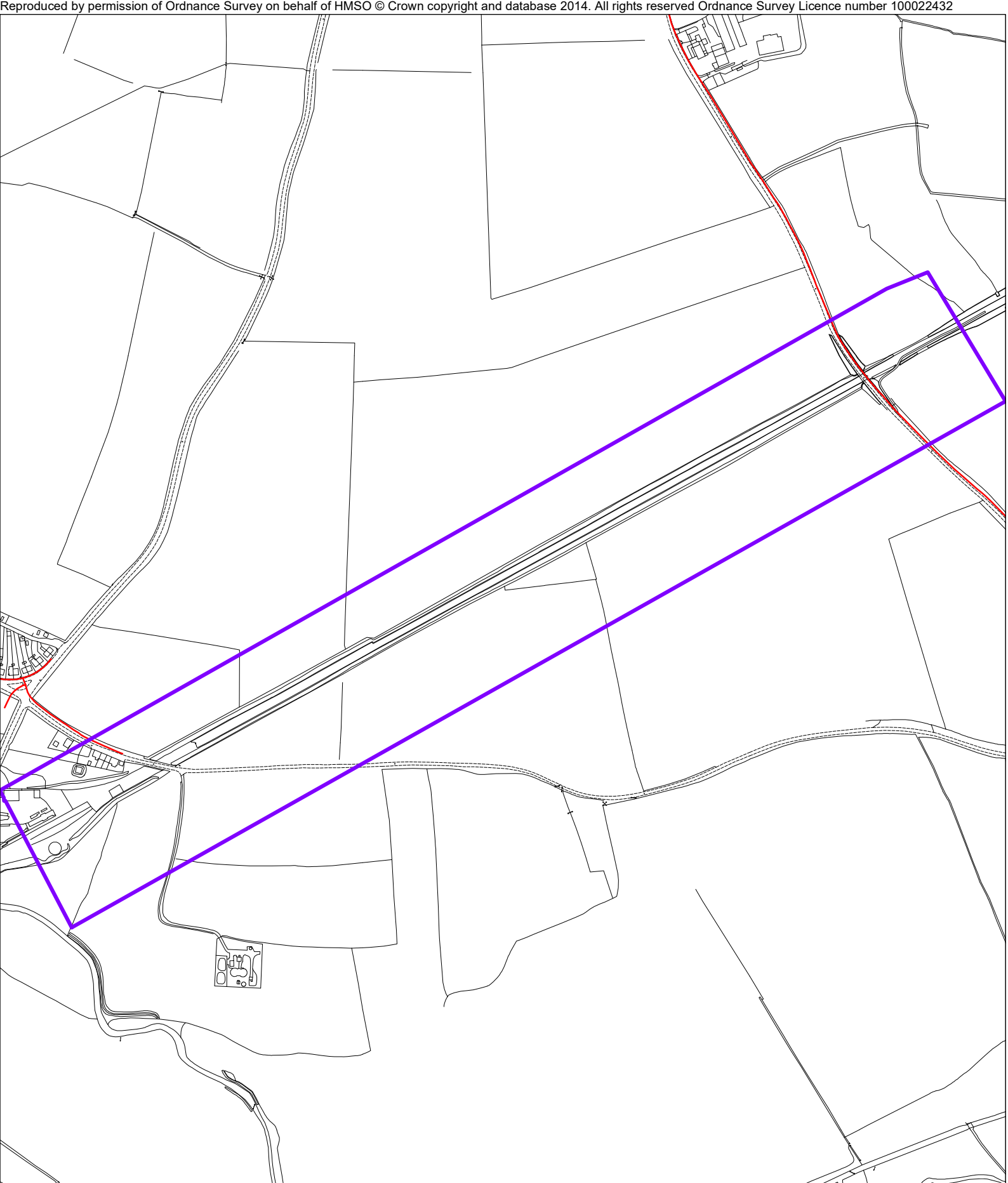
Pumping Station



Public Sewer Treatment Works

Water Legend



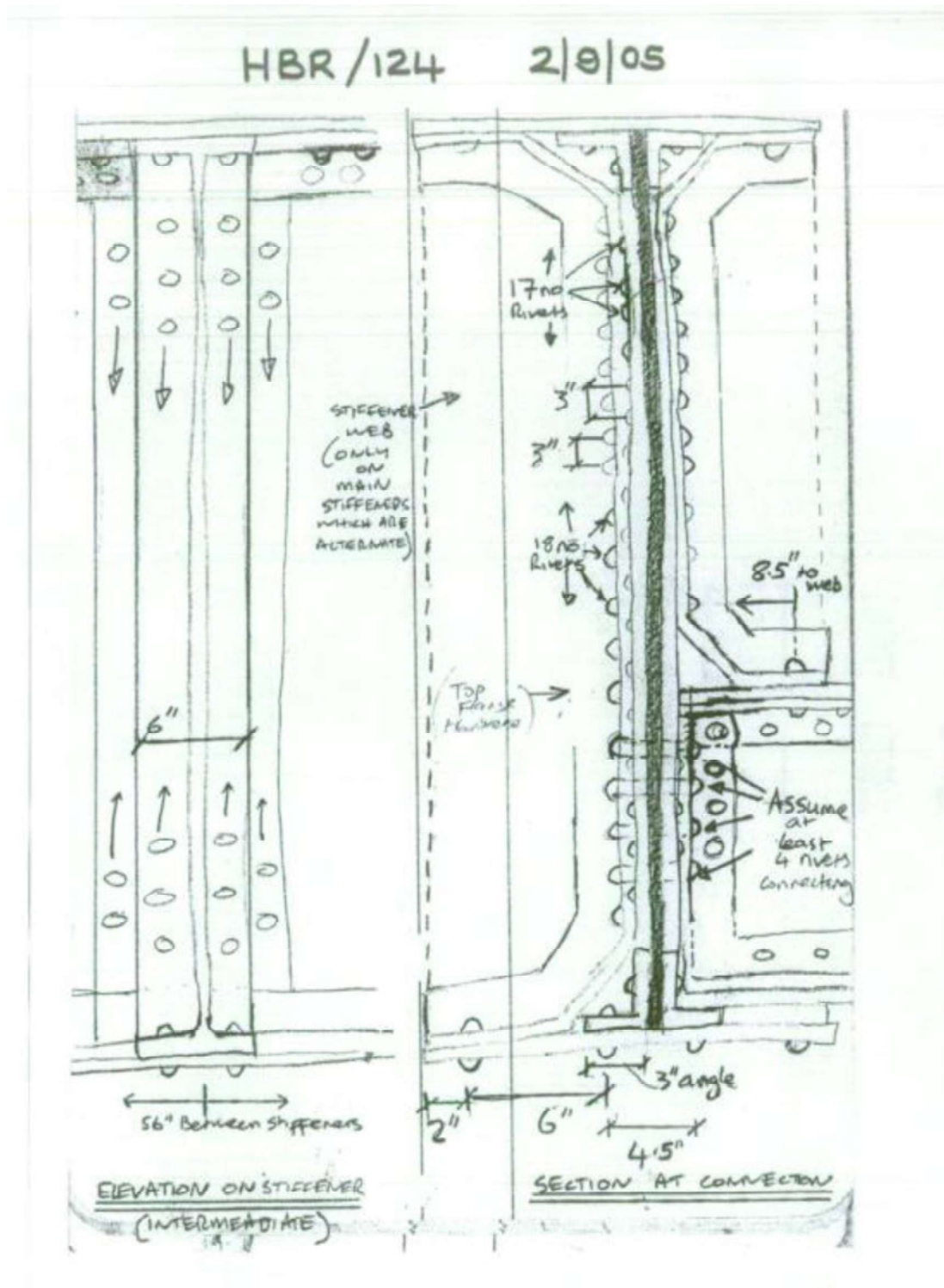


Public Clean Water Network 15/06/2021 21:10:39 OS Grid Coordinates: 453031 : 415928 Map Name : SE5315NW svcGISSafeMovePD

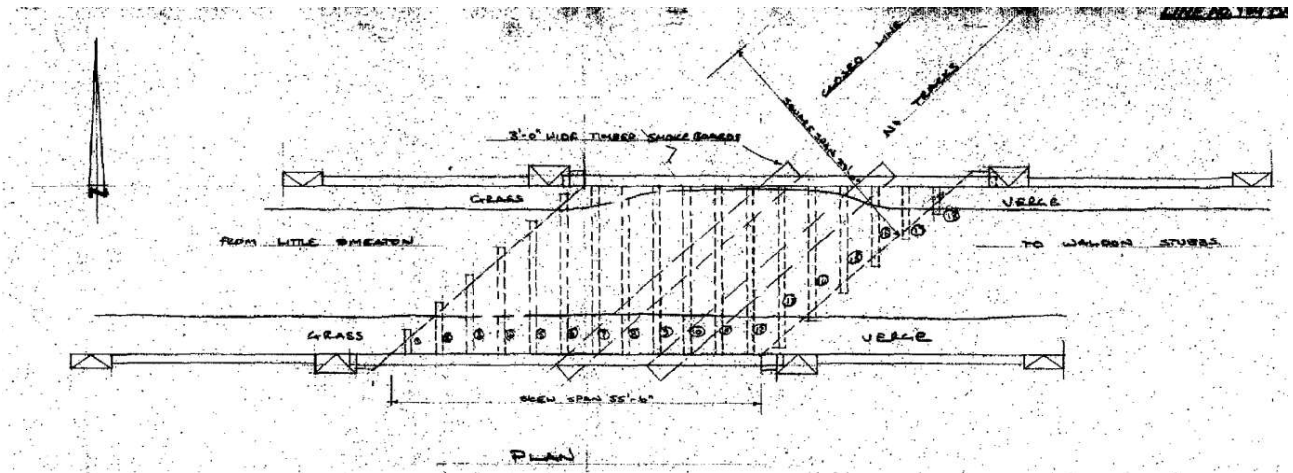


Public Waste Water Network 15/06/2021 21:10:44 OS Grid Coordinates: 453031 : 415928 Map Name : SE5315NW svcGISSafeMovePD

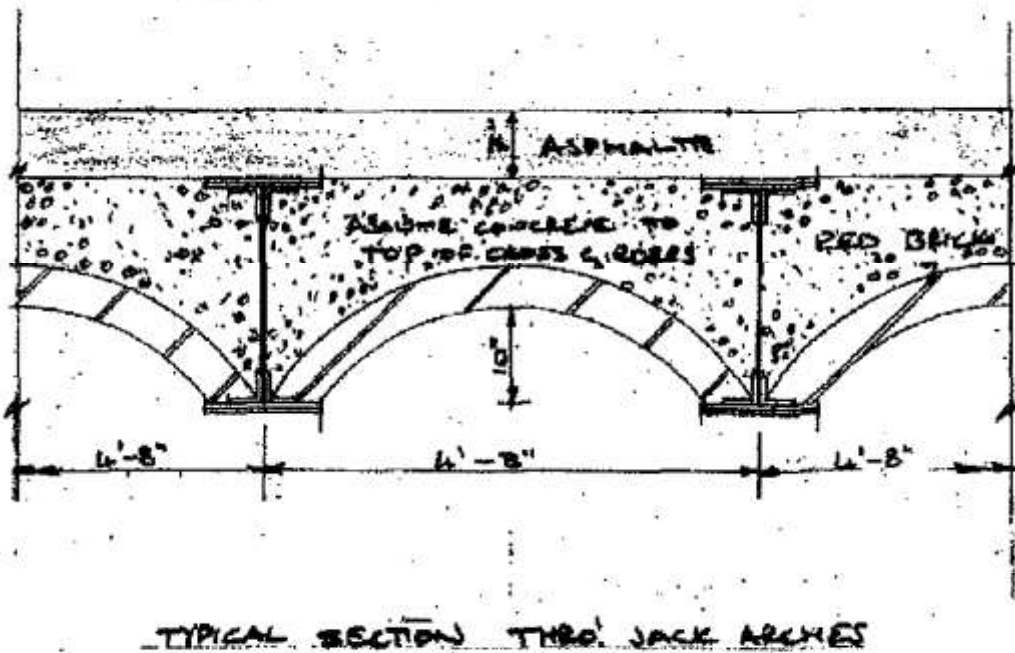
Appendix E. Existing / Historical Information



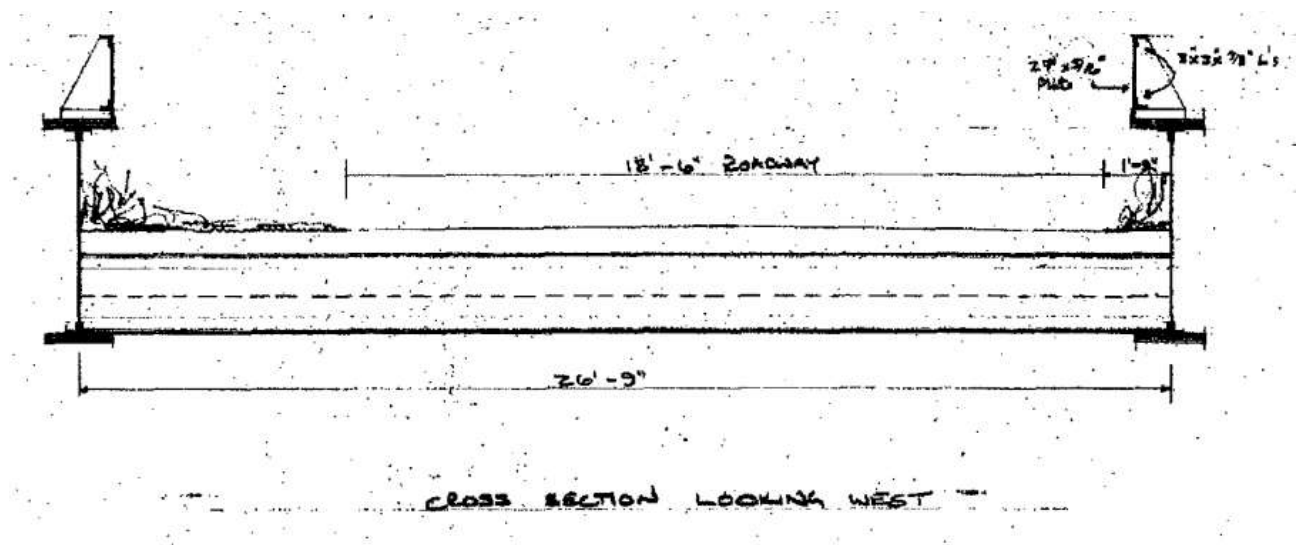
Sketch from Jacobs 2005 investigation into girder-to-girder connection



Plan from 1981 BR Assessment Drawing

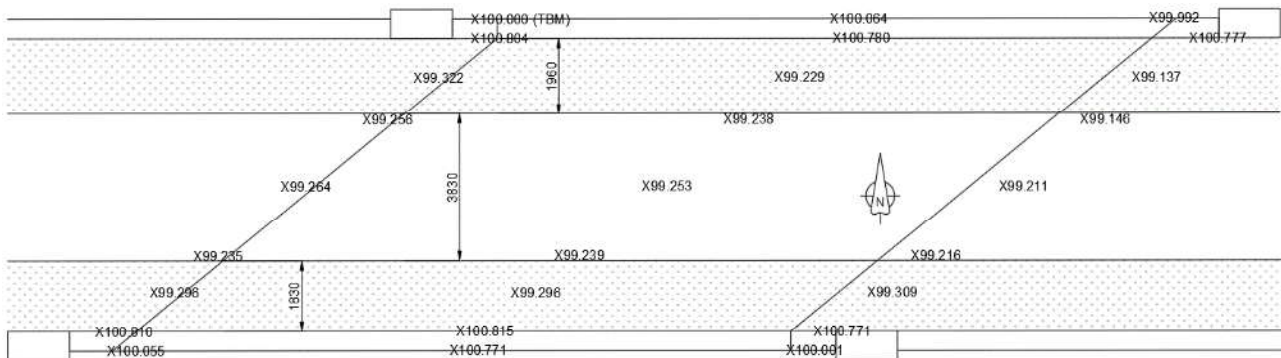


Jack Arch Cross Section from 1981 BR Assessment Drawing

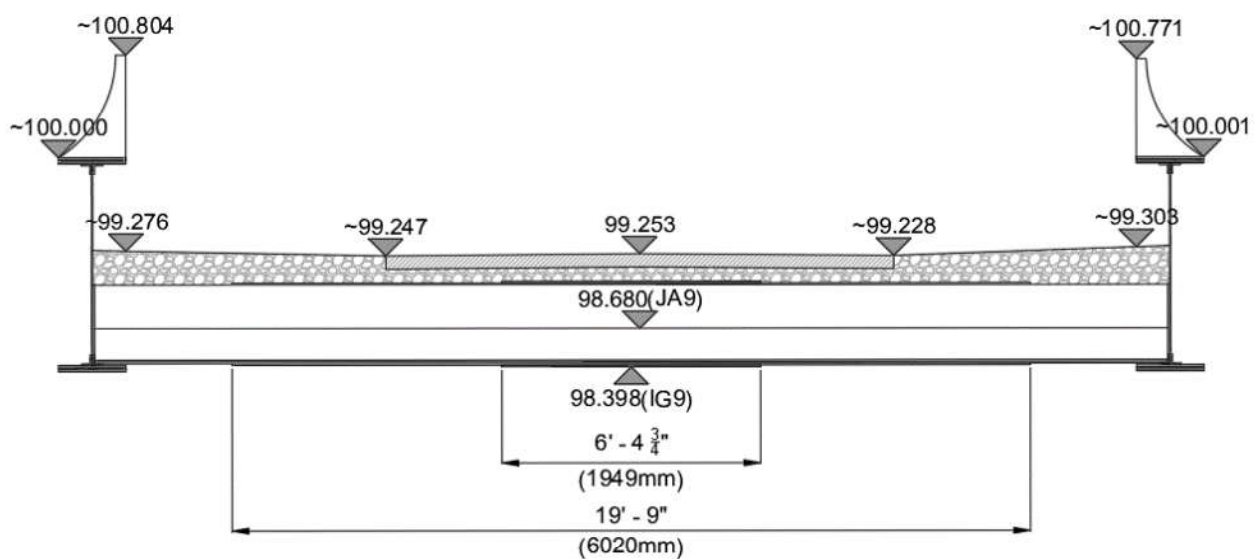


Cross Section from 1981 BR Assessment Drawing

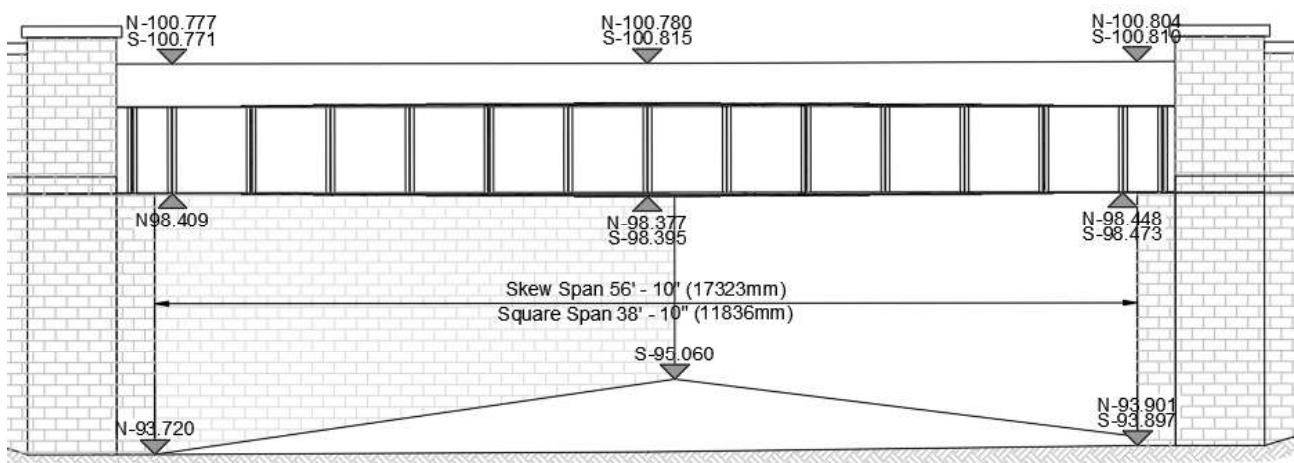
Appendix F. Survey Sketches



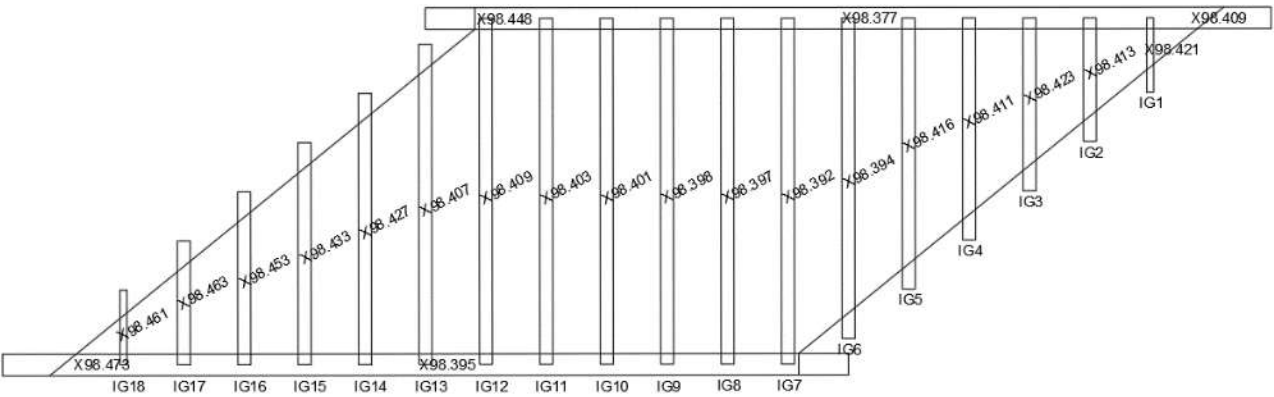
Plan at Road Level



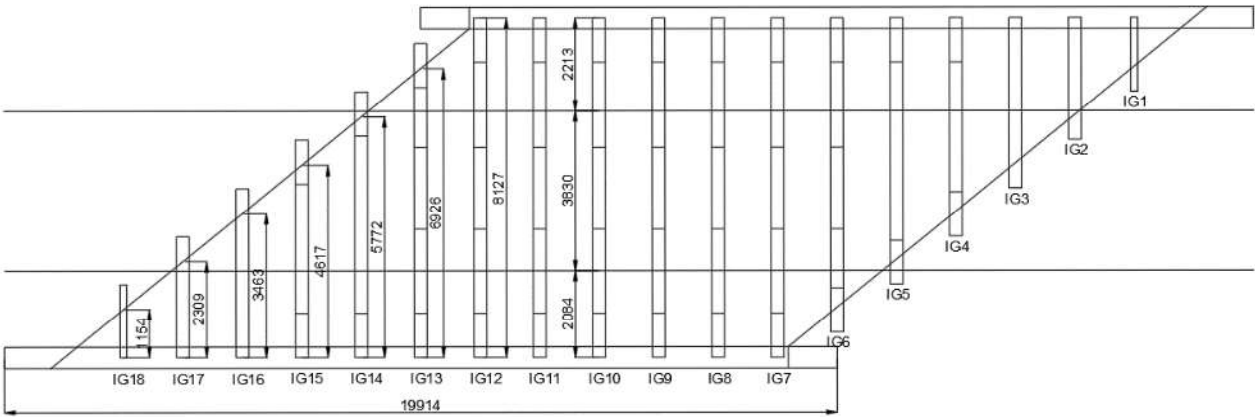
Section at Mid Span



North Elevation



Plan of girder soffit levels



Girder layout plan

Appendix G. Calculations

R SHEET

Jacobs
York

		Calc. No.: 0451632
		File: B38380DE
Subject: HBR3/124 Little Smeaton, North Yorkshire BE4 Assessment		
Project Group	31200	

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original									
Rev									
Rev									
Rev									
Rev									
Rev									

Superseded by Calculation No.	Date
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For assessment criteria, refer to Approval in Principle (Form AA) document

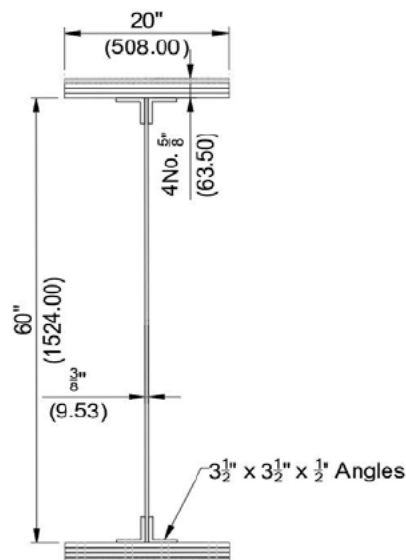
Office	York Office	1	Calc No.	0451632
Job No. & Title	HBR3/124 BE4 Assessment		Date	May-23
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Form AA

Edge Girders

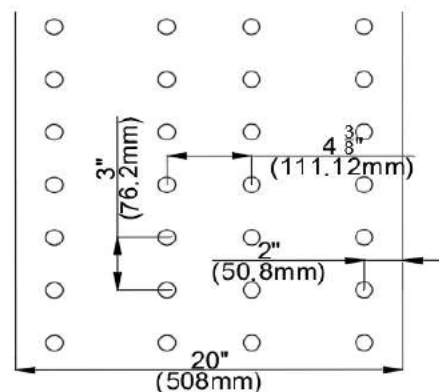
The girders are wrought iron. The locations of all joints within the web plates are not known and it is suspected the plates are limited in length between stiffeners where there are no obvious splices. Where the splices are formed from a flat plate and at the stiffeners with a single line of rivets each side, they may not be effective. Therefore, initially the webs of the edge girders between the ends of the connecting angles will be ignored when determining the section properties about x-x. Should the girder be found to be deficient, a check with the web included will also be completed. At each location considered for the section properties, one curtailment plate will be ignored as it is suspected that the flange plates will have multiple joint locations but the exact locations are not known.

Girder at midspan - 4no. flange plates (3No. Plates considered)



Rivets are 7/8" therefore rivet holes are 15/16"

Rivet Layout:



Elastic section properties about x-x (web included)

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	I _{xx} in ⁴
1	Flange	20.00	1.88	37.50	0.94	35.16	30553.26	10.99
2	Angle H	7.38	0.50	3.69	2.13	7.84	2759.62	0.08
3	Angle V	1.38	3.00	4.13	3.88	15.98	2704.71	3.09
4	Web	0.38	53.00	19.88	31.88	633.52	113.87	4652.41
5	Angle V	1.38	3.00	4.13	59.88	246.98	3810.56	3.09
6	Angle H	7.38	0.50	3.69	61.63	227.24	3809.97	0.08
7	Flange	20.00	1.88	37.50	62.81	2355.47	41661.11	10.99
8	Rivets - angles	-1.88	2.38	-4.45	62.56	-278.60	-4873.32	-2.09
9	Rivets - plates	-1.88	1.88	-3.52	62.81	-220.83	-3905.73	-1.03
				Net Area	102.53	3022.76	76634.05	4677.60
				Gross Area	110.50			

Depth of full section
 Depth of web panel
 Depth of web panel between flanges
 Distance to NA from top of section
 Distance to NA from bottom of section
 Second moment of area of section
 Elastic section modulus (compression flange)
 Elastic section modulus (tension flange)
 Radius of Gyration

D = 63.8 in
 dw = 60.0 in
 dwe = 53.0 in
 yt = 29.5 in
 yb = 34.3 in
 I_{xx} = 81311.65 in⁴
 Z_{xc} = 2758.07 in³
 Z_{xt} = 2372.77 in³
 Rx = 28.2 in

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Elastic section properties about x-x (web excluded)

No	Section	b in	d in	A in ²	y in	A·y in ³	A(y-yt) ² in ³	I _{xx} in ⁴
1	Flange	20.00	1.88	37.50	0.94	35.16	29333.54	10.99
2	Angle H	7.38	0.50	3.69	2.13	7.84	2644.72	0.08
3	Angle V	1.38	3.00	4.13	3.88	15.98	2584.49	3.09
4	Web	0.38	53.00	-	-	-	-	-
5	Angle V	1.38	3.00	4.13	59.88	246.98	3956.24	3.09
6	Angle H	7.38	0.50	3.69	61.63	227.24	3947.63	0.08
7	Flange	20.00	1.88	37.50	62.81	2355.47	43112.32	10.99
8	Rivets - angles	-1.88	2.38	-4.45	62.56	-278.60	-5044.37	-2.09
9	Rivets - plates	-1.88	1.88	-3.52	62.81	-220.83	-4041.78	-1.03
Net Area				82.66		2389.25	76492.80	25.19

Depth of full section	D	=	63.8	in
Depth of web panel	dw	=	60.0	in
Depth of web panel between flanges	dwe	=	53.0	in
Distance to NA from top of section	yt	=	28.9	in
Distance to NA from bottom of section	yb	=	34.8	in
Second moment of area of section	I _{xx}	=	76517.99	in ⁴
Elastic section modulus (compression flange)	Z _{xc}	=	2647.15	in ³
Elastic section modulus (tension flange)	Z _{xt}	=	2196.01	in ³
Radius of Gyration	R _x	=	30.4	in

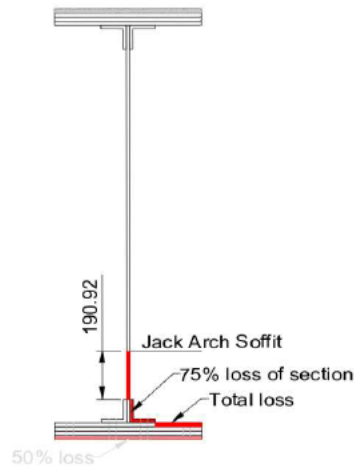
Gross elastic section properties about y-y

No	Section	b in	d in	A in ²	x in	A·x in ³	A(x-xt) ² in ³	I _{yy} in ⁴
1	Flange	1.88	20.00	37.5	0.00	0.00	0.00	1250.00
2	Angle H	0.50	7.38	3.7	0.00	0.00	0.00	16.71
3	Angle V	3.00	1.38	4.1	0.00	0.00	0.00	0.65
4	Web	53.00	0.38	19.9	0.00	0.00	0.00	0.23
5	Angle V	3.00	1.38	4.1	0.00	0.00	0.00	0.65
6	Angle H	0.50	7.38	3.7	0.00	0.00	0.00	16.71
7	Flange	1.88	20.00	37.5	0.00	0.00	0.00	1250.00
Net Area				110.5		0.00	0.00	2534.96

Width of full section	B	=	20.0	in
Distance to NA	x _t	=	0.0	in
Second moment of area of section	I _{yy}	=	2.53E+03	in ⁴
Radius of Gyration	R _y	=	4.8	in

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Corroded Section Properties



Corroded Elastic section properties about x-x (web included)

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	102.5	29.48	3022.76	574.47	81311.65
1	Web hole	-0.38	1.00	-0.38	25.95	-9.73	-0.51	-0.031
2	Web hole (JA)	-0.38	7.52	-2.82	54.62	-153.94	-2131.90	-13.268
3	Angle V	-0.38	3.00	-1.13	59.88	-67.36	-1207.42	-0.844
4	Angle H	-2.44	0.38	-0.91	61.56	-56.27	-1084.70	-0.011
5	Flange	-4.44	0.63	-2.77	62.19	-172.47	-3411.68	-0.090
Net Area				94.53		2562.99	-7261.73	81297.40

Depth of full section	D	=	63.8	in
Depth of web panel	dw	=	60.0	in
Depth of web panel between flanges	dwe	=	53.0	in
Distance to NA from top of section	yt	=	27.1	in
Distance to NA from bottom of section	yb	=	36.6	in
Second moment of area of section	Ixx	=	74035.67	in ⁴
Elastic section modulus (compression flange)	Zxc	=	2730.50	in ³
Elastic section modulus (tension flange)	Zxt	=	2020.86	in ³
Radius of Gyration	Rx	=	28.0	in

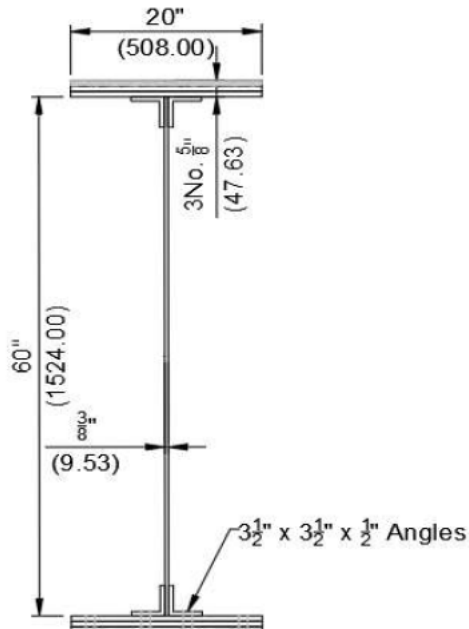
Corroded Elastic section properties about x-x (web excluded)

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	82.7	28.91	2389.25	336.20	76517.99
1	Angle V	-0.38	3.00	-1.13	59.88	-67.36	-1224.08	-0.844
2	Angle H	-2.44	0.38	-0.91	61.56	-56.27	-1098.93	-0.011
3	Flange	-4.44	0.63	-2.77	62.19	-172.47	-3455.65	-0.090
Net Area				77.84		2093.14	-5442.46	76517.04

Depth of full section	D	=	63.8	in
Distance to NA from top of section	yt	=	26.9	in
Distance to NA from bottom of section	yb	=	36.9	in
Second moment of area of section	Ixx	=	71074.58	in ⁴
Elastic section modulus (compression flange)	Zxc	=	2643.25	in ³
Elastic section modulus (tension flange)	Zxt	=	1928.18	in ³
Radius of Gyration	Rx	=	30.2	in

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2No. Flange plates considered (4 lines of rivets)



Elastic section properties about x-x (web included)

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
1	Flange	20.00	1.25	25.00	0.63	15.63	20275.74	3.26
2	Angle H	7.38	0.50	3.69	1.50	5.53	2809.72	0.08
3	Angle V	1.38	3.00	4.13	3.25	13.41	2757.18	3.09
4	Web	0.38	53.00	19.88	31.25	621.09	91.57	4652.41
5	Angle V	1.38	3.00	4.13	59.25	244.41	3748.83	3.09
6	Angle H	7.38	0.50	3.69	61.00	224.94	3751.59	0.08
7	Flange	20.00	1.25	25.00	61.88	1546.88	26849.15	3.26
8	Rivets - angles	-1.88	1.75	-3.28	61.63	-202.21	-3470.39	-0.84
9	Rivets - plates	-1.88	1.25	-2.34	61.88	-145.02	-2517.11	-0.31
Net Area				79.88		2324.65	54296.28	4664.12
Gross Area				85.50				

Depth of full section
 Depth of web panel
 Depth of web panel between flanges
 Distance to NA from top of section
 Distance to NA from bottom of section
 Second moment of area of section
 Elastic section modulus (compression flange)
 Elastic section modulus (tension flange)
 Radius of Gyration

D	=	62.5	in
dw	=	60.0	in
dwe	=	53.0	in
yt	=	29.1	in
yb	=	33.4	in
Ixx	=	58960.39	in ⁴
Zxc	=	2025.88	in ³
Zxt	=	1765.47	in ³
Rx	=	27.2	in

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Elastic section properties about x-x (web excluded)

No	Section	b in	d in	A in ²	y in	A·y in ³	A(y-yt) ² in ³	I _{xx} in ⁴
1	Flange	20.00	1.25	25.00	0.63	15.63	19275.96	3.26
2	Angle H	7.38	0.50	3.69	1.50	5.53	2666.84	0.08
3	Angle V	1.38	3.00	4.13	3.25	13.41	2607.62	3.09
4	Web	0.38	53.00	-	-	-	-	-
5	Angle V	1.38	3.00	4.13	59.25	244.41	3927.74	3.09
6	Angle H	7.38	0.50	3.69	61.00	224.94	3920.71	0.08
7	Flange	20.00	1.25	25.00	61.88	1546.88	28026.81	3.26
8	Rivets - angles	-1.88	1.75	-3.28	61.63	-202.21	-3623.79	-0.84
9	Rivets - plates	-1.88	1.25	-2.34	61.88	-145.02	-2627.51	-0.31
Net Area				60.00		1703.55	54174.38	11.71

Depth of full section	D	=	62.5	in
Depth of web panel	dw	=	60.0	in
Depth of web panel between flanges	dwe	=	53.0	in
Distance to NA from top of section	yt	=	28.4	in
Distance to NA from bottom of section	yb	=	34.1	in
Second moment of area of section	I _{xx}	=	54186.09	in ⁴
Elastic section modulus (compression flange)	Z _{xc}	=	1908.46	in ³
Elastic section modulus (tension flange)	Z _{xt}	=	1588.69	in ³
Radius of Gyration	R _x	=	30.1	in

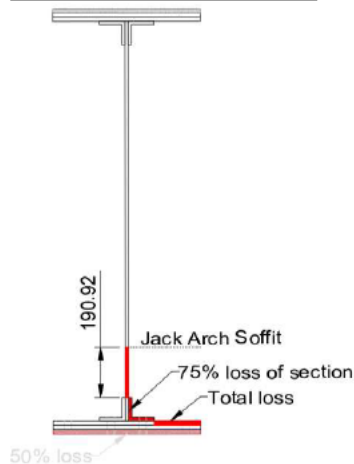
Gross elastic section properties about y-y

No	Section	b in	d in	A in ²	x in	A·x in ³	A(x-xt) ² in ³	I _{yy} in ⁴
1	Flange	1.25	20.00	25.0	0.00	0.00	0.00	833.33
2	Angle H	0.50	7.38	3.7	0.00	0.00	0.00	16.71
3	Angle V	3.00	1.38	4.1	0.00	0.00	0.00	0.65
4	Web	53.00	0.38	19.9	0.00	0.00	0.00	0.23
5	Angle V	3.00	1.38	4.1	0.00	0.00	0.00	0.65
6	Angle H	0.50	7.38	3.7	0.00	0.00	0.00	16.71
7	Flange	1.25	20.00	25.0	0.00	0.00	0.00	833.33
Net Area				85.5		0.00	0.00	1701.63

Width of full section	B	=	20.0	in
Distance to NA	xt	=	0.0	in
Second moment of area of section	I _{yy}	=	1.70E+03	in ⁴
Radius of Gyration	R _y	=	4.5	in

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Corroded Section Properties



Corroded Elastic section properties about x-x (web included)

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	79.9	29.10	2324.65	774.09	58960.39
1	Web hole	-0.38	1.00	-0.38	25.95	-9.73	0.00	-0.031
2	Web hole (JA)	-0.38	7.52	-2.82	53.99	-152.18	-2209.94	-13.268
3	Angle V	-0.38	3.00	-1.13	59.25	-66.66	-1244.47	-0.844
4	Angle H	-2.44	0.38	-0.91	60.94	-55.70	-1116.34	-0.011
5	Flange	-4.44	0.63	-2.77	62.19	-172.47	-3633.82	-0.090
Net Area				71.87		1867.91	-7430.48	58946.15

Depth of full section	D	=	62.5	in
Depth of web panel	dw	=	60.0	in
Depth of web panel between flanges	dwe	=	53.0	in
Distance to NA from top of section	yt	=	26.0	in
Distance to NA from bottom of section	yb	=	36.5	in
Second moment of area of section	Ixx	=	51515.67	in ⁴
Elastic section modulus (compression flange)	Zxc	=	1982.10	in ³
Elastic section modulus (tension flange)	Zxt	=	1411.02	in ³
Radius of Gyration	Rx	=	26.8	in

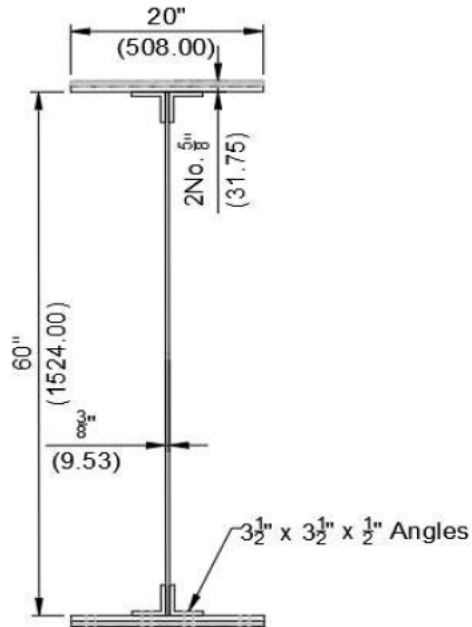
Corroded Elastic section properties about x-x (web excluded)

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	60.0	28.39	1703.55	480.10	54186.09
1	Angle V	-0.38	3.00	-1.13	59.25	-66.66	-1276.60	-0.844
2	Angle H	-2.44	0.38	-0.91	60.94	-55.70	-1143.76	-0.011
3	Flange	-4.44	0.63	-2.77	61.44	-170.39	-3569.19	-0.090
Net Area				55.19		1410.80	-5509.45	54185.14

Depth of full section	D	=	62.5	in
Distance to NA from top of section	yt	=	25.6	in
Distance to NA from bottom of section	yb	=	36.9	in
Second moment of area of section	Ixx	=	48675.69	in ⁴
Elastic section modulus (compression flange)	Zxc	=	1904.08	in ³
Elastic section modulus (tension flange)	Zxt	=	1317.83	in ³
Radius of Gyration	Rx	=	29.7	in

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1No. Flange plate considered (4 lines of rivets)



Elastic section properties about x-x (web included)

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
1	Flange	20.00	0.63	12.50	0.31	3.91	10212.65	0.41
2	Angle H	7.38	0.50	3.69	0.88	3.23	2895.32	0.08
3	Angle V	1.38	3.00	4.13	2.63	10.83	2846.92	3.09
4	Web	0.38	53.00	19.88	30.63	608.67	59.42	4652.41
5	Angle V	1.38	3.00	4.13	58.63	241.83	3645.75	3.09
6	Angle H	7.38	0.50	3.69	60.38	222.63	3654.06	0.08
7	Flange	20.00	0.63	12.50	60.94	761.72	12833.28	0.41
8	Rivets - angles	-1.88	1.13	-2.11	60.69	-128.01	-2131.95	-0.22
9	Rivets - plates	-1.88	0.63	-1.17	60.94	-71.41	-1203.12	-0.04
Net Area				57.22		1653.39	32812.33	4659.30
Gross Area				60.50				

Depth of full section
 Depth of web panel
 Depth of web panel between flanges
 Distance to NA from top of section
 Distance to NA from bottom of section
 Second moment of area of section
 Elastic section modulus (compression flange)
 Elastic section modulus (tension flange)
 Radius of Gyration

D	=	61.3	in
dw	=	60.0	in
dwe	=	53.0	in
yt	=	28.9	in
yb	=	32.4	in
Ixx	=	37471.63	in ⁴
Zxc	=	1296.78	in ³
Zxt	=	1158.17	in ³
Rx	=	25.6	in

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Elastic section properties about x-x (web excluded)

No	Section	b in	d in	A in ²	y in	A·y in ³	A(y-yt) ² in ³	I _{xx} in ⁴
1	Flange	20.00	0.63	12.50	0.31	3.91	9565.64	0.41
2	Angle H	7.38	0.50	3.69	0.88	3.23	2708.27	0.08
3	Angle V	1.38	3.00	4.13	2.63	10.83	2650.96	3.09
4	Web	0.38	53.00	-	-	-	-	-
5	Angle V	1.38	3.00	4.13	58.63	241.83	3874.95	3.09
6	Angle H	7.38	0.50	3.69	60.38	222.63	3870.83	0.08
7	Flange	20.00	0.63	12.50	60.94	761.72	13581.02	0.41
8	Rivets - angles	-1.88	1.13	-2.11	60.69	-128.01	-2257.16	-0.22
9	Rivets - plates	-1.88	0.63	-1.17	60.94	-71.41	-1273.22	-0.04
Net Area				37.34		1044.72	32721.28	6.89

Depth of full section	D	=	61.3	in
Depth of web panel	dw	=	60.0	in
Depth of web panel between flanges	dwe	=	53.0	in
Distance to NA from top of section	yt	=	28.0	in
Distance to NA from bottom of section	yb	=	33.3	in
Second moment of area of section	I _{xx}	=	32728.18	in ⁴
Elastic section modulus (compression flange)	Z _{xc}	=	1169.88	in ³
Elastic section modulus (tension flange)	Z _{xt}	=	983.59	in ³
Radius of Gyration	R _x	=	29.6	in

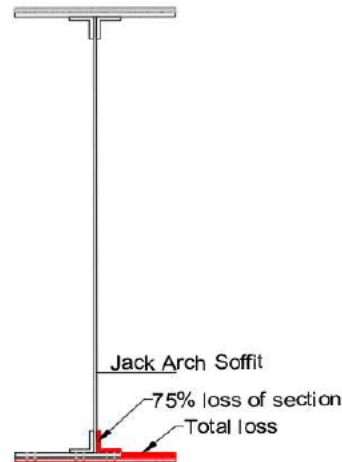
Gross elastic section properties about y-y

No	Section	b in	d in	A in ²	x in	A·x in ³	A(x-xt) ² in ³	I _{yy} in ⁴
1	Flange	0.63	20.00	12.5	0.00	0.00	0.00	416.67
2	Angle H	0.50	7.38	3.7	0.00	0.00	0.00	16.71
3	Angle V	3.00	1.38	4.1	0.00	0.00	0.00	0.65
4	Web	53.00	0.38	19.9	0.00	0.00	0.00	0.23
5	Angle V	3.00	1.38	4.1	0.00	0.00	0.00	0.65
6	Angle H	0.50	7.38	3.7	0.00	0.00	0.00	16.71
7	Flange	0.63	20.00	12.5	0.00	0.00	0.00	416.67
Net Area				60.5		0.00	0.00	868.29

Width of full section	B	=	20.0	in
Distance to NA	x _t	=	0.0	in
Second moment of area of section	I _{yy}	=	8.68E+02	in ⁴
Radius of Gyration	R _y	=	3.8	in

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Corroded Section Properties



Corroded Elastic section properties about x-x (web included)

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	57.2	28.90	1653.39	1132.01	37471.63
1	Web hole	-0.38	1.00	-0.38	25.95	-9.73	-0.85	-0.031
2	Web hole (JA)	-0.38	7.52	-2.82	53.37	-150.41	-2357.13	-13.268
3	Angle V	-0.38	3.00	-1.13	58.63	-65.95	-1314.08	-0.844
4	Angle H	-2.44	0.38	-0.91	60.31	-55.13	-1175.72	-0.011
5	Flange	-4.44	0.63	-2.77	60.94	-169.01	-3692.79	-0.090
Net Area				49.21		1203.15	-7408.55	37457.39

Depth of full section	D	=	61.3	in
Depth of web panel	dw	=	60.0	in
Depth of web panel between flanges	dwe	=	53.0	in
Distance to NA from top of section	yt	=	24.4	in
Distance to NA from bottom of section	yb	=	36.8	in
Second moment of area of section	Ixx	=	30048.84	in ⁴
Elastic section modulus (compression flange)	Zxc	=	1229.09	in ³
Elastic section modulus (tension flange)	Zxt	=	816.50	in ³
Radius of Gyration	Rx	=	24.7	in

Corroded Elastic section properties about x-x (web excluded)

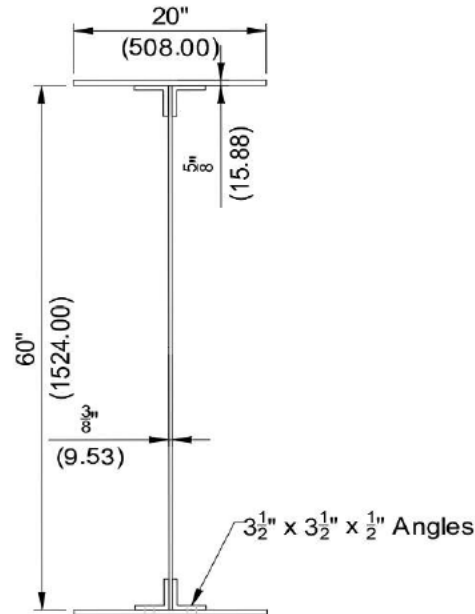
No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	37.3	27.98	1044.72	848.97	32728.18
1	Angle V	-0.38	3.00	-1.13	58.63	-65.95	-1411.19	-0.844
2	Angle H	-2.44	0.38	-0.91	60.31	-55.13	-1258.45	-0.011
3	Flange	-4.44	0.63	-2.77	60.81	-168.66	-3921.98	-0.090
Net Area				32.53		754.97	-5742.65	32727.23

Depth of full section	D	=	61.3	in
Distance to NA from top of section	yt	=	23.2	in
Distance to NA from bottom of section	yb	=	38.0	in
Second moment of area of section	Ixx	=	26984.58	in ⁴
Elastic section modulus (compression flange)	Zxc	=	1162.74	in ³
Elastic section modulus (tension flange)	Zxt	=	709.33	in ³
Radius of Gyration	Rx	=	28.8	in

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Between Support and end of first curtailment plate - 1No Plate

(2 lines of rivets)



Elastic section properties about x-x (web included)

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
1	Flange	20.00	0.63	12.50	0.31	3.91	10677.34	0.41
2	Angle H	7.38	0.50	3.69	0.88	3.23	3029.74	0.08
3	Angle V	1.38	3.00	4.13	2.63	10.83	2988.00	3.09
4	Web	0.38	53.00	19.88	30.63	608.67	23.44	4652.41
5	Angle V	1.38	3.00	4.13	58.63	241.83	3489.73	3.09
6	Angle H	7.38	0.50	3.69	60.38	222.63	3506.30	0.08
7	Flange	20.00	0.63	12.50	60.94	761.72	12323.33	0.41
8	Rivets - angles	-1.88	1.13	-2.11	60.69	-128.01	-2046.58	-0.22
Net Area				58.39		1724.80	33991.30	4659.34
Gross Area				60.50				

Depth of full section

Depth of web panel

Depth of web panel between flanges

Distance to NA from top of section

Distance to NA from bottom of section

Second moment of area of section

Elastic section modulus (compression flange)

Elastic section modulus (tension flange)

Radius of Gyration

D	=	61.3	in
dw	=	60.0	in
dwe	=	53.0	in
yt	=	29.5	in
yb	=	31.7	in
Ixx	=	38650.64	in ⁴
Zxc	=	1308.46	in ³
Zxt	=	1218.84	in ³
Rx	=	25.7	in

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Elastic section properties about x-x (web excluded)

No	Section	b in	d in	A in ²	y in	A·y in ³	A(y-yt) ² in ³	I _{xx} in ⁴
1	Flange	20.00	0.63	12.50	0.31	3.91	10271.80	0.41
2	Angle H	7.38	0.50	3.69	0.88	3.23	2912.43	0.08
3	Angle V	1.38	3.00	4.13	2.63	10.83	2864.86	3.09
4	Web	0.38	53.00	-	-	-	-	-
5	Angle V	1.38	3.00	4.13	58.63	241.83	3625.51	3.09
6	Angle H	7.38	0.50	3.69	60.38	222.63	3634.90	0.08
7	Flange	20.00	0.63	12.50	60.94	761.72	12767.16	0.41
8	Rivets - angles	-1.88	1.13	-2.11	60.69	-128.01	-2120.88	-0.22
Net Area				38.52		1.12E+03	3.40E+04	6.93E+00

Depth of full section	D	=	61.3	in
Depth of web panel	d _w	=	60.0	in
Depth of web panel between flanges	d _{we}	=	53.0	in
Distance to NA from top of section	y _t	=	29.0	in
Distance to NA from bottom of section	y _b	=	32.3	in
Second moment of area of section	I _{xx}	=	33962.70	in ⁴
Elastic section modulus (compression flange)	Z _{xc}	=	1171.99	in ³
Elastic section modulus (tension flange)	Z _{xt}	=	1052.41	in ³
Radius of Gyration	R _x	=	29.7	in

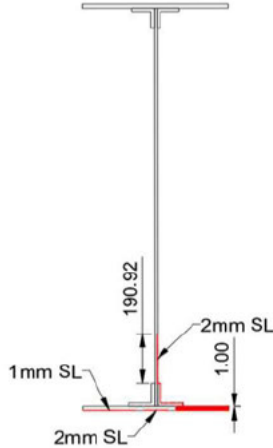
Gross elastic section properties about y-y

No	Section	b in	d in	A in ²	x in	A·x in ³	A(x-xt) ² in ³	I _{yy} in ⁴
1	Flange	0.63	20.00	12.5	0.00	0.00	0.00	416.67
2	Angle H	0.50	7.38	3.7	0.00	0.00	0.00	16.71
3	Angle V	3.00	1.38	4.1	0.00	0.00	0.00	0.65
4	Web	53.00	0.38	19.9	0.00	0.00	0.00	0.23
5	Angle V	3.00	1.38	4.1	0.00	0.00	0.00	0.65
6	Angle H	0.50	7.38	3.7	0.00	0.00	0.00	16.71
7	Flange	0.63	20.00	12.5	0.00	0.00	0.00	416.67
Net Area				60.5		0.00	0.00	868.29

Width of full section	B	=	20.0	in
Distance to NA	x _t	=	0.0	in
Second moment of area of section	I _{yy}	=	8.68E+02	in ⁴
Radius of Gyration	R _y	=	3.8	in

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Corroded Section Properties



Corroded Elastic section properties about x-x (web included)

No	Section	b in	d in	A in ²	y in	A·y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	58.4	29.54	1724.80	639.29	38650.64
1	Web	-0.08	7.52	-0.59	36.43	-21.56	-61.56	-2.786
2	Angle H	-0.58	0.08	-0.05	57.16	-2.60	-43.61	-2.35E-05
3	Angle V	-0.08	2.92	-0.23	58.66	-13.49	-241.98	-0.164
4	Angle H	-3.08	0.08	-0.24	60.16	-14.59	-279.15	-1.25E-04
5	Angle V	-0.08	0.42	-0.03	60.41	-2.00	-38.76	-4.91E-04
6	Flange 1	-7.34	0.04	-0.29	61.23	-17.70	-354.18	-3.73E-05
7	Flange 2	-3.44	0.08	-0.27	61.21	-16.57	-331.20	-1.40E-04
8	Flange	-7.34	0.59	-4.30	60.96	-262.16	-5186.53	-0.123
Net Area				52.39		1374.12	-5897.69	38647.57

Depth of full section	D	=	61.2	in
Depth of web panel	dw	=	60.0	in
Depth of web panel between flanges	dwe	=	53.0	in
Distance to NA from top of section	yt	=	26.2	in
Distance to NA from bottom of section	yb	=	35.0	in
Second moment of area of section	Ixx	=	32749.88	in ⁴
Elastic section modulus (compression flange)	Zxc	=	1248.56	in ³
Elastic section modulus (tension flange)	Zxt	=	936.23	in ³
Radius of Gyration	Rx	=	25.0	in

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Corroded Elastic section properties about x-x (web excluded)

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	I _{xx} in ⁴
0	Girder	-	-	38.5	28.98	1116.13	1043.34	33962.70
1	Angle H	-0.58	0.08	-0.05	57.16	-2.60	-50.81	-2.35E-05
2	Angle V	-0.08	2.92	-0.23	58.66	-13.49	-280.01	-0.164
3	Angle H	-3.08	0.08	-0.24	60.16	-14.59	-321.03	-1.25E-04
4	Angle V	-0.08	0.42	-0.03	60.41	-2.00	-44.53	-4.91E-04
5	Flange 1	-7.34	0.04	-0.29	61.23	-17.70	-405.64	-3.73E-05
6	Flange 2	-3.44	0.08	-0.27	61.21	-16.57	-379.35	-1.40E-04
7	Flange	-7.34	0.59	-4.30	60.96	-262.16	-5946.17	-0.123
Net Area				33.10		787.01	-6384.19	33962.41

Depth of full section

Distance to NA from top of section

Distance to NA from bottom of section

Second moment of area of section

Elastic section modulus (compression flange)

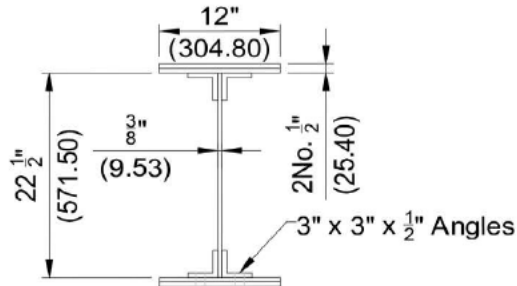
Elastic section modulus (tension flange)

Radius of Gyration

D	=	61.2	in
yt	=	23.8	in
yb	=	37.4	in
I _{xx}	=	27578.22	in ⁴
Z _{xc}	=	1160.02	in ³
Z _{xt}	=	736.66	in ³
R _x	=	28.9	in

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Internal Girders



Rivets are 7/8" therefore rivet holes are 15/16"

Two flange plates

Elastic section properties about x-x

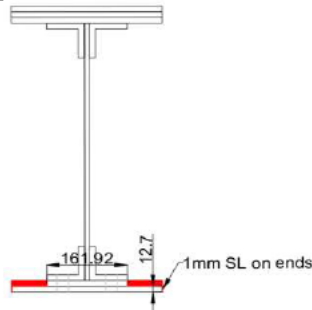
No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
1	Flange	12.00	1.00	12.00	0.50	6.00	1439.84	1.00
2	Angle H	6.38	0.50	3.19	1.25	3.98	331.88	0.07
3	Angle V	1.38	2.50	3.44	2.75	9.45	260.41	1.79
4	Web	0.38	16.50	6.19	12.25	75.80	3.92	140.38
5	Angle V	1.38	2.50	3.44	21.75	74.77	364.41	1.79
6	Angle H	6.38	0.50	3.19	23.25	74.11	443.54	0.07
7	Flange	12.00	1.00	12.00	24.00	288.00	1888.87	1.00
8	Rivets	-1.88	1.50	-2.81	23.75	-66.80	-425.24	-0.53
Net Area				40.63		465.31	4307.64	145.57
Gross Area				43.44				

Depth of full section
 Depth of web panel
 Depth of web panel between flanges
 Distance to NA from top of section
 Distance to NA from bottom of section
 Second moment of area of section
 Elastic section modulus (compression flange)
 Elastic section modulus (tension flange)
 Radius of Gyration

D	=	24.5	in
dw	=	22.5	in
dwe	=	16.5	in
yt	=	11.5	in
yb	=	13.0	in
Ixx	=	4453.21	in ⁴
Zxc	=	388.80	in ³
Zxt	=	341.34	in ³
Rx	=	10.5	in

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IG8 Midspan



Corroded Elastic section properties about x-x

No	Section	b in	d in	A in ²	y in	A·y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	40.6	11.45	465.31	35.05	4453.21
1	Flange	-5.63	0.50	-2.81	23.75	-66.80	-491.91	-0.059
2	Flange ends	-0.08	0.50	-0.04	24.25	-0.95	-7.42	-0.001
Net Area				37.77		397.56	-464.27	4453.15

Depth of full section

Distance to NA from top of section

Distance to NA from bottom of section

Second moment of area of section

Elastic section modulus (compression flange)

Elastic section modulus (tension flange)

Radius of Gyration

D	=	24.5	in
yt	=	10.5	in
yb	=	14.0	in
Ixx	=	3988.87	in ⁴
Zxc	=	378.99	in ³
Zxt	=	285.43	in ³
Rx	=	10.3	in

IG8 Thirdspan



Corroded Elastic section properties about x-x

No	Section	b in	d in	A in ²	y in	A·y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	40.6	11.45	465.31	613.55	4453.21
1	Flange	-5.63	0.12	-0.66	23.56	-15.65	-169.90	-0.001
2	Flange	-10.13	0.88	-8.93	24.06	-214.83	-2428.44	-0.579
Net Area				31.03		234.83	-1984.78	4452.63

Depth of full section

Distance to NA from top of section

Distance to NA from bottom of section

Second moment of area of section

Elastic section modulus (compression flange)

Elastic section modulus (tension flange)

Radius of Gyration

D	=	23.6	in
yt	=	7.6	in
yb	=	16.1	in
Ixx	=	2467.84	in ⁴
Zxc	=	326.11	in ³
Zxt	=	153.75	in ³
Rx	=	8.9	in

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One flange plate

Elastic section properties about x-x

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
1	Flange	12.00	0.50	6.00	0.25	1.50	698.09	0.13
2	Angle H	6.38	0.50	3.19	0.75	2.39	337.27	0.07
3	Angle V	1.38	2.50	3.44	2.25	7.73	265.38	1.79
4	Web	0.38	16.50	6.19	11.75	72.70	3.15	140.38
5	Angle V	1.38	2.50	3.44	21.25	73.05	358.59	1.79
6	Angle H	6.38	0.50	3.19	22.75	72.52	437.35	0.07
7	Flange	12.00	0.50	6.00	23.25	139.50	895.02	0.13
8	Rivets	-1.88	1.00	-1.88	23.00	-43.13	-268.36	-0.16
Net Area				29.56		326.27	2726.49	144.19
Gross Area				31.44				

Depth of full section

D = 23.5 in

Depth of web panel

dw = 22.5 in

Depth of web panel between flanges

dwe = 16.5 in

Distance to NA from top of section

yt = 11.0 in

Distance to NA from bottom of section

yb = 12.5 in

Second moment of area of section

Ixx = 2870.67 in⁴

Elastic section modulus (compression flange)

Zxc = 260.11 in³

Elastic section modulus (tension flange)

Zxt = 230.33 in³

Radius of Gyration

Rx = 9.9 in

IG3 Midspan / IG8 Support



Corroded Elastic section properties about x-x

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	29.6	11.04	326.27	85.45	2870.67
1	Flange ends	-1.00	0.50	-0.50	23.25	-11.63	-96.79	-0.010
2	Flange (triangle)	-6.19	0.50	-3.09	23.33	-72.19	-606.11	-0.021
Net Area				25.97		242.45	-617.46	2870.64

Depth of full section

D = 23.5 in

Distance to NA from top of section

yt = 9.3 in

Distance to NA from bottom of section

yb = 14.2 in

Second moment of area of section

Ixx = 2253.18 in⁴

Elastic section modulus (compression flange)

Zxc = 241.33 in³

Elastic section modulus (tension flange)

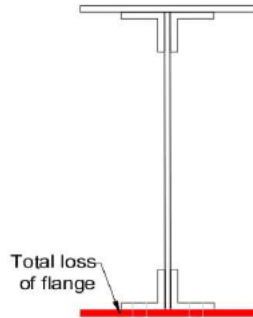
Zxt = 159.08 in³

Radius of Gyration

Rx = 9.3 in

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IG3 Support



Corroded Elastic section properties about x-x

No	Section	b in	d in	A in ²	y in	A·y in ³	A(y-yt) ² in ³	I _{xx} in ⁴
0	Girder	-	-	29.6	11.04	326.27	188.29	2870.67
1	Flange	-10.13	0.50	-5.06	23.25	-117.70	-1099.51	-0.105
Net Area				24.50		208.56	-911.22	2870.57

Depth of full section

D = 23.0 in

Distance to NA from top of section

yt = 8.5 in

Distance to NA from bottom of section

y_b = 14.5 in

Second moment of area of section

I_{xx} = 1959.35 in⁴

Elastic section modulus (compression flange)

Z_{xc} = 230.17 in³

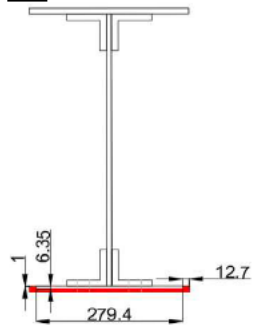
Elastic section modulus (tension flange)

Z_{xt} = 135.25 in³

Radius of Gyration

R_x = 8.9 in

IG2



Corroded Elastic section properties about x-x

No	Section	b in	d in	A in ²	y in	A·y in ³	A(y-yt) ² in ³	I _{xx} in ⁴
0	Girder	-	-	29.6	11.04	326.27	0.22	2870.67
1	Flange ends	-1.00	0.21	-0.21	23.14	-4.87	-31.33	-0.001
2	Flange	-10.13	0.25	-2.53	23.38	-59.17	-390.80	-0.013
Net Area				29.35		321.39	-31.10	2870.67

Depth of full section

D = 23.3 in

Distance to NA from top of section

yt = 10.9 in

Distance to NA from bottom of section

y_b = 12.3 in

Second moment of area of section

I_{xx} = 2839.57 in⁴

Elastic section modulus (compression flange)

Z_{xc} = 259.33 in³

Elastic section modulus (tension flange)

Z_{xt} = 230.85 in³

Radius of Gyration

R_x = 9.8 in

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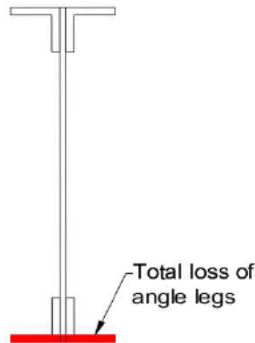
IG1 and IG18 - no flange plates

Elastic section properties about x-x

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
1	Angle H	6.38	0.50	3.19	0.25	0.80	339.82	0.07
2	Angle V	1.38	2.50	3.44	1.75	6.02	267.73	1.79
3	Web	0.38	16.50	6.19	11.25	69.61	2.82	140.38
4	Angle V	1.38	2.50	3.44	20.75	71.33	355.87	1.79
5	Angle H	6.38	0.50	3.19	22.25	70.92	434.46	0.07
6	Rivets	-1.38	0.94	-1.29	20.75	-26.75	-133.45	-0.09
Net Area				18.15		191.92	1267.24	144.00
Gross Area				19.44				

Depth of full section	D	=	22.5	in
Depth of web panel	dw	=	22.5	in
Depth of web panel between flanges	dwe	=	16.5	in
Distance to NA from top of section	yt	=	10.6	in
Distance to NA from bottom of section	yb	=	11.9	in
Second moment of area of section	Ixx	=	1411.24	in ⁴
Elastic section modulus (compression flange)	Zxc	=	133.45	in ³
Elastic section modulus (tension flange)	Zxt	=	118.35	in ³
Radius of Gyration	Rx	=	8.8	in

Corroded Section



Corroded Elastic section properties about x-x

No	Section	b in	d in	A in ²	y in	A-y in ³	A(y-yt) ² in ³	Ixx in ⁴
0	Girder	-	-	18.1	10.58	191.92	112.28	1411.24
1	Angle H	-6.38	0.50	-3.19	22.25	-70.92	-639.30	-0.07
Net Area				14.96		121.00	-527.02	1411.17

Depth of full section	D	=	22.0	in
Distance to NA from top of section	yt	=	8.1	in
Distance to NA from bottom of section	yb	=	13.9	in
Second moment of area of section	Ixx	=	884.15	in ⁴
Elastic section modulus (compression flange)	Zxc	=	109.32	in ³
Elastic section modulus (tension flange)	Zxt	=	63.55	in ³
Radius of Gyration	Rx	=	7.7	in

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Effective Spans

Edge Girders

BE4 303(a)

The effective span of a beam shall be taken as the distance between points of support.

303(a)(iii)

Where the beam has bearing stiffeners, the point underneath the bearing stiffener.

Distance between bearing stiffeners = **60.667** ft

Transverse Girders

303(a)(i)

Where a beam is supported by other beams, the web of the supporting beam. And,

303(a)(iv)

Where there are no bearing stiffeners and the beam rests directly on masonry, concrete or brick, the reaction shall be assumed to be distributed linearly from a maximum at the front edge of the support to zero at the back of the bearing area, The length of the bearing area may be taken as the depth of the beam where the support is of soft brick.

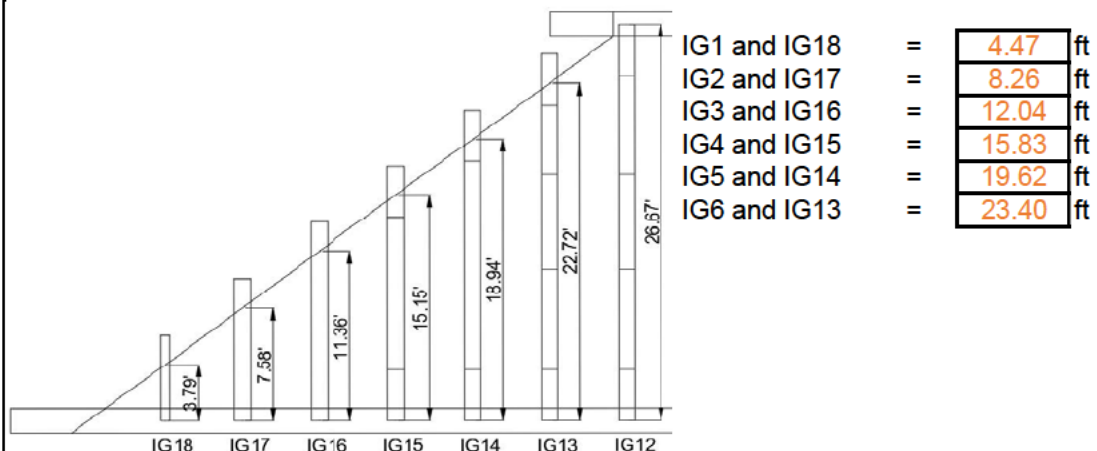
The effective span should be taken as the distance between the centroids of the bearing pressure diagrams.

For IG7 to IG12 Effective span = **26.67** ft

For the remaining transverse girders:

The bearing lengths are not known, therefore assume **2.04** ft
(taken as the depth of the girder at midspan with 2 plates for a considered assessment)

Effective span taken as $\text{Span} + (1/3)\text{Bearing}$



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Dead Loads

Unit Weights of Materials

Material	lb/cu.ft
Wrought Iron	480
Concrete	150
Brickwork	140
Miscellaneous Fill	135
Macadam (tar)	144

1 ton	=	2240 lb
1 ft	=	12 in
1 sq.ft	=	144 sq.in
1 cu.ft	=	1728 cu.in

Self Weight

Gross midspan used for a conservative assessment
Area increased by 12% to account for fixings

Edge Girders

Area of girder

$$135.50 \times 1.12 = 151.76 \text{ sq.in}$$

Girder self weight UDL

$$151.76/144 \times 480 = 505.87 \text{ lb/ft}$$

$$= 0.226 \text{ ton/ft}$$

Transverse Girders

IG4 - IG15

Area of girder

$$43.44 \times 1.12 = 48.65 \text{ sq.in}$$

Girder self weight UDL

$$48.65/144 \times 480 = 162.17 \text{ lb/ft}$$

$$= 0.072 \text{ ton/ft}$$

IG2, IG3, IG16, IG17

Area of girder

$$31.44 \times 1.12 = 35.21 \text{ sq.in}$$

Girder self weight UDL

$$35.21/144 \times 480 = 117.37 \text{ lb/ft}$$

$$= 0.052 \text{ ton/ft}$$

IG1 and IG18

Area of girder

$$19.44 \times 1.12 = 21.77 \text{ sq.in}$$

Girder self weight UDL

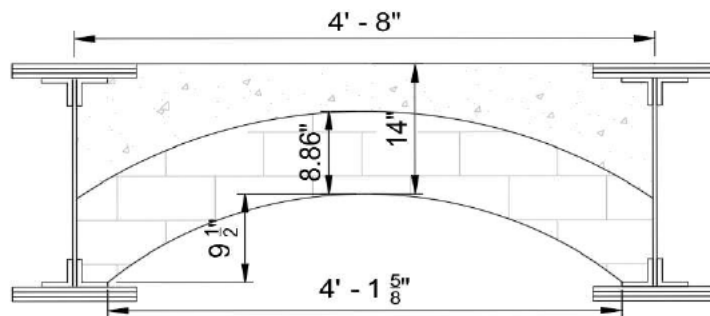
$$21.77/144 \times 480 = 72.57 \text{ lb/ft}$$

$$= 0.032 \text{ ton/ft}$$

BE4

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Jack Arch



Arch Barrel Thickness

Arch Barrel Rise

Jack Arch Span

Jack Arch Radius

R(Intrados)

$(a^2+b^2)/2a$

R(Extrados)

R(Intrados)+darch

$\sin\theta = (b/R(\text{Intrados}))$

Area of sector

$(2\theta/360) \times \pi \times R(\text{Intrados})^2$

Area of triangle

$b(R(\text{Intrados})-a)$

Area of segment

Area of sector - Area of triangle

Area of jack arch

$(2\theta/360) \times \pi (R(\text{Extrados})^2 - R(\text{Intrados})^2)$

darch= 8.86 in

a= 9.50 in

2b= 49.63 in

b= 24.81 in

= 37.15 in

= 46.01 in

$\theta = 41.90^\circ$

= 1009.47 sq.in

= 686.14 sq.in

Aseg = 323.32 sq.in

Aarch = 538.87 sq.in

Jack arch UDL

$538.87/144 \times 140 = 523.90$ lb/ft

= 0.234 ton/ft

Concrete Backing

Transverse girder spacing

= 54 in

Total depth

= 23.5 in

Total area - Jack arch

= 406.81 sq.in

For IG4 to IG15 Area

= 378.56 sq.in

Concrete backing UDL

= 394.33 lb/ft

= 0.176 ton/ft

For IG2, IG3, IG1, IG17 Area

= 384.56 sq.in

Concrete backing UDL

= 400.58 lb/ft

= 0.179 ton/ft

For IG1 and IG18 Area

= 390.56 sq.in

Concrete backing UDL

= 406.83 lb/ft

= 0.182 ton/ft

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Miscellaneous Fill

The average depth of fill across the deck will be used.

Average jack arch soffit level	=	98.697	m	
Average deck level	=	99.243	m	
Difference	=	0.546	m	= 21.51 in
Average fill level				= 7.510 in

Transverse girder spacing	=	54	in
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Where there is no carriageway surfacing

Area	=	405.52	sq.in
Miscellaneous fill UDL	=	380.17	lb/ft
	=	0.170	ton/ft

Where the top 4" will be considered as surfacing

Area	=	189.52	sq.in
Miscellaneous fill UDL	=	177.67	lb/ft
	=	0.079	ton/ft

Surfacing

The top 4" of the deck makeup will be assumed as surfacing

Depth	=	4	in
Transverse girder spacing	=	54	in
Area	=	216	sq.in

Surfacing UDL	=	216	lb/ft
	=	0.096	ton/ft

Total UDLs on Transverse Girders

IG4 to IG15

Verges	=	0.652	ton/ft
Carriageway	=	0.658	ton/ft

IG2, IG3, IG16, IG17

Verges	=	0.635	ton/ft
Carriageway	=	0.641	ton/ft

IG1 and IG18

Verges Only	=	0.618	ton/ft
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Dead Load Effects

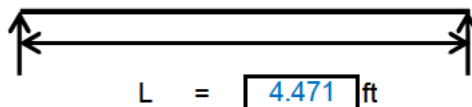
IG1 and IG18

The maximum bending moment and shear force in a beam with a UDL are given by:

$$\text{Maximum Bending Moment} \quad M_{max} = \frac{wl^2}{8}$$

$$\text{Maximum Shear Force} \quad V_{max} = \frac{wl}{2}$$

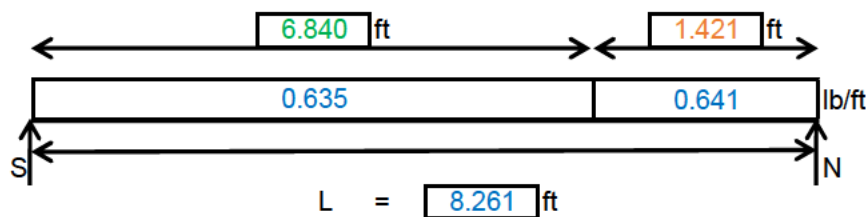
$$\text{DL + SDL UDL} = 0.618 \text{ ton/ft} \quad \text{MDL} = 1.54 \text{ ton.ft}$$



$$\text{VDL} = 1.38 \text{ ton}$$

IG2 and IG17

The verge on the south side is narrower, therefore the imposed loads will be more onerous on IG17



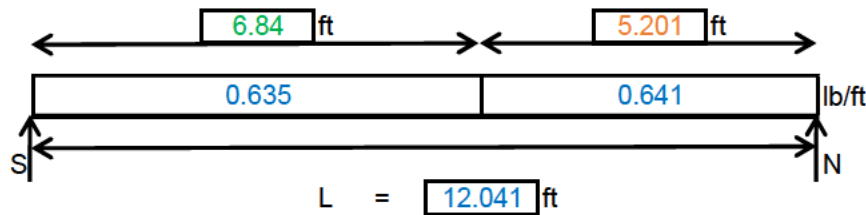
$$\begin{aligned} \text{Reaction at N} &= ((0.635 \times 6.840 \times 3.420) + (0.641 \times 1.421 \times 7.550)) / 8.261 \\ &= 2.630 \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{Reaction at S} &= (0.635 \times 6.840) + (0.641 \times 1.421) - 2.630 \\ &= 2.623 \text{ ton} \end{aligned}$$

$$\begin{aligned} M_{max} \text{ occurs when shear} &= 0 \text{ at } 4.131 \text{ ft from the south support} \\ &= 0.5 \times 2.623 \times 4.131 \\ &= 5.418 \text{ ton.ft} \end{aligned}$$

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IG3 and IG16

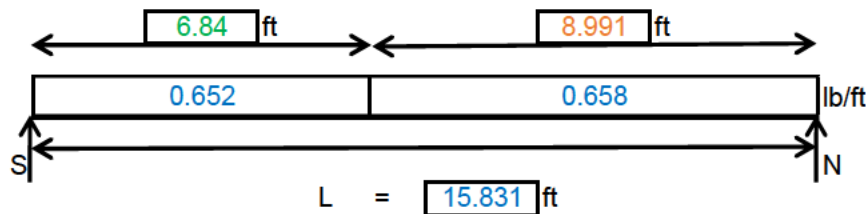


$$\begin{aligned} \text{Reaction at N} &= ((0.635 \times 6.840 \times 3.420) + (0.641 \times 5.201 \times 9.440)) / 12.041 \\ &= 3.846 \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{Reaction at S} &= (0.635 \times 6.840) + (0.641 \times 5.201) - 3.846 \\ &= 3.829 \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{Mmax} &\text{ occurs when shear } = 0 \text{ at } 6.031 \text{ ft from the south support} \\ &= 0.5 \times 3.829 \times 6.031 \\ &= 11.545 \text{ ton.ft} \end{aligned}$$

IG4 and IG15



$$\begin{aligned} \text{Reaction at N} &= ((0.652 \times 6.840 \times 3.420) + (0.658 \times 8.991 \times 11.335)) / 15.831 \\ &= 5.200 \text{ ton} \end{aligned}$$

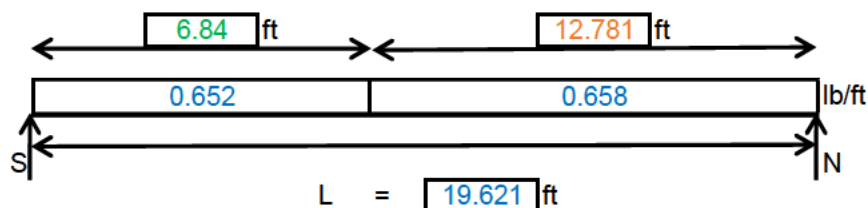
$$\begin{aligned} \text{Reaction at S} &= (0.652 \times 6.840) + (0.658 \times 8.991) - 5.200 \\ &= 5.176 \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{Mmax} &\text{ occurs when shear } = 0 \text{ at } 7.902 \text{ ft from the north support} \\ &= 0.5 \times 5.200 \times 7.902 \\ &= 20.544 \text{ ton.ft} \end{aligned}$$

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IG5 and IG14

The length of north verge carried is negligible and will therefore be ignored.



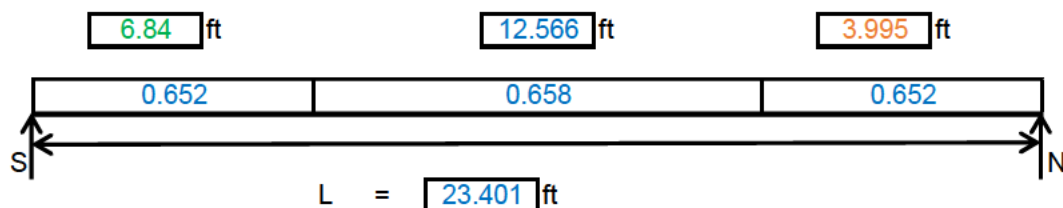
$$\begin{aligned} \text{Reaction at N} &= ((0.652 \times 6.840 \times 3.420) + (0.658 \times 12.781 \times 13.230)) / 19.621 \\ &= 6.449 \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{Reaction at S} &= (0.652 \times 6.840) + (0.658 \times 12.781) - 6.449 \\ &= 6.422 \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{Mmax occurs when shear} &= 0 \text{ at } 9.799 \text{ ft from the north support} \\ &= 0.5 \times 6.449 \times 9.799 \\ &= 31.596 \text{ ton.ft} \end{aligned}$$

IG6 and IG13

Width of the carriageway is 12.566 ft



$$\begin{aligned} \text{Reaction at N} &= ((0.652 \times 6.840 \times 3.420) + (0.658 \times 12.566 \times 13.123) + (0.652 \times 3.995 \times 21.403)) / 23.401 \\ &= 7.672 \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{Reaction at S} &= (0.652 \times 6.840) + (0.658 \times 12.566) + (0.652 \times 3.995) - 7.672 \\ &= 7.662 \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{Mmax occurs when shear} &= 0 \text{ at } 11.706 \text{ ft from the south support} \\ &= ((7.662 + 3.202) / 2) \times 6.840 + (0.5 \times 3.202 \times 4.866) \\ &= 44.949 \text{ ton.ft} \end{aligned}$$

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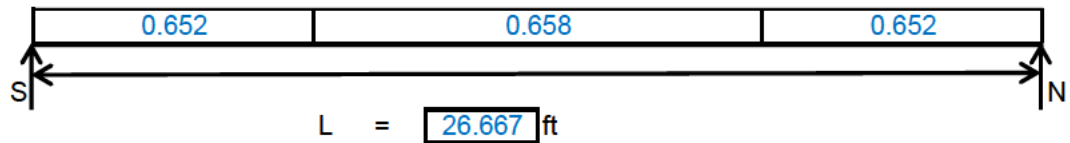
IG7 to IG12

Width of the carriageway is 12.566 ft

6.84 ft

12.566 ft

7.261 ft



Reaction at N

$$= ((0.652 \times 6.840 \times 3.420) + (0.658 \times 12.566 \times 13.123) + (0.652 \times 7.261 \times 23.036)) / 26.667$$

$$= \text{span style="border: 1px solid black; padding: 2px;">8.731 ton$$

Reaction at S

$$= (0.652 \times 6.840) + (0.658 \times 12.566) + (0.652 \times 7.261) - 8.731$$

$$= \text{span style="border: 1px solid black; padding: 2px;">8.732 ton$$

Mmax occurs when shear=0 at 13.332 ft from the south support

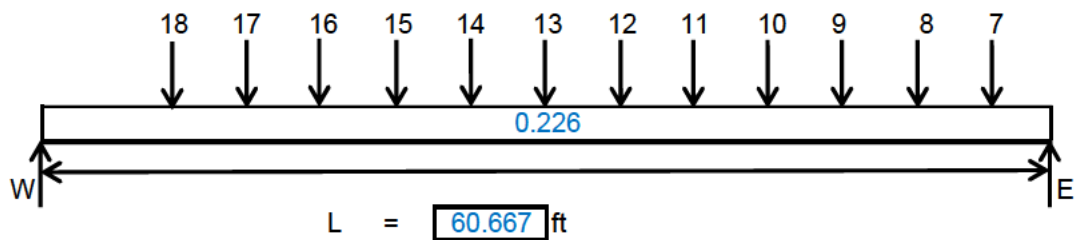
$$= ((8.732 + 4.272) / 2) \times 6.840 + (0.5 \times 4.272 \times 6.492)$$

$$= \text{span style="border: 1px solid black; padding: 2px;">58.345 ton.ft$$

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Edge Girders

The south edge girder will be used as the imposed loads are marginally more onerous.



Girder	Load (ton)	Distance from W(ft)
18	1.38	7.00
17	2.623	11.67
16	3.829	16.33
15	5.176	21.00
14	6.422	25.67
13	7.662	30.33
12	8.732	35.00
11	8.732	39.67
10	8.732	44.33
9	8.732	49.00
8	8.732	53.67
7	8.732	58.33

Shear Force (ton)	
34.419	33.04
31.984	29.36
28.307	24.48
23.425	18.25
17.195	10.77
9.7189	2.06
1.0027	-7.73
-8.7836	-17.52
-18.57	-27.30
-28.356	-37.09
-38.142	-46.87
-47.929	-56.66

Moment (ton.ft)	
	Total
246.46	246.46
151.72	398.18
134.56	532.74
111.78	644.52
82.7	727.22
47.814	775.03
7.1382	782.17
-38.531	743.64
-84.2	659.44
-129.87	529.57
-175.54	354.03
-221.21	132.82

Reaction at E = 57.19 ton
Reaction at W = 36.00 ton

Maximum moment occurs at IG 12 35.00 ft from the W support

Mmax = 782.17 ton.ft

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Live Loads

Transverse Girders

BE4 302(a)

For transverse members the vehicle train in Fig.1(b) or a single 11 ton axle shall be applied as appropriate.

One axle in one vehicle train shall be subjected to an increase of 25% for impact at the position where it will have the greatest effect on the member being considered.

Width of carriageway = 12.566 ft

For carriageway widths less than 18' - 0" one train of vehicles shall be applied.

For IG6 to IG13 the proportion of bending moment carried by the members will be determined by the methods given in Part II Section 3 as the deck consists of jack arches between the members.

IG6 and IG13 span = 23.40 ft
IG7 to IG12 span = 26.67 ft

From BE4 Part II. Graph for moments on cross girders for an individual axle (single train).

IG6 and IG13 = 41.50 ton.ft
IG7 to IG12 = 48.00 ton.ft

From BE4 Part II Graph No.6 proportion factors for internal transverse girders single lane

Girder spacing 4' - 8"
IG6 and IG13 = 0.975
IG7 to IG12 = 0.965

Imposed moment on the girders

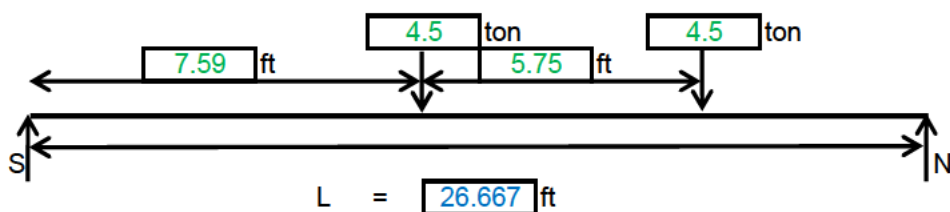
IG6 and IG13 = 41.50 x 0.975
= 40.46 ton.ft

IG7 to IG12 = 48.00 x 0.965
= 46.32 ton.ft

For the imposed shear on the girders

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IG7 to IG12



BE4 302

7.59ft = width of verge (6.84ft) + limit of wheel load position (9")

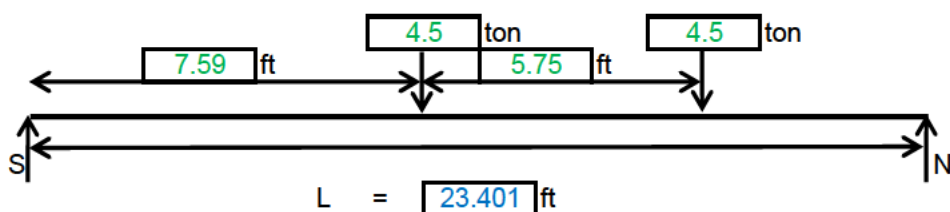
$$R_s = \frac{4.50(19.077 + 13.327)}{26.667}$$

$$= 5.47 \text{ ton}$$

$$\text{Imposed shear on girder} = 5.47 \times 0.965$$

$$= 5.28 \text{ ton}$$

IG13



BE4 302

7.59ft = width of verge (6.84ft) + limit of wheel load position (9")

$$R_s = \frac{4.50(15.811 + 10.061)}{23.401}$$

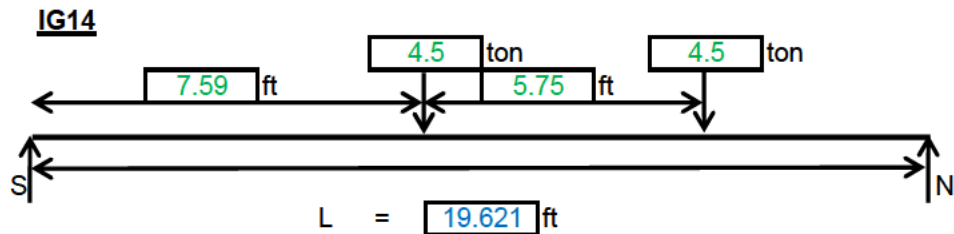
$$= 4.98 \text{ ton}$$

$$\text{Imposed shear on girder} = 4.98 \times 0.975$$

$$= 4.85 \text{ ton}$$

The remaining girders will be checked for single axle and single wheel loads as appropriate.

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$$R_s = \frac{(4.50(12.031 + 6.281))}{19.621}$$

$$= 4.20 \text{ ton}$$

$$M_{\max} = 4.20 \times 7.59$$

$$= 31.88 \text{ tonft}$$

$$M_{\max(DL)} = (4.20 \times 7.59) + (-0.30 \times 2.231)$$

$$= 31.21 \text{ ton.ft.}$$

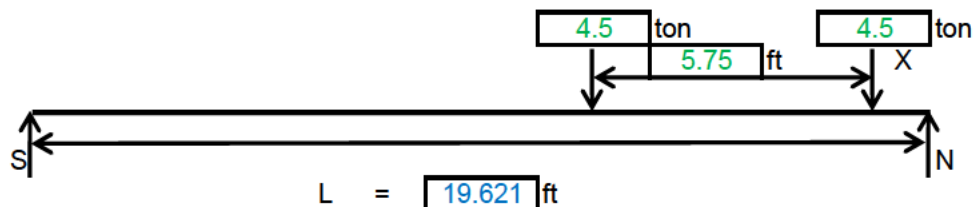
From Table 6, proportion factor = 1.0

Moment imposed on girder:

$$M_{\max} = 31.88 \text{ tonft}$$

$$M_{\max(DL)} = 31.21 \text{ tonft}$$

For maximum imposed shear on the girder:



$$X = 19.621 - 0.215 + 0.75$$

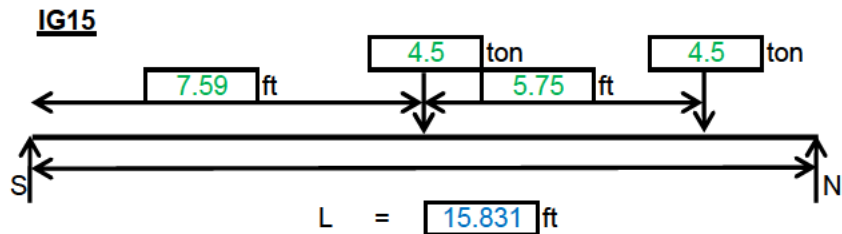
$$= 0.965 \text{ ft}$$

$$R_N = \frac{(4.50(18.656 + 12.906))}{19.621}$$

$$= 7.24 \text{ ton}$$

Imposed shear on girder = 7.24 ton

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$$R_s = \frac{(4.50(8.241 + 2.491))}{15.831}$$

$$= 3.05 \text{ ton}$$

$$M_{\max} = 3.05 \times 7.59$$

$$= 23.15 \text{ tonft}$$

$$M_{\max}(\text{DL}) = (3.05 \times 7.59) + (-1.45 \times 0.339)$$

$$= 22.66 \text{ ton.ft.}$$

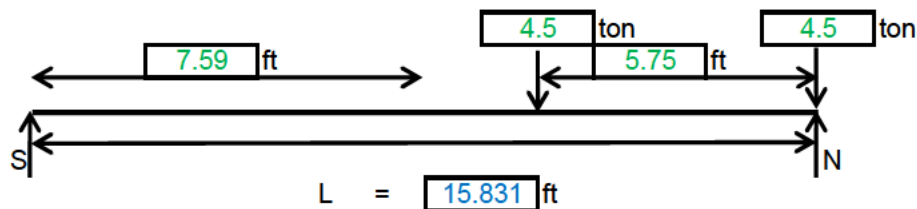
$$\text{From Table 6, proportion factor} = 1.028$$

Moment imposed on girder:

$$M_{\max} = 23.80 \text{ tonft}$$

$$M_{\max}(\text{DL}) = 23.30 \text{ tonft}$$

For maximum imposed shear on the girder:



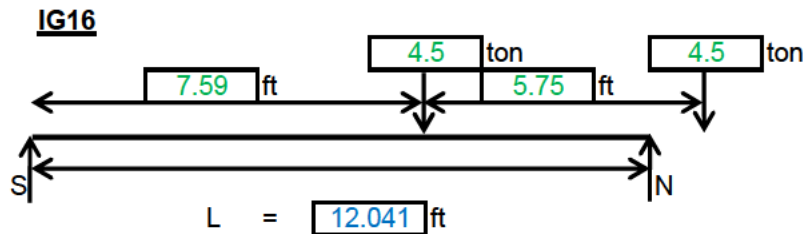
$$R_N = \frac{(4.50(15.831 + 10.081))}{15.831}$$

$$= 7.37 \text{ ton}$$

$$\text{Shear imposed on girder} = 7.37 \times 1.028$$

$$= 7.57 \text{ ton}$$

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$$R_s = (4.50 \times 4.451) / 12.041$$

$$= 3.87 \text{ ton}$$

$$M_{\max} = 3.87 \times 7.59$$

$$= 29.37 \text{ ton.ft.}$$

$$M_{\max}(\text{DL}) = 3.87 \times 3.015$$

$$= 23.34 \text{ ton.ft.}$$

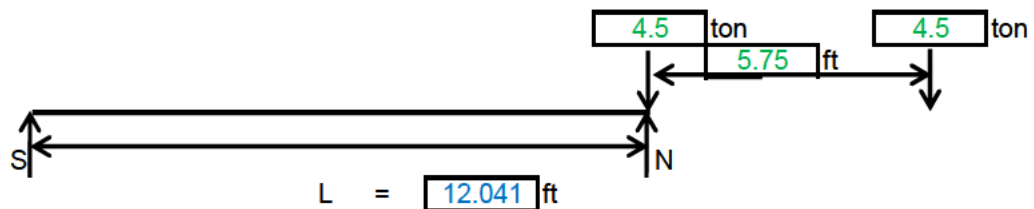
$$\text{From Table 6, proportion factor} = 1.080$$

Moment imposed on girder:

$$M_{\max} = 31.72 \text{ ton.ft.}$$

$$M_{\max}(\text{DL}) = 25.20 \text{ ton.ft.}$$

For maximum imposed shear on the girder:



$$R_N = 4.50 \text{ ton}$$

$$\text{Shear imposed on girder} = 4.50 \times 1.080$$

$$= 4.86 \text{ ton}$$

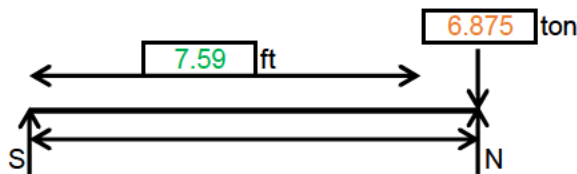
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IG17

The span for IG17 is less than the minimum 10ft included on the graphs for determining proportion factors for imposed loads.

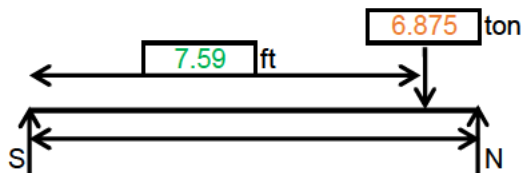
As a conservative assessment an 11ton axle with no distribution of the loads will be used.

$$\text{Wheel load} = 11 \times 1.25 \times 0.5$$



$$L = 8.261 \text{ ft}$$

$$RN = 6.88 \text{ ton}$$



$$L = 8.261 \text{ ft}$$

$$Rs = 0.56 \text{ ton}$$

$$\begin{aligned} M_{\max} &= 6.32 \times 0.671 \\ &= 4.61 \text{ tonft} \end{aligned}$$

$$\begin{aligned} M_{\text{midspan}} &= 0.56 \times 4.130 \\ &= 2.31 \text{ tonft} \end{aligned}$$

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Edge Girders

Loading will be applied to the edge girders by simple statics with the load train applied transversely for maximum effect within the carriageway positioning limits as indicated in BE4 Pt1 302. Longitudinal position of the vehicle trains will be adjusted to maximise load effects at the positions under consideration.

Using the 4 axle vehicle. $W = 24$ ton

Axle	0.33W	0.167W
Axle Load (ton)	8	4
Wheel Load (ton)	4	2
Factored Load (ton)	5	2.5

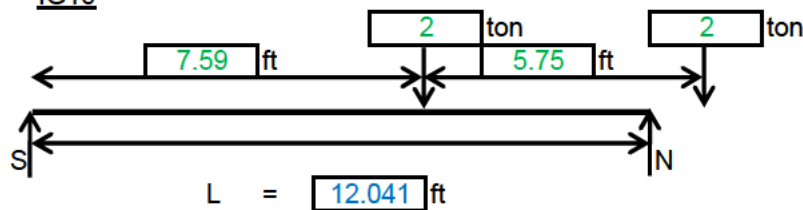
Consider the following arrangement for imposing the max. bending moment at midspan



■ = 0.33W axle
■ = 0.167W axle

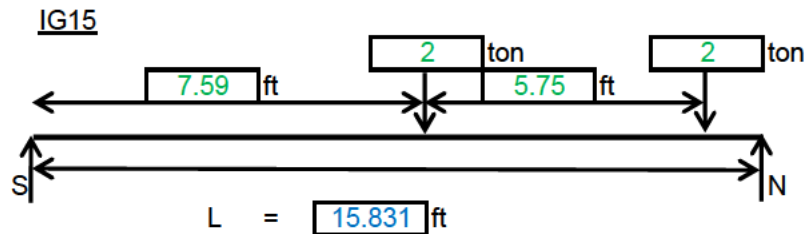
It will be assumed that IG12, IG13, IG15 and IG16 will carry 100% of the adjacent wheel loads.

IG16



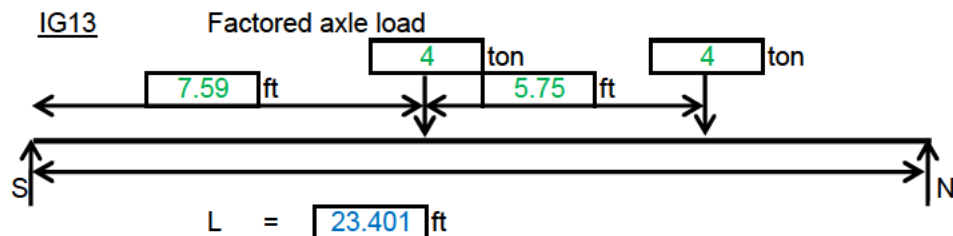
$$\begin{aligned}
 R_s &= (2.00 \times 4.451) / 12.041 \\
 &= 0.74 \text{ ton}
 \end{aligned}$$

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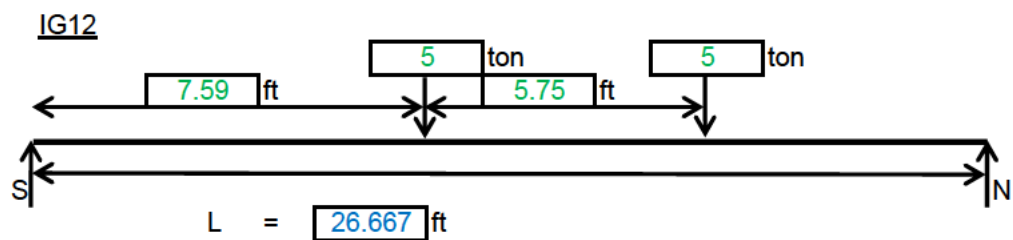
$$R_s = (2.00(8.241 + 2.491))/15.831$$

$$= 1.36 \text{ ton}$$



$$R_s = (4.00(15.811 + 10.061))/23.401$$

$$= 4.42 \text{ ton}$$



$$R_s = (5.00(19.077 + 13.327))/26.667$$

$$= 6.08 \text{ ton}$$

The wheel loads carried by IG11, IG10, IG9, IG8 and IG7 will be determined by simple statics

IG11 carries	42.9%	of 0.167W axle	Wheel load =	0.86	ton
IG10 carries	103.5%	of 0.167W axle	Wheel load =	2.07	ton
IG9 carries	53.6%	of 0.167W axle	Wheel load =	1.07	ton
IG8 carries	32.1%	of 0.33W axle	Wheel load =	1.29	ton
IG7 carries	103.6%	of 0.33W axle	Wheel load =	4.14	ton

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IG11, IG10, IG9, IG8 and IG7 all have the same arrangement as IG12

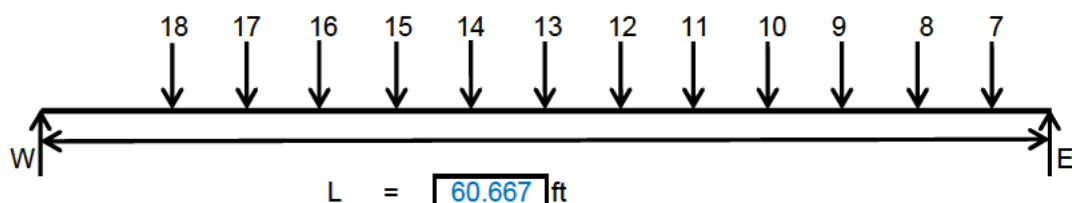
$$\begin{aligned} \text{IG11} \quad R_s &= (0.86(19.077 + 13.327))/26.667 \\ &= \boxed{1.04} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG10} \quad R_s &= (2.07(19.077 + 13.327))/26.667 \\ &= \boxed{2.52} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG9} \quad R_s &= (1.07(19.077 + 13.327))/26.667 \\ &= \boxed{1.30} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG8} \quad R_s &= (1.29(19.077 + 13.327))/26.667 \\ &= \boxed{1.56} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG7} \quad R_s &= (4.14(19.077 + 13.327))/26.667 \\ &= \boxed{5.03} \text{ ton} \end{aligned}$$



Girder	Load (ton)	Distance from W(ft)	Shear Force (ton)	Moment (ton.ft)
18	0.00	7.00	7.87	55.10
17	0.000	11.67	7.87	91.83
16	0.739	16.33	7.13	128.56
15	1.356	21.00	5.78	161.84
14	0.000	25.67	5.78	188.79
13	4.422	30.33	1.35	215.75
12	6.076	35.00	-4.72	222.06
11	1.043	39.67	-5.76	200.03
10	2.516	44.33	-8.28	173.12
9	1.302	49.00	-9.58	134.48
8	1.562	53.67	-11.14	89.76
7	5.035	58.33	-16.18	37.75

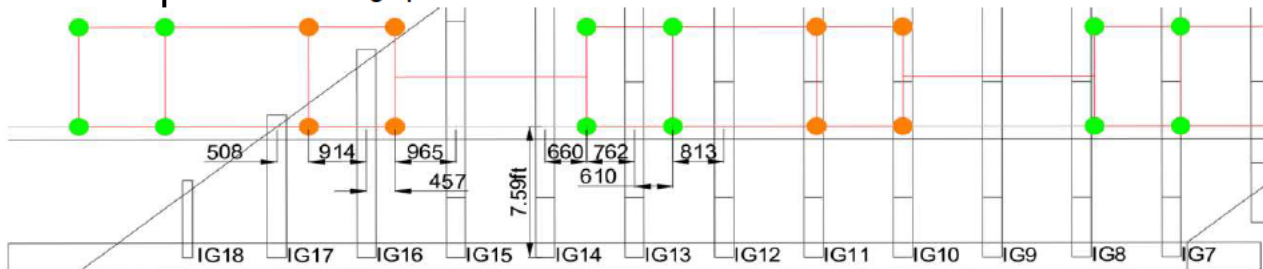
$$\begin{aligned} \text{Reaction at E} &= \boxed{16.18} \text{ ton} \\ \text{Reaction at W} &= \boxed{7.87} \text{ ton} \end{aligned}$$

Maximum moment occurs at IG 12 35.00 ft from the W support

$$M_{\max} = \boxed{222.06} \text{ ton.ft}$$

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Consider the following arrangement to impose the max. bending moment at IG10 where 2 flange plates will be considered



It will be assumed that IG11, IG10, IG8 and IG7 will carry 100% of the adjacent wheel loads.

$$\begin{aligned} \text{IG11 } R_s &= (5.0(19.077 + 13.327))/26.667 \\ &= \boxed{6.08} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG10 } R_s &= (4.0(19.077 + 13.327))/26.667 \quad (\text{factored axle}) \\ &= \boxed{4.86} \text{ ton} \end{aligned}$$

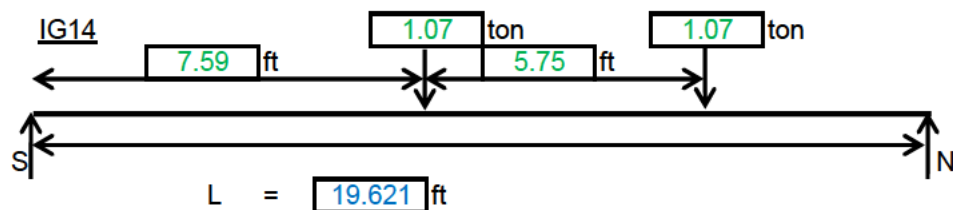
$$\begin{aligned} \text{IG8 } R_s &= (2.0(19.077 + 13.327))/26.667 \\ &= \boxed{2.43} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG7 } R_s &= (2.0(19.077 + 13.327))/26.667 \\ &= \boxed{2.43} \text{ ton} \end{aligned}$$

IG17 carries	64%	of 0.33W axle	Wheel load	=	2.57	ton
IG16 carries	104%	of 0.33W axle	Wheel load	=	4.14	ton
IG15 carries	32%	of 0.33W axle	Wheel load	=	1.29	ton
IG14 carries	54%	of 0.167W axle	Wheel load	=	1.07	ton
IG13 carries	104%	of 0.167W axle	Wheel load	=	2.07	ton
IG12 carries	43%	of 0.167W axle	Wheel load	=	0.86	ton

$$\begin{aligned} \text{IG12 } R_s &= (0.86(19.077 + 13.327))/26.667 \\ &= \boxed{1.04} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG13 } R_s &= (2.07(15.811 + 10.061))/23.401 \\ &= \boxed{2.29} \text{ ton} \end{aligned}$$

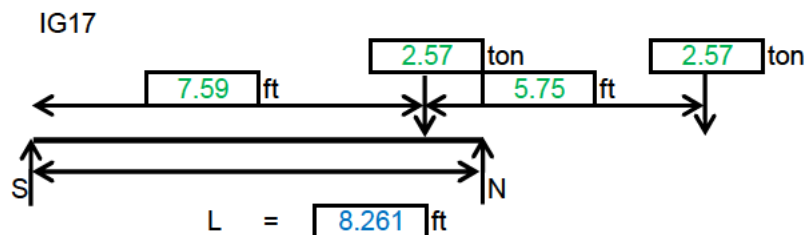


$$\begin{aligned} R_s &= (1.07(12.031 + 6.281))/19.621 \\ &= \boxed{1.00} \text{ ton} \end{aligned}$$

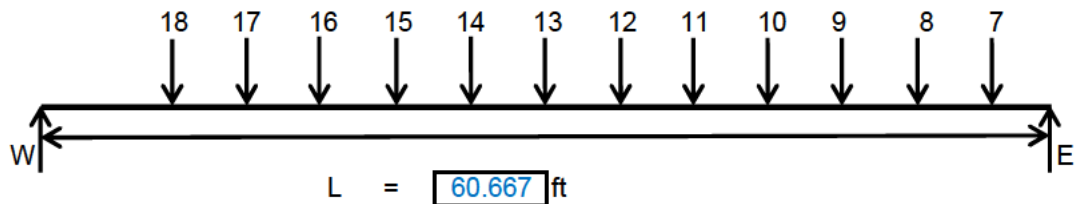
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$$\begin{aligned} \text{IG15 } R_s &= (1.29(8.241 + 2.491))/15.831 \\ &= \boxed{0.87} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG16 } R_s &= (4.14 \times 4.451)/12.041 \\ &= \boxed{1.53} \text{ ton} \end{aligned}$$



$$\begin{aligned} R_s &= (2.57 \times 0.671)/8.261 \\ &= \boxed{0.21} \text{ ton} \end{aligned}$$



Girder	Load (ton)	Distance from W(ft)
18	0.00	7.00
17	0.209	11.67
16	1.532	16.33
15	0.871	21.00
14	1.000	25.67
13	2.290	30.33
12	1.042	35.00
11	6.076	39.67
10	4.861	44.33
9	0.000	49.00
8	2.430	53.67
7	2.430	58.33

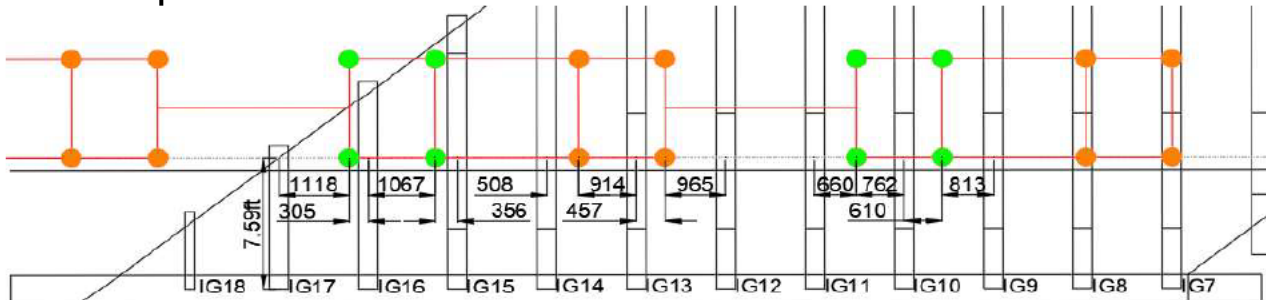
Shear Force (ton)
7.81
7.60
6.07
5.19
4.19
1.90
0.86
-5.21
-10.07
-10.07
-12.50
-14.93

Moment (ton.ft)
54.64
91.07
126.52
154.82
179.06
198.63
207.52
211.55
187.22
140.21
93.20
34.85

$$\begin{aligned} \text{Reaction at E} &= \boxed{14.93} \text{ ton} \\ \text{Reaction at W} &= \boxed{7.81} \text{ ton} \end{aligned}$$

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Consider the following arrangement to impose the worst case shear at the support (E)



It will be assumed that IG8 and IG7 will carry 100% of the adjacent wheel loads.

$$\begin{aligned} \text{IG7 } R_s &= (4.0(19.077 + 13.327))/26.667 \\ &= \boxed{4.86} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG8 } R_s &= (5.0(19.077 + 13.327))/26.667 \\ &= \boxed{6.08} \text{ ton} \end{aligned}$$

IG9 carries	43%	of 0.167W axle	Wheel load	=	0.86	ton
IG10 carries	104%	of 0.167W axle	Wheel load	=	2.07	ton
IG11 carries	54%	of 0.167W axle	Wheel load	=	1.07	ton
IG12 carries	32%	of 0.33W axle	Wheel load	=	1.29	ton
IG13 carries	104%	of 0.33W axle	Wheel load	=	4.14	ton
IG14 carries	67%	of 0.33W axle	Wheel load	=	2.67	ton
IG15 carries	75%	of 0.167W axle	Wheel load	=	1.50	ton
IG16 carries	104%	of 0.167W axle	Wheel load	=	2.07	ton
IG17 carries	21%	of 0.167W axle	Wheel load	=	0.43	ton

$$\begin{aligned} \text{IG9 } R_s &= (0.86(19.077 + 13.327))/26.667 \\ &= \boxed{1.04} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG10 } R_s &= (2.07(19.077 + 13.327))/26.667 \\ &= \boxed{2.52} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG11 } R_s &= (1.07(19.077 + 13.327))/26.667 \\ &= \boxed{1.30} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG12 } R_s &= (1.29(19.077 + 13.327))/26.667 \\ &= \boxed{1.56} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG13 } R_s &= (4.14(15.811 + 10.061))/23.401 \\ &= \boxed{4.58} \text{ ton} \end{aligned}$$

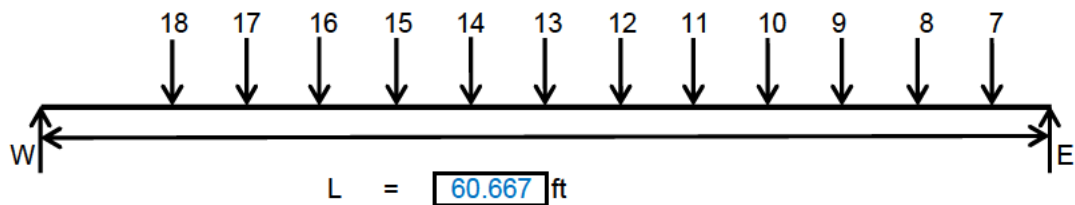
$$\begin{aligned} \text{IG14 } R_s &= (2.67(12.031 + 6.281))/19.621 \\ &= \boxed{2.49} \text{ ton} \end{aligned}$$

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$$\begin{aligned} \text{IG15 } R_s &= (1.50(8.241 + 2.491))/15.831 \\ &= \boxed{1.02} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG16 } R_s &= (2.07 \times 4.451)/12.041 \\ &= \boxed{0.77} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG17 } R_s &= (0.43 \times 0.671)/8.261 \\ &= \boxed{0.03} \text{ ton} \end{aligned}$$



Girder	Load (ton)	Distance from W(ft)
18	0.00	7.00
17	0.035	11.67
16	0.766	16.33
15	1.017	21.00
14	2.489	25.67
13	4.581	30.33
12	1.562	35.00
11	1.302	39.67
10	2.516	44.33
9	1.042	49.00
8	6.076	53.67
7	4.861	58.33

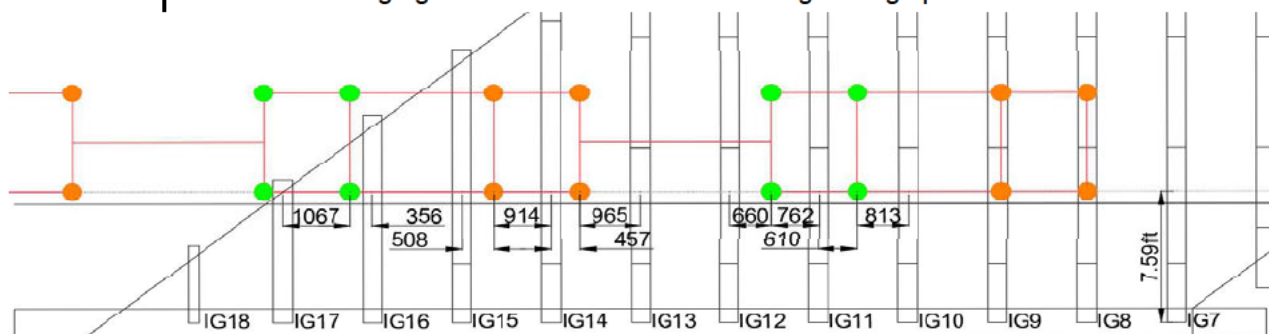
Shear Force (ton)
7.86
7.82
7.06
6.04
3.55
-1.03
-2.59
-3.89
-6.41
-7.45
-13.53
-18.39

Moment (ton.ft)
54.99
91.65
128.15
161.08
189.26
205.83
201.02
188.92
170.74
140.82
106.04
42.91

$$\begin{aligned} \text{Reaction at E} &= \boxed{18.39} \text{ ton} \\ \text{Reaction at W} &= \boxed{7.86} \text{ ton} \end{aligned}$$

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Consider the following arrangement for imposing the maximum bending at IG8 where the edge girder will be checked considering 1 flange plate.



$$\begin{aligned} \text{IG8} \quad R_s &= (4.0(19.077 + 13.327))/26.667 \\ &= \boxed{4.86} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG9} \quad R_s &= (4.0(19.077 + 13.327))/26.667 \\ &= \boxed{4.86} \text{ ton} \end{aligned}$$

IG10 carries	43%	of 0.167W axle	Wheel load	=	0.86	ton
IG11 carries	104%	of 0.167W axle	Wheel load	=	2.07	ton
IG12 carries	54%	of 0.167W axle	Wheel load	=	1.07	ton
IG13 carries	32%	of 0.33W axle	Wheel load	=	1.29	ton
IG14 carries	102%	of 0.33W axle	Wheel load	=	4.09	ton
IG15 carries	64%	of 0.33W axle	Wheel load	=	2.57	ton
IG16 carries	75%	of 0.167W axle	Wheel load	=	1.50	ton

$$\begin{aligned} \text{IG10} \quad R_s &= (0.86(19.077 + 13.327))/26.667 \\ &= \boxed{1.04} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG11} \quad R_s &= (2.07(19.077 + 13.327))/26.667 \\ &= \boxed{2.52} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG12} \quad R_s &= (1.07(19.077 + 13.327))/26.667 \\ &= \boxed{1.30} \text{ ton} \end{aligned}$$

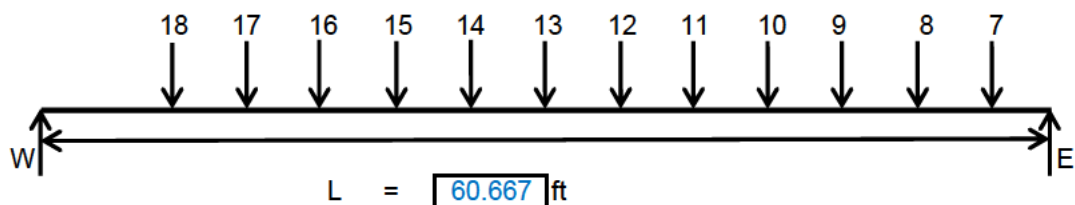
$$\begin{aligned} \text{IG13} \quad R_s &= (1.29(15.811 + 10.061))/23.401 \\ &= \boxed{1.42} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG14} \quad R_s &= (4.09(12.031 + 6.281))/19.621 \\ &= \boxed{3.82} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG15} \quad R_s &= (2.57(8.241 + 2.491))/15.831 \\ &= \boxed{1.74} \text{ ton} \end{aligned}$$

$$\begin{aligned} \text{IG16} \quad R_s &= (1.50 \times 4.451)/12.041 \\ &= \boxed{0.55} \text{ ton} \end{aligned}$$

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Girder	Load (ton)	Distance from W(ft)	Shear Force (ton)	Moment (ton.ft)
18	0.00	7.00	7.66	53.60
17	0.000	11.67	7.66	89.34
16	0.554	16.33	7.10	125.07
15	1.743	21.00	5.36	158.22
14	3.821	25.67	1.54	183.24
13	1.421	30.33	0.12	190.42
12	1.302	35.00	-1.18	190.98
11	2.516	39.67	-3.70	185.45
10	1.042	44.33	-4.74	168.18
9	4.861	49.00	-9.60	146.05
8	4.861	53.67	-14.46	101.24
7	0.000	58.33	-14.46	33.75

Reaction at E = 14.46 ton
 Reaction at W = 7.66 ton

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Transverse Girder Capacity

Bending Capacity

The jack arch construction offers restraint to the top flanges of the internal girders against lateral torsional buckling, therefore capacity (μ) can be derived from the section modulus of the bottom flange.

$$\mu = P_{bt} \cdot Z_{xt}$$

Where:

Z_{xt} = Elastic section modulus (tension flange)

P_{bt} = Permissible stress in bending

The permissible stresses for wrought iron shall be as given in BE4 Part I Clause 304(b)

Permissible Stress = 8.4 ton/sq.in.

IG1 / IG18

Z_{xt} = 63.55 cu.in.

μ = (63.55 x 8.4)/12
= 44.49 ton.ft

Moment due to dead loads = 1.54 ton.ft.

Moment due to live loads = 0 ton.ft.

Total imposed moment = 1.54 ton.ft.

Girder capacity is sufficient for imposed loading

IG2 / IG17

Z_{xt} = 230.85 cu.in.

μ = (230.85 x 8.4)/12
= 161.60 ton.ft

	Midspan (ton.ft.)	At max M due to LL (ton.ft.)
Moment due to dead loads	5.42	1.62
Moment due to live loads	2.31	4.61
Total imposed moment	7.72	6.23

Girder capacity is sufficient for imposed loading

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IG3 / IG16

$$Z_{xt} = 159.08 \text{ cu.in.}$$

$$\begin{aligned} \mu &= (159.08 \times 8.4)/12 \\ &= 111.36 \text{ ton.ft} \end{aligned}$$

	At max M due to DL (ton.ft.)	At max M due to LL (ton.ft.)
Moment due to dead loads	11.55	10.77
Moment due to live loads	23.34	29.37
Total imposed moment	34.88	40.14

Girder capacity is sufficient for imposed loading

IG4 / IG15

$$Z_{xt} = 153.75 \text{ cu.in. (using IG8 at thirdspan for typical condition)}$$

$$\begin{aligned} \mu &= (153.75 \times 8.4)/12 \\ &= 107.63 \text{ ton.ft} \end{aligned}$$

	At max M due to DL (ton.ft.)	At max M due to LL (ton.ft.)
Moment due to dead loads	20.54	20.51
Moment due to live loads	23.30	23.80
Total imposed moment	43.84	44.31

Girder capacity is sufficient for imposed loading

IG5 / IG14

$$Z_{xt} = 153.75 \text{ cu.in. (using IG8 at thirdspan for typical condition)}$$

$$\begin{aligned} \mu &= (153.75 \times 8.4)/12 \\ &= 107.63 \text{ ton.ft} \end{aligned}$$

	At max M due to DL (ton.ft.)	At max M due to LL (ton.ft.)
Moment due to dead loads	31.60	29.96
Moment due to live loads	31.21	31.88
Total imposed moment	62.80	61.83

Girder capacity is sufficient for imposed loading

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IG6 / IG13

$$Z_{xt} = 285.43 \text{ cu.in. (using IG8 at midspan for typical condition)}$$

$$\begin{aligned} \mu &= (285.43 \times 8.4)/12 \\ &= 199.80 \text{ ton.ft} \end{aligned}$$

$$\begin{aligned} \text{Moment due to dead loads} &= 44.95 \text{ ton.ft.} \\ \text{Moment due to live loads} &= 40.46 \text{ ton.ft.} \\ \text{Total imposed moment} &= 85.41 \text{ ton.ft.} \end{aligned}$$

Girder capacity is sufficient for imposed loading

IG7 to IG12

$$Z_{xt} = 285.43 \text{ cu.in. (using IG8 at midspan for typical condition)}$$

$$\begin{aligned} \mu &= (285.43 \times 8.4)/12 \\ &= 199.80 \text{ ton.ft} \end{aligned}$$

$$\begin{aligned} \text{Moment due to dead loads} &= 58.35 \text{ ton.ft.} \\ \text{Moment due to live loads} &= 46.32 \text{ ton.ft.} \\ \text{Total imposed moment} &= 104.67 \text{ ton.ft.} \end{aligned}$$

Girder capacity is sufficient for imposed loading

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Shear Resistance at Supports

BS 153 Part 4
Cl. 20d(ii)

The effective sectional area for parts in shear is the product of the thickness of the web and the full depth of the web plate.

BS 153 Part 3B
Cl. 29 a

As the locations of the stiffeners on the transverse girders are not known, and therefore the value of P_q from BS 153 Part 3B Clause 29a, the allowable average shear stress shall be obtained from Table 3 of BS 153 Part 3B

BS 153 Part 3B
Table 3

Using a yield stress of 16 to/sq.in. for mild steel, the average shear stress shall not exceed 6 ton/sq.in. (steel to BS 15 / BS 2762)

BE4 Part I
Cl. 304(a)

The stresses for mild steel shall be as in BS 153, Part 3B Case II
The allowable stresses shall be increased by 25% = 7.50 ton/sq.in.

BE4 Part I
Cl. 304(b)

Using the conversion ratio from steel to wrought iron gives a permissible stress of:

$$10.75/16 \times 7.50 = \text{5.04 ton/sq.in}$$

t = thickness of the web
d = depth of the web panel

IG2 to IG17 all have the same web dimensions.

$$\begin{aligned} t &= \text{0.38 in} \\ d &= \text{22.5 in} \end{aligned}$$

$$\text{Shear capacity} = 0.38 \times 22.50 \times 5.04 = \text{42.52 ton}$$

Girder	Shear due to DL (ton)	Shear due to LL (ton)	Total load (ton)	
IG2 / IG17	2.63	6.88	9.50	Girder Passes
IG3 / IG16	3.85	4.86	8.71	Girder Passes
IG4 / IG15	5.20	7.57	12.77	Girder Passes
IG5 / IG14	6.45	7.24	13.69	Girder Passes
IG6 / IG13	7.67	4.85	12.52	Girder Passes
IG7 - IG12	8.73	5.28	14.01	Girder Passes

IG1 and IG18 have section loss to the bottom of the web plate.

$$\begin{aligned} t &= \text{0.38} \\ d &= \text{22} \end{aligned}$$

$$\text{Shear capacity} = 0.38 \times 22.00 \times 5.04 = \text{41.57 ton}$$

$$\begin{aligned} \text{Shear due to dead loads} &= \text{1.38 ton} \\ \text{Shear due to Live Loads} &= \text{0 ton} \\ \text{Total imposed shear} &= \text{1.38 ton Girder Passes} \end{aligned}$$

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Edge Girder Capacity Bending Resistance

The girders are subject to U-frame or L-frame action restraining the girders against compression flange buckling.

For simply supported girders where there is no lateral bracing of the compression flange, but where cross members and stiffeners forming U-frames provide lateral restraint: $l = 2.5 \sqrt[4]{(EIa\delta)}$

Where:

E = Young's Modulus
= 13000 ton/sq.in

a = distance between frames
= 186.67 in (Average distance between gusseted stiffeners will be used)

I = maximum moment of inertia of compression flange about the y-y axis.

The girder is to be checked at locations where there are 4 flanges plates, 3 flange plates and 2 flange plates.

4 plates (3 considered for assessment)

Section	b in	d in	A in ²	x in	A·x in ³	A(x-xt) ² in ³	I _{yy} in ⁴
Flange	1.88	20.00	37.5	0.00	0.00	0.00	1250.00
Angle L	0.50	3.50	1.75	-1.94	-3.39	6.57	1.79
Angle R	0.50	3.50	1.75	1.94	3.39	6.57	1.79
			41.0		0.0	13.14	1253.57

Width of full section

B = 0.0 in

Distance to NA

xt = 0.0 in

Second moment of area of section

I_{yy} = 1266.71 in⁴

3 plates (2 considered for assessment)

Section	b in	d in	A in ²	x in	A·x in ³	A(x-xt) ² in ³	I _{yy} in ⁴
Flange	1.25	20.00	25.0	0.00	0.00	0.00	833.33
Angle L	0.50	3.50	1.75	-1.94	-3.39	6.57	1.79
Angle R	0.50	3.50	1.75	1.94	3.39	6.57	1.79
			28.5		0.0	13.14	836.91

Width of full section

B = 0.0 in

Distance to NA

xt = 0.0 in

Second moment of area of section

I_{yy} = 850.04 in⁴

BS 153: Pt 4
Cl. 21 b

BS 153 Pt 3B
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2 plates (1 considered for assessment)

Section	b in	d in	A in ²	x in	A·x in ³	A(x-x _t) ² in ³	I _{yy} in ⁴
Flange	0.63	20.00	12.5	0.00	0.00	0.00	416.67
Angle L	0.50	3.50	1.75	-1.94	-3.39	6.57	1.79
Angle R	0.50	3.50	1.75	1.94	3.39	6.57	1.79
			16.0		0.0	13.14	420.24

Width of full section

B = 0.0 in

Distance to NA

x_t = 0.0 in

Second moment of area of section

I_{yy} = 433.38 in⁴

δ = the virtual lateral displacement of the compression flange at the frame nearest midspan of the girder, taken as the horizontal deflection of the stiffener at the point of its intersection with the centroid of the compression flange, under the action of unit horizontal force applied at this point to the frame only.

*A flexibility coefficient will be added as a third term for calculating the virtual lateral displacement of the compression flange. A coefficient appropriate to the type of connection will be obtained from NR/GN/CIV/025 Fig. A42.

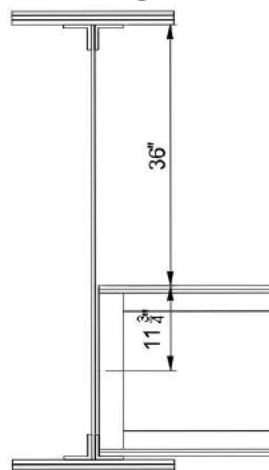
$$\delta = \frac{(d')^3}{3EI_1} + \frac{(d'')^2 b}{EI_2} [+ f(d'')^2]$$

Where:

d' = distance from the centroid of the compression flange to the top of the cross member.

d'' = distance from the centroid of the compression flange to the neutral axis of the cross member.

Where the girder is to be checked, the transverse girders all have the same section.



4No. Plates centroid 1.04 in from top of section
d' = 36.84 in
d'' = 48.59 in

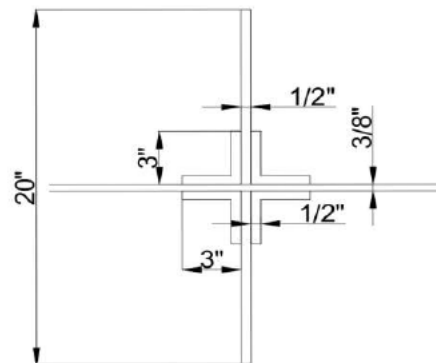
3No. Plates centroid 0.73 in from top of section
d' = 36.52 in
d'' = 48.27 in

2No. Plates centroid 0.44 in from top of section
d' = 36.19 in
d'' = 47.94 in

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b = half the distance between centres of the main girders
 = 320 in

I1 = moment of inertia of the stiffener in its plane of bending



Neutral axis taken at girder web centreline

b	d	A	y	A·y	A(y-yt) ²	Ixx
in	in	in ²	in	in ³	in ³	in ⁴
0.50	6.81	3.41	6.59	22.46	148.10	13.17
6.50	3.00	19.50	1.69	32.91	55.53	14.63
6.50	0.38	2.44	0.00	0.00	0.00	0.03
6.50	3.00	19.50	-1.69	-32.91	55.53	14.63
0.50	6.81	3.41	-6.59	-22.46	148.10	13.17
		48.25		0.00	407.25	55.63

Distance to neutral axis = 0.0 in
 I1 = 462.88 in⁴

I2 = moment of inertia of the cross member in its plane of bending
 = 3988.87 in⁴ (taken as corroded midspan)

f = 2.00E-05 rad/kNm
 = 5.06E-06 rad/ton.in

Section	$\frac{(d')^3}{3EI_1}$	$\frac{(d'')^2 b}{EI_2}$	$[f(d'')^2]$	δ
4 Plates	0.00276881	0.01456737	0.01194413	0.02928031
3 Plates	0.00269759	0.01437696	0.01178800	0.02886255
2 Plates	0.00262553	0.01418217	0.01162829	0.02843600

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When δ is not greater than $\frac{a^3}{40EI}$ then $l = a$

Section	$\frac{a^3}{40EI}$	l		
			in	ft
4 Plates	0.00987459	$l=a$	243.5	20.292
3 Plates	0.01471482	$l=a$	219.6	18.300
2 Plates	0.02886223	$l=a$	186.67	15.556

Critical stress in Compression Flange

Due to the corrosion on the girder, the moment of inertia for the compression flange about the y-y axis exceeds that of the tension flange

$$C_s = \frac{170000}{(l/r_y)^2} \sqrt{1 + \frac{1}{20} \left(\frac{lT}{r_y D} \right)^2} + K_2 \frac{170000}{(l/r_y)^2}$$

Where:

- l = effective length of the compressive flange
- r_y = radius of gyration about the y-y axis of the gross section of the whole girder at the point of maximum bending.
- D = overall depth of the girder, at the point of the maximum bending moment.
- T = effective thickness of the compression flange given by:
K1 x the mean thickness of the horizontal portion of the compression flange at the point of maximum bending moment.

K1 makes allowance for reduction of thickness or breadth of flanges between points of effective lateral restraint and depends on N, the ratio of the total area of both flanges at the point of least bending moment to the corresponding area at the point of greatest bending moment between such points of restraint.

Minimum bending moment occurs where there is 1 flange plate
Corroded area ignoring rivet holes = 26.6 sq.in

4 flange plates (3 considered) Area = 77.2 sq.in
N = 0.34 K1 = 0.54

3 flange plates (2 considered) Area = 51.2 sq.in
N = 0.52 K1 = 0.72

2 flange plate (1 considered) Area = 27.2 sq.in
N = 0.98 K1 = 1.0

TABLE 5. VALUES OF K_1

N	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
K_1	1.0	1.0	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2

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K_2 = a coefficient to allow for inequality of tension and compression flanges, and depends on M , the ratio of the moment of inertia of the compression flange alone to the that of the sum of the moments of inertia of the compression and tension flanges, each calculated about its own axis parallel to the y-y axis of the girder, at the point of maximum bending moment.

TABLE 6. VALUES OF K_2

M	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
K_2	0.5	0.4	0.3	0.2	0.1	0.0	-0.2	-0.4	-0.6	-0.8	-1.0

4 plates (3 considered for assessment) tension flange

Section	b in	d in	A in ²	x in	A·x in ³	A(x-xt) ² in ³	I _{yy} in ⁴
Angle L	0.50	3.50	1.8	-1.94	-3.39	2.16	1.79
Angle R	0.13	3.50	0.44	1.94	0.85	3.34	0.45
Flange	0.63	13.69	8.55	-3.16	-27.00	46.42	133.56
Flange	1.25	20.00	25.00	0.00	0.00	17.08	833.33
			35.7		-29.5	69.00	969.12

Width of full section

B = 20.0 in

Distance to NA

xt = -0.8 in

Second moment of area of section

I_{yy} = 1038.13 in⁴

M = 0.55

K_2 = 0.05

T = 1.11

r_y = 4.79 in

D = 63.75 in

Cs = 70.33 ton/sq.in.

3 plates (2 considered for assessment) tension flange

Section	b in	d in	A in ²	x in	A·x in ³	A(x-xt) ² in ³	I _{yy} in ⁴
Angle L	0.50	3.50	1.8	-1.94	-3.39	0.78	1.79
Angle R	0.13	3.50	0.44	1.94	0.85	4.50	0.45
Flange	0.63	13.69	8.55	-3.16	-27.00	30.40	133.56
Flange	0.63	20.00	12.50	0.00	0.00	20.19	416.67
			23.2		-29.5	55.87	552.46

Width of full section

B = 20.0 in

Distance to NA

xt = -1.3 in

Second moment of area of section

I_{yy} = 608.33 in⁴

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$$\begin{aligned}
 M &= 0.58 \\
 K2 &= 0.08 \\
 T &= 1.03 \\
 r_y &= 4.46 \text{ in} \\
 D &= 62.5 \text{ in} \\
 C_s &= 76.91 \text{ ton/sq.in.}
 \end{aligned}$$

2 plates (1 considered for assessment) tension flange

Section	b in	d in	A in ²	x in	A-x in ³	A(x-xt) ² in ³	I _{yy} in ⁴
Angle L	0.50	3.50	1.8	-1.94	-3.39	1.16	1.79
Angle R	0.13	3.50	0.44	1.94	0.85	9.61	0.45
Flange	0.63	13.69	8.55	-3.16	-27.00	1.41	133.56
			10.74		-29.5	12.18	135.79

Width of full section

$$B = 13.7 \text{ in}$$

Distance to NA

$$x_t = -2.8 \text{ in}$$

Second moment of area of section

$$I_{yy} = 147.97 \text{ in}^4$$

$$\begin{aligned}
 M &= 0.75 \\
 K2 &= 0.25 \\
 T &= 0.80 \\
 r_y &= 3.79 \text{ in} \\
 D &= 58960 \text{ in} \\
 C_s &= 87.53 \text{ ton/sq.in.}
 \end{aligned}$$

The value of C_s shall be increased for plate girders provided that:

T/t is not greater than 2

d_1/t is not greater than 85

$$\begin{aligned}
 d_1 &= \text{clear distance between flange angles} = 53 \text{ in} \\
 t &= \text{the web thickness} = 0.38 \text{ in}
 \end{aligned}$$

$$d_1/t = 141.33 > 85 \quad (\text{same at each location})$$

$$\begin{aligned}
 T/t &= 2.95 > 2 && 4 \text{ flange plates} \\
 T/t &= 2.74 > 2 && 3 \text{ flange plates} \\
 T/t &= 2.13 > 2 && 2 \text{ flange plates}
 \end{aligned}$$

C_s values shall not be increased.

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Allowable Working Stress pbc

The imposed bending stress (compression) should not exceed the allowable working stress (pbc) given in BS153 Part 3B Table 8

4 Plates		3 Plates		2 Plates	
Cs	pbc	Cs	pbc	Cs	pbc
70	9.9	70	9.9	80	10
70.33	9.90	76.91	9.97	87.53	10.00
80	10	80	10	90	10

BE4 Part I
Cl. 304(b)

Basic permissible stress for wrought iron = 8.4 ton/sq.in.

Using the conversion ratio from steel to wrought iron gives an allowable working stress of:

10.75/16 x 9.9	=	6.65	ton/sq.in.	4 flange plates
10.75/16 x 9.97	=	6.70	ton/sq.in.	3 flange plates
10.75/16 x 10	=	6.72	ton/sq.in.	2 flange plates

4 flanges Plates (3 considered for assessment)

Web excluded

Elastic Section Modulus, tension	=	1928.18	in ³
Elastic Section Modulus, compression	=	2643.25	in ³

Bending Capacity, tension	=	1349.7	ton.ft
Bending Capacity, compression	=	1465.64	ton.ft

Web included

Elastic Section Modulus, tension	=	2020.86	in ³
Elastic Section Modulus, compression	=	2730.50	in ³

Bending Capacity, tension	=	1414.6	ton.ft
Bending Capacity, compression	=	1514	ton.ft

Moment due to dead loads	=	782.17	ton.ft (IG12)
Moment due to live loads	=	222.06	ton.ft (IG12)
Total applied moment	=	1004.23	ton.ft

Girder capacity is sufficient for full C&U loading at location checked

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3 Flange Plates (2 considered for assessment)

Web excluded

Elastic Section Modulus, tension = 1317.83 in³

Elastic Section Modulus, compression = 1904.08 in³

Bending Capacity, tension = 922.48 ton.ft

Bending Capacity, compression = 1062.79 ton.ft

Web included

Elastic Section Modulus, tension = 1411.02 in³

Elastic Section Modulus, compression = 1982.10 in³

Bending Capacity, tension = 987.71 ton.ft

Bending Capacity, compression = 1106.3 ton.ft

Moment due to dead loads = 659.44 ton.ft (IG10)

Moment due to live loads = 187.22 ton.ft (IG10)

Total applied moment = 846.66 ton.ft

Girder capacity is sufficient for full C&U loading at location checked

2 Flange Plates (1 considered for assessment)

Web excluded

Elastic Section Modulus, tension = 709.33 in³

Elastic Section Modulus, compression = 1162.74 in³

Bending Capacity, tension = 496.53 ton.ft

Bending Capacity, compression = 651.02 ton.ft

Web included

Elastic Section Modulus, tension = 816.50 in³

Elastic Section Modulus, compression = 1229.09 in³

Bending Capacity, tension = 571.55 ton.ft

Bending Capacity, compression = 688.16 ton.ft

Moment due to dead loads = 354.03 ton.ft (IG8)

Moment due to live loads = 101.24 ton.ft (IG8)

Total applied moment = 455.27 ton.ft

Girder capacity is sufficient for full C&U loading at location checked

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Shear Resistance at Supports

BS153 Part 4
Cl. 20 d (ii)

The effective sectional area for parts in shear is the product of the thickness of the web and the full depth of the web plate.

$$\begin{aligned} t &= \text{thickness of the web} = 0.385 \text{ in} \\ d &= \text{full depth of the web panel} = 60 \text{ in} \end{aligned}$$

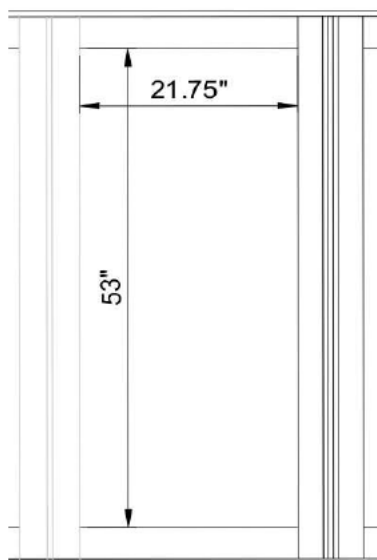
BS153 Part 3B
Cl. 29 a

The calculated average shear stress, f_q , on the effective sectional area of the web shall not exceed the value given in Table 3 or the value of P_q given by the following equation:

$$p_q = 6 \left[1.3 - \frac{b/t}{250 \left\{ 1 + \frac{1}{2} \left(\frac{b}{a} \right)^2 \right\}} \right]$$

Where:

- a = the greater clear dimension of the web in a panel, not greater than $270t$
- b = the lesser clear dimension of the web in a panel, not greater than $180t$



$$\begin{aligned} 270t &= 103.91 \text{ in} \\ \text{Therefore } a &= 53 \text{ in} \end{aligned}$$

$$\begin{aligned} 180t &= 69.28 \text{ in} \\ \text{Therefore } b &= 21.75 \text{ in} \end{aligned}$$

$$p_q = 6.55 \text{ ton/sq.in}$$

BE4 Part I
Cl. 304(b)

Using the conversion ratio from steel to wrought iron gives a permissible stress of:

$$10.75/16 \times 6.55 = 4.40 \text{ ton/sq.in}$$

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BS.153 Part 3B
Table 3

Using a yield stress of 16 ton/sq.in for mild steel, the average shear stress shall not exceed **6.00** ton/sq.in (steel to BS 15 / BS 2762)

BE4 Part I
Cl. 304(a)

The stresses for mild steel shall be as in BS153, Part 3B Case II
Therefore the allowable stresses shall be increased by 25% = **7.5** ton/sq.in

BE4 Part I
Cl. 304(b)

Using the conversion ratio from steel to wrought iron gives a permissible stress of:

$$10.75/16 \times 7.50 = \mathbf{5.04} \text{ ton/sq.in}$$

$$\text{Therefore the stresses in the web shall not exceed } p_{bc} = \mathbf{4.40} \text{ ton/sq.in}$$

$$\text{Therefore Shear Capacity} = 0.38 \times 60.0 \times 4.40 = \mathbf{101.61} \text{ ton}$$

$$\text{Shear due to dead loads} = \mathbf{57.19} \text{ ton}$$

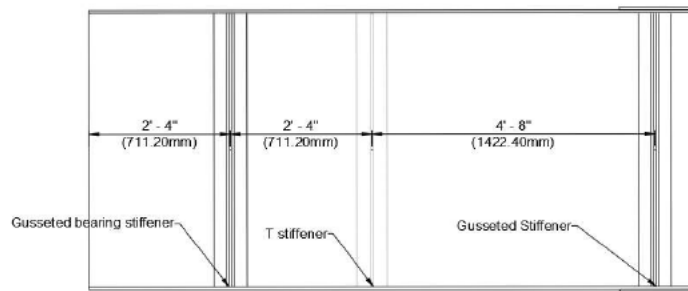
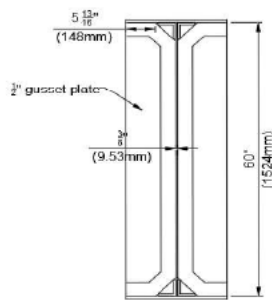
$$\text{Shear due to live loads} = \mathbf{18.39} \text{ ton}$$

$$\text{Total applied shear} = \mathbf{75.58} \text{ ton}$$

Girder shear capacity is sufficient for full C&U loading

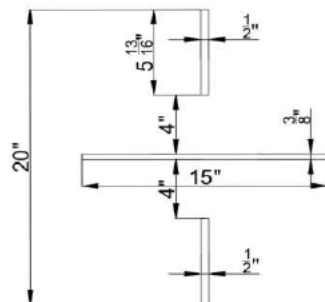
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Bearing Stiffener



Load bearing stiffeners shall be designed as struts assuming the section to consist of the pair of stiffeners together with a length of web on each side of the centreline of the stiffeners equal to twenty times the web thickness.

The radius of gyration shall be taken about the axis parallel to the web of the girder, and the working stress shall be in accordance with the appropriate allowable value for a strut assuming an effective length equal to 0.7 times the length of the stiffener.



Section	b in	d in	A in ²	y in	A·y in ³	A(y-ȳ) ² in ³	I _{xx} in ⁴
Gusset plate	0.50	5.81	2.91	7.09	20.62	146.25	8.18
Web	15.00	0.38	5.63	0.00	0.00	0.00	0.07
Gusset plate	0.50	5.81	2.91	-7.09	-20.62	146.25	8.18
			11.44		0.00	292.49	16.43

Depth of full section

$$D = 20.0 \text{ in}$$

Second moment of area of section

$$I_{xx} = 308.92 \text{ in}^4$$

Radius of Gyration

$$R_x = 5.2 \text{ in}$$

depth of stiffener = 60 in

effective length taken as 42.00 in

$$l/r = 8.08$$

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BS153 Table4.

Using a yield stress of 16 ton/sq.in for mild steel, the average shear stress shall not exceed 9.18 ton/sq.in (steel to BS 15 / BS 2762) determined by linear interpolation

The stresses for mild steel shall be as in BS153, Part 3B Case II

Therefore the allowable stresses shall be increased by 25% = 11.47 ton/sq.in

Using the conversion ratio from steel to wrought iron gives a permissible stress of:

$$10.75/16 \times 11.47 = \text{7.71 ton/sq.in}$$

$$\text{Capacity of strut/stiffener} = \text{88.15 ton}$$

Maximum imposed loads at the bearing stiffener.

$$\text{Loads due to dead loads} = \text{57.19 ton}$$

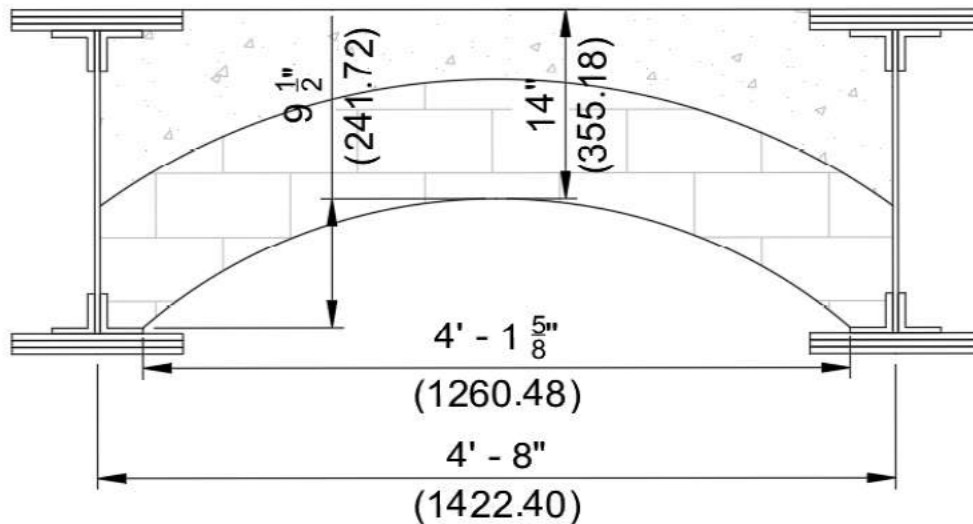
$$\text{Maximum load due to live loads} = \text{18.39 ton}$$

$$\text{Total imposed loads} = \text{75.58 ton}$$

Therefore bearing stiffener has sufficient capacity for full C&U loading.

Jacobs		ON SHEET	
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Section	Jack Arches	Date	Sep-23

Jack Arch Assessment



The jack arches themselves are in fair condition. There are isolated missing bricks at the springing points throughout. The jack arches spring from the angles and not the bottom flanges of the girders. The jack arches springing from IG1 and IG18 are no longer supported due to the loss of the horizontal angle legs, the angles are intact on all other girders.

**Review of the adequacy of the jack arches and tie-rods will be based upon the empirical method described in Bridgeguard 3 Current Information Sheet No 22 (Pro-forma for the empirical assessment of brick, masonry and concrete jack arches and associated ties.)*

SECTION 1 Check for Compliance with 40T Configuration Requirements

					Compliant Yes/No		
What is the maximum span of the arch?			1.261	m	Yes		
*Non-compliant if greater than 2.0m							
Do jack arches spring from bottom flanges of beams?					Yes		
*If not, non-compliant			Yes				
What is the beam spacing?		(web - web) b	=	1.422	m	Yes	
What is the rise of the arch?		r _c	=	0.242	m		
Gross aspect ratio?		b/r _c	=	5.88			
*Non-compliant if b/r _c greater than 10							
What is the arch barrel thickness?			d	=	355	mm	Yes
(include concrete fill above)							
How is thickness derived?		From previous assessment calculations					
*Non-compliant if thickness is less than 220mm							

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Section	Jack Arches	Date	Sep-23

SECTION 2 Check for Deficiency

Type No.	Deficiency	Pass/ Fail
1	What is the backing material? Is it structural? » Concrete - Yes Does the structural backing extend to at least the crown level of the arch extrados? Yes *If not, fail What is effective shear depth of deck? $D_s =$ » arch rise + barrel thickness + height of structural fill above crown of extrados Is $D_s \geq$ minimum requirement Fig1. Fig1. Min = *Fail if $D_s < \text{Fig 1}$ 597 > 382.64	Pass Pass
2	Do jack arches span longitudinally or transversely between longitudinal girders? Longitudinally For Longitudinal spanning jack arches, ignore following questions on ties/lateral restraint and state N/A. Are ties provided in edge bays of transverse spanning jack arches? N/A *If yes, go to 3a/3b *If not, fail, unless edge bay is 'hard' (see 5)	N/A N/A
3a	What is the cross sectional area of one tie? $A =$ (Allowing for corrosion losses) What is the number of ties per beam length? $n =$ What is the clear skew span? $L =$ Specific area of tie ($A_s = (n+1) \times A / L$) $A_s =$ *Non-compliant if less than $260\text{mm}^2/\text{m}$ What is the maximum tie spacing? $S =$ *Non compliant if greater than 3.0m for wrought iron/steel	mm² m mm²/m m
3b	What is the cross sectional area of one tie? $A =$ (Allowing for coorsion losses) What is the number of ties per beam length? $n =$ What is the clear skew span? $L =$ Specific area of tie ($A_s = (n+1) \times A / L$) $A_s =$ *Non-compliant if less than $260\text{mm}^2/\text{m}$ What is the maximum tie spacing? $S =$ *Non compliant if greater than 3.0m for wrought iron/steel	mm² m mm²/m m
4	Are ties located within crown of external arch? No *If so, then fail CI or possible fail for wrought iron/steel	Pass
5	Does external bay construction provide alternative lateral restraint? (ie not soft edge) Yes *If so, pass *If not, are ties provided in first Jack Arch bay? *If yes, treat as 3a (or 3b) Otherwise fail.	Pass

Jacobs			N SHEET	
Office	York		Calc No.	0451632
Job No. & Title	HBR3/124 BE4 Assessment		Date	Sep-23
Section	Jack Arches		Date	Sep-23

SECTION 3 Checks for Defects

Type No.	Defect	Empirical Assessment		Pass/ Fail
		CI Decks	WI/Steel Decks	
6	Rotation of supporting beam	Fail	Fail	Pass
			No	
7	Horizontal Displacement of supporting beam	Fail	Fail	Pass
			No	
8	Inadequate support to springings eg. Corrosion of bottom flange of supporting beam over a significant length, missing bedding mortar	Possible fail	Possible Fail	Fail
			Yes - IG1&IG18	
9	Transversely bowed bottom flange of supporting beam	Fail	Fail	Pass
			No	
10	Cracking at crown of arch owing to spreading of springings (other than 12, 13)	Fail	Fail	Pass
			No	
11	Distortion and any associated cracking of jack arch barrel	Fail	Fail	Pass
			No	
12	Arch crack resulting in substructure crack	Fail	Fail ⁽⁵⁾	Pass
			No	
13	Substructure crack or other distress resulting in crack to jack arch	Possible fail ⁽³⁾	Possible Fail ^{(3) (5)}	Pass
			No	

Notes

(3) Substructure renovation' or 'Monitoring' as appropriate; 'Repair of arch' (if appropriate)

(5) Not applicable in general to longitudinally spanning arches