JACOBS

BRB (Residuary) Ltd

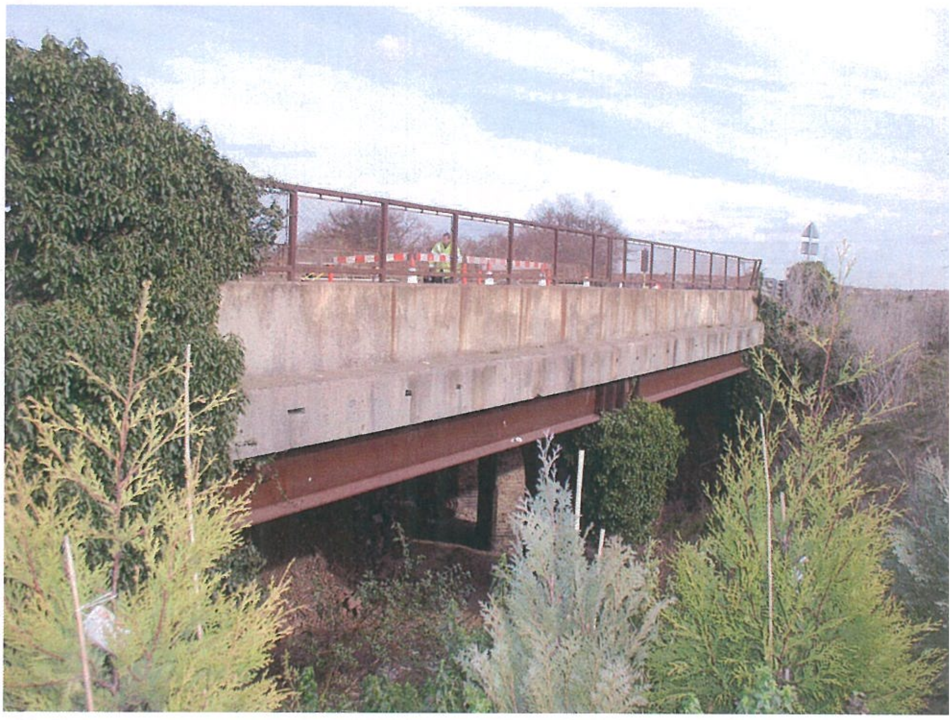
Major Works Programme 2004/2007

VAR9/1423-01

BD21/01 Assessment

STATION ROAD, SOUTHFLEET

BRIDGE REF: END 709



December 2006

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Document control sheet — Form IP180/B

Client: BRB (Residuary) Ltd
Project: VAR9-1423-01 Major Works Programme 2004/2007 — Job No: J24110IS – END/709
Title: BD21 Assessment Programme

	Prepared by	Reviewed by	Approved by
ORIGINAL	NAME [redacted]	NAME	NAME
DATE **2 February 2007**			

REVISION **Final Report**	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

REVISION	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

REVISION	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

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Contents

1 BD21 Assessment

This report presents the BD21 Assessment for bridge END/709

1.1 Location of Structure

Bridge END/709 carries the B262, Station Road north of Southfleet over the track bed of the former Gravesend West Branch at track mileage 25m 01ch.

The OS grid reference is TQ 614 720.

1.2 Construction Type

This is a two span heavily skewed bridge (43^{o}). Span lengths are 8.34m west and 9.27m east. Each span comprises six longitudinally spanning metal girders with brick jack arch infill construction. Five of the girders are riveted wrought iron plate construction, but the sixth girder, the south edge girder, is a modern weathering steel universal beam. This appears to be a replacement of the original edge girder. The deck between the new edge girder and the fifth original girder is constructed with pre-cast concrete saddle arch units. The girders appear not to be continuous over the two spans; the original north edge girders are merely bolted back to back through the end stiffeners. The new south edge girders are clearly separate. The north edge girder is nominally 32" deep with 15" flanges. Internal girders are 32" deep with 14" wide flanges with additional flange plates at mid-span. The edge girder appears to be a 914 x 419 x 343kg/m UB built in compositely with the concrete deck edge. Girder spacing is 62" (1575 mm).

1.3 Information used to form the Assessment

The assessment was carried out on the bridge in its current corroded state. All dimensions and corroded sections were obtained from site measurements. (See Jacobs report "03/04 BE4 Assessment Programme – Assessment and Inspection Report – Bridge Ref.: END/709 – March 2004").

1.4 Results of BD21 Assessment

Element: North edge girder

Assessed for Accidental Vehicle Loads from critical road vehicles BD21/01 Table D1 (also refer to clause D4 a.). Critical axle loads and axles spacings for full and reduced loads are given:

Vehicle gross weight (tonnes)	**Axle weights W (tonnes) and spacings A (m)**								
Full Assessment Live Loading	W1	A1	W2	A2	W3	A3	W4	A4	W5
44[8]	**7.0**	2.8	**11.5**	1.3	**7.5**	7.6	9.0	1.35	9.0
40[5]	5.0	2.8	10.5	1.3	4.5	4.8	10.0	1.8	10.0
26 tonne RC	**7.0**	3.42	**11.5**	1.3	**7.5**				
18 tonne RE	**6.5**	3.0	**11.5**						
7.5 tonne RF	**1.5**	2.0	**6.0**						

Action	Location	Assessed Resistance	Dead load effect	Live load capacity	Live load effect	Live Load Rating
Bending 40t AVL	East span 4m from abutment	749 kN.m	527 kN.m	222 kN.m	353 kN.m	<40 tonnes
Bending 18t AVL	East span 4m from abutment	749 kN.m	527 kN.m	222 kN.m	285 kN.m	<18 tonnes
Bending 7.5t AVL	East span 4m from abutment	749 kN.m	527 kN.m	222 kN.m	142 kN.m	**7.5 tonnes**
Shear	Support	489 kN	229 kN	260 kN	109 kN	40 tonnes
Bearing stiffener 40t AVL	Support	317kN	229 kN	88kN	393 kN	<40 tonnes
Bearing stiffener 7.5t AVL	Support	317kN	229 kN	88kN	63 kN	**7.5 tonnes**

Element: 1st internal girder (north side) (part carriageway/ part footway loading)

40 tonne loading K factors for road surface and HGV flow combinations:

	HGV Flow		
Road Surface	High (H)	Med. (M)	Low (L)
Good (g)	0.81	**0.79**	0.76
Poor (p)	0.91	0.90	0.87

C = Available live load capacity / Live load capacity required for Adjusted HA loading and relates directly to the K factors in Figures 5.2 to 5.7 of BD21/01.

C > K = 0.79 for 40 tonne loading (Mg) Medium HGV flow, good road condition.

Action	Location	Assessed Resistance	Dead load effect	Live load capacity	Adjusted HA loading	C factor	Rating
Bending	Mid-span	1053 kN.m	656 kN.m	397 kN.m	543 kN.m	0.73	**18 tonnes**
Shear	Support	489 kN	278 kN	211 kN	230 kN	0.92	40 tonnes

Element: Internal girder (full carriageway loading)

Action	Location	Assessed Resistance	Dead load effect	Live load capacity	Adjusted HA loading	C factor	Rating
Bending	Mid-span	1312 kN.m	656 kN.m	656 kN.m	751 kN.m	0.873	40 tonnes
Shear*	Support	489 kN	278 kN	211 kN	299 kN	0.705	**18 tonnes**

* the value of shear is based on a web thickness of ¼". This was the measurement obtained on the edge girder at mid-span. It is likely that the web on an internal girder at the support may be greater, though this measurement could not be confirmed on site in the 2004 investigation. If the web thickness at the support was a more usual $^3/_8$", the shear rating would be:

Shear	Support	733 kN	278 kN	455 kN	299 kN	1.52	**40 tonnes**

Bearing stiffeners on the internal girders were not checked as the girder ends are fully built in to the jack arches and concrete infill.

Element: South edge girder

Assessed for Accidental Vehicle Loads from critical road vehicles BD21/01 Table D1 (also refer to clause D4 a.). Critical axle loads and axles spacings for full Assessment Live Loading are given:

Vehicle gross weight (tonnes)	Axle weights W (tonnes) and spacings A (m)								
Full Assessment Live Loading	W1	A1	W2	A2	W3	A3	W4	A4	W5
44[8]	**7.0**	2.8	**11.5**	1.3	**7.5**	7.6	9.0	1.35	9.0
40[5]	5.0	2.8	10.5	1.3	4.5	4.8	10.0	1.8	10.0

Action	Location	Assessed Resistance	Dead load effect	Live load capacity	Live load effect	Live Load Rating
Bending	Mid-span	4163 kN.m	567 kN.m	3596 kN.m	249 kN.m	40 tonnes
Shear	Support	3147 kN	280 kN	2867 kN	152 kN	40 tonnes

Element: tie-rods to edge girders

Based on an empirical assessment in accordance with Bridgeguard 3 Information Sheet 22 the internal jack arches are compliant and are rated at 40 tonnes. There is a possible non-compliance with the jack arch adjacent to the north edge girder through lack of support to the arch on the bottom flange of the girder.

Element: Substructure

The substructure is qualitatively assessed at 40 tonnes GVW

1.5 Load Rating

With respect to the girders supporting the carriageway, the first internal girder from the north side carries a proportion of carriageway loading and its capacity is limited by bending to 18 tonnes. The bottom flange of this girder is heavily corroded.

The other carriageway girders are limited to 18 tonnes capacity by shear effects at the support. The web thickness of the web dictates the shear capacity. The actual thickness of the internal girder webs could not be ascertained because the girders are built into the jack-arch construction. A thickness of ¼" based on a measurement taken on the edge girder was used in assessment. If the thickness were $^3/_8$", which might be considered to be more usual, these girders could be rated at 40 tonnes.

The north edge girder is heavily corroded and there is some holing of the bottom flange about 4m from the east support. The girder was checked for accidental vehicle loading in accordance with Annex D of BD21/01. The girder is limited in bending to a capacity of 7.5 tonnes and the same rating is obtained from checks of the bearing stiffeners.

The south edge girder is a substantial modern weathering steel girder and is easily rated at 40 tonnes.

1.6 Recommendations

There is some doubt about the shear rating of the 2nd, 3rd and 4th internal girders from the north edge because the web thickness could not be verified. If investigation could demonstrate that the web thickness was ³/₈" as opposed to the ¼" measured in the edge girder and assumed throughout, then there three girders could be rated at 40 tonnes. However, the 1st internal girder from the north, which in part supports carriageway loading, is rated at 18 tonnes owing to heavy corrosion on the bottom flange limiting bending capacity. Therefore a general weight limit of 18 tonnes gross vehicle weight should be applied on the carriageway.

The north edge girder is heavily corroded and can only be rated at 7.5 tonnes accidental vehicle load on the footway. It is recommended that suitable barriers are provided to prevent heavy vehicles mounting the footway. A substantial barrier preventing loading of the footway and positioned to relieve loading on the 1st internal girder could, subject to confirmation of the shear capacity of the other internal girders, allow the bridge to be rated at 40 tonnes.

It is noted that the bridge is already partially infilled on the north side and full infilling may be considered to remove the liability.

Appendix A - Form AA

Appendix B - Form BA

CERTIFICATION FOR ASSESSMENT CHECK

Assessment Group: Jacobs UK Ltd

Bridge/Line Name: Station Road, Southfleet / Gravesend West Branch

Category of Check: 2

ELR/ Bridge No: END/709

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 (where appropriate) as recorded on Form AA approved on 16 August 2006.

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

BD21/01 - "The Assessment of Highway Bridges and Structures"

BD56/96 – "The Assessment of Steel Highway Bridges and Structures"

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

None

Category 1

[redacted]

Engineers to whom Assessor/Checker is responsible.

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

Appendix: 4

ELR/ Bridge No END/709 Issue: 1

Revision: A (Feb 1993)

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	
[redacted]			ssor
			ssment Checker
			orised signatory of the firm of consulting engineers to whom Assessor/Checker is responsible.

This Certificate is accepted by..[redacted]

FORM 'BAA' (BRIDGES) **GC/TP0356**
Appendix: 4
ELR/ Bridge No END/709 Issue: 1
Revision: A (Feb 1993)

CERTIFICATION FOR ASSESSMENT CHECK

Notification of Assessment Check

Assessment Group	Jacobs UK Ltd
Bridge Name/Road No.	Station Road, Southfleet / B262
Line Name	Gravesend West Branch
ELR Code/Structure No.	END/709

The above bridge 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 is as follows:-

STATEMENT OF CAPACITY (ALL=Assessment Live Loading)

Internal Girders below carriageway	18 tonnes ALL
North Edge Girder (Accidental Wheel Loading)	7.5 tonnes
South Edge Girder (Accidental Wheel Loading)	40 tonnes ALL

Carriageway jack arches and ties - full C&U vehicle loading to BD21.

Jack arch between north edge girder and first internal girder – possible failure indicated due to lack of support from girder bottom flange and reduced tie bar .

Recommended Loading Restrictions

18 tonnes Gross Vehicle Weight on carriageway
7.5 tonnes Accidental Vehicle Loading on verges

Description of Structural Deficiencies and Recommended Strengthening

- Extensive corrosion to the exposed flanges of the North Edge Girder and first Internal Girder from the north side
- Loss of tie bar section in jack arch adjacent to the north edge girder and possible lack of support from edge girder flange

The bridge is already partially infilled. If the bridge is retained:

- Consider plating over holed sections of bottom flange of north edge girder
- replace tie-straps to outer girders
- apply paint system to arrest further corrosion.

FORM 'BAA' (BRIDGES)

GC/TP0356
Appendix: 4
Issue: 1
Revision: A (Feb 1993)

ELR/ Bridge No END/709

CERTIFICATION FOR ASSESSMENT CHECK

[redacted]

Appendix C - Calculations

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	
Subject:		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By:	Date: 9/06	Checked By:	Date:

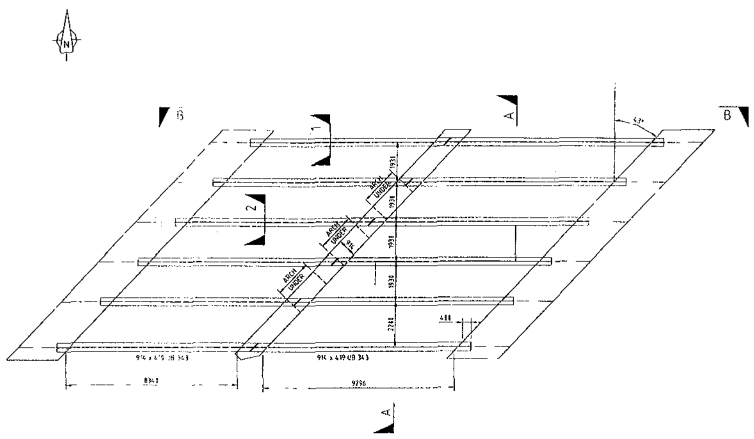
Introduction

The worst corroded section for the north edge girder is 4m from the abutment on the east span, where there is total section loss of the bottom flange plate outstands and there is 50% flange loss beneath the connecting angles. ✓

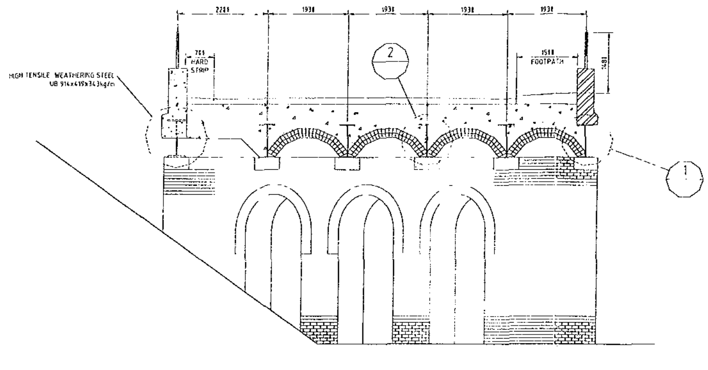
There is 40% section loss reported on the bottom flange roughly at mid-span of the internal girder adjacent to the north edge girder. This is the critical section of all the internal girders.

The new south edge girder is in good condition.

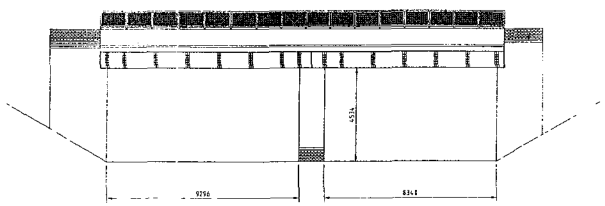
200mm jack arch construction assumed between girders.



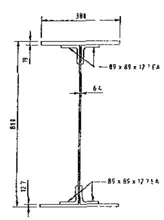
PLAN
SCALE 1:100



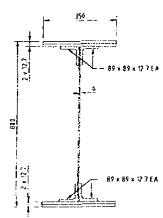
SECTION (A)
SCALE 1:50



ELEVATION (B)
SCALE 1:100



EDGE GIRDER (1)
SCALE 1:10



INTERMEDIATE GIRDER (2)
AT MID SPAN
SCALE 1:10

0 1000 2000 3000 4000 5000MM
SCALE 1:50

0 1000 5000 10000MM
SCALE 1:100

REV	REVISION DATE	PURPOSE OF REVISION	DRAWN	CHECKED	APPROVED
0	31/03/04	FIRST ISSUE	LMG	ME	JR

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CLIENT
BRB (RESIDUARY) LTD

PROJECT
MAJOR WORKS PROGRAMME (2003/04)
PHASE 3 BE4 ASSESSMENTS

DRAWING TITLE
END/714 STATION ROAD SOUTHFLEET
GENERAL ARRANGEMENT

DRAWING STATUS

SCALE: AS SHOWN @ A1 — DO NOT SCALE
JACOBS No. J203088-1142
CLIENT No.
DRAWING NUMBER J203088/1142/001 — REV 0

THIS DRAWING IS NOT TO BE USED IN WHOLE OR PART OTHER THAN FOR THE INTENDED PURPOSE AND PROJECT AS DEFINED ON THIS DRAWING. REFER TO THE CONTRACT FOR FULL TERMS AND CONDITIONS.

CALCULATION COVER SHEET

Jacobs
Reading

Project Title: BRB (Residuary) Ltd - Major Works 2004/2007		Calc. No.: 80.1
Job No: J24110IS		File: R9
Project Manager [redacted]	Subject: END/709 BD21 Assessment	
Designer	Station Road, Southfleet / Gravesend West Branch	
Project Group 31400	Section Properties	

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	8	[redacted]	Feb-07	[redacted]	Feb-07				
Rev									
Rev									
Rev									
Rev									
Rev									

Superseded by Calculation No. Date

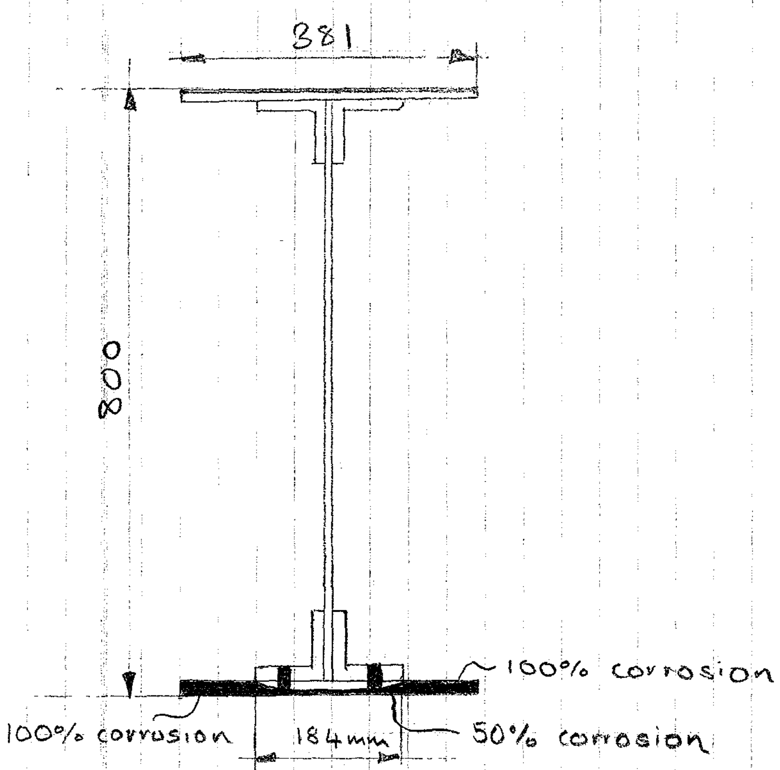
For design criteria, refer to Approval in Principle (Form AA) document

CALCULATION SHEET

JACOBS

Project Title: BD21 Assessments VAR9 1423		Sheet No: 1	
Subject: END / 709 : Section properties		Calc No:	
Job No: J24110IS		File:	
Made By: [redacted]	Date: 09/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

North edge girder . 4.0m from abutment face



file R5
calc no. 24.2
sht 1

$\bar{y} = 472$ mm ✓

$Z_{bot} = 4.68 \times 10^6$ mm^3

$Z_{top} = 6.73 \times 10^6$ mm^3 ✓

$I_{xx} = 2.209 \times 10^9$ mm^4

$I_{yy} = 75.5 \times 10^6$ mm^4

$r_y = 62.8$ mm

$A = 19134$ mm^2

CALCULATION SHEET

JACOBS

Project Title:				Sheet No: 2	
Subject:				Calc No:	
Job No:				File:	
Made By: [redacted]	Date: 9/06	Revised By:		Date:	
Checked By: [redacted]	Date: Jan 07	Checked By:		Date:	

Plastic section properties (Zpe)

File R.S, 24.2, p.1
use 800 − 2×12.7 = 774.6mm = 30.5 in
Accept 30.25 in ✓

Element	Dimension b	Dimension d	Area	y from top	A*(y1-y)
Top flange	**15** ✓	**0.5** ✓	7.50	**0.25**	29.96
Top angles (hor)	**7** ✓	**0.5** ✓	3.50	**0.75**	12.23
Top angles (vert)	**1** ✓	**3**	3.00	**2.5** ✓	5.24
Web	**0.25** ✓	**30.25**	7.56 ✓	**15.87**	15.625 =
Bottom angles (vert)	**1** ✓	**3**	3.00	**29.24**	74.99
Bottom angles (hor)	**7** ✓	**0.5** ✓	3.50	30.75 **31**	93.64
Bottom flange	**7.24** ✓	**0.25** ✓	1.81	**31.37** ✓	49.10
Deduct rivets 1	**0**	**0.95**	0.00	**0**	0.00
Deduct rivets 2	**0**	**1.45**	0.00	**0**	0.00
NET AREA			29.87 ✓		

$\frac{30.25}{2} + 0.5$ accept 15.8[illegible]

→ 30.25 + 0.75 (top flange) − 0.5 (bot horiz angle) − $\frac{3}{2}$ = 2[illegible]

} ignored because of conservative assumptions about corrosion

Sum top - sum bottom excl web	5.69 ✓	
Ht. axis of EA above mid-height	11.38 ✓	
Depth to axis of equal area (y1)	4.25 ✓	
Upper web area	0.93625	1.75
Lower web area	6.63	87.81
Upper web centroid	2.37	
Lower web centroid	17.4975	

Zpe 354.72 in^3

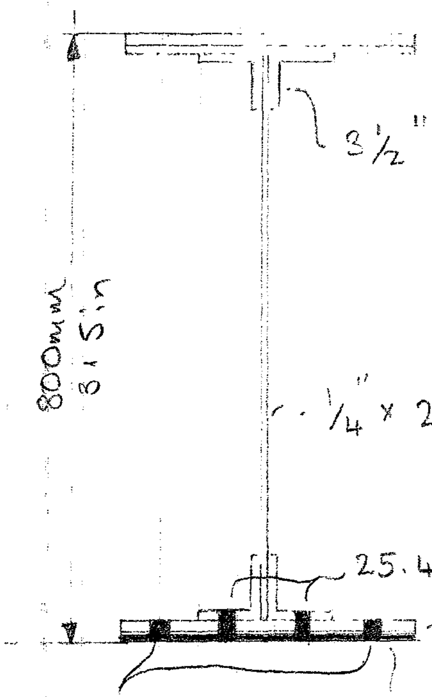
$= 5.813 \times 10^6\ mm^3$ ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	3
Subject:		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By:	Date: Jan 07	Checked By:	Date:

Internal girder . 2nd girder from north - mid-span of east span



$3\frac{1}{2}" \times 3\frac{1}{2}" \times \frac{1}{2}"$ Ls ✓

$\frac{1}{4}" \times 29\frac{1}{2}"$ web ✓

25.4mm ϕ rivets ✓

$2 \times \frac{1}{2}"$ plates

assume $\frac{13}{16}"\ \phi$ flange plate rivets

40% section loss corroded flange thickness = 15.2mm ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 4	
Subject:		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Element	Dimension b	d	Area	y from top	Ay	A(y-y1)^2	I=bd^3/12
Top flange	**14**	**1**	14.00	**0.5**	7.00	2012.19	1.17
Top angles (hor)	**7**	**0.5**	3.50	**1.25**	4.38	442.08	0.07
Top angles (vert)	**1**	**3**	3.00	**3**	9.00	270.10	2.25
Web	**0.25**	**29.5**	7.38	**15.75**	116.16	78.44	534.84
Bottom angles (vert)	**1**	**3**	3.00	**28.9**	86.70	808.00	2.25
Bottom angles (hor)	**7**	**0.5**	3.50	**30.66**	107.31	1155.69	0.07
Bottom flange	**14**	**0.6**	8.40	**31.2**	262.08	2940.96	0.25
Deduct rivets 1	**-2**	**1.1**	-2.20	**30.75**	-67.65	-733.65	-0.22
Deduct rivets 2	**-1.625**	**0.6**	-0.98	**31.2**	-30.42	-341.361	-0.03
NET AREA			39.60		494.55		
GROSS AREA			42.78				
Depth to Neutral Axis y1		12.49					
					Sum	6632.45	540.65
						Ixx=	7173.11 in^4
						Ztop	574.37 in^3
						Zbot	385.42 in^3

accept

29.9

accept

$$\frac{7173.11}{31.5-12.49} = 377.3\ in^3$$

$$I_{xx} = 2.986 \times 10^9\ mm^4$$

$$Z_{top} = 9.412 \times 10^6\ mm^3$$

$$Z_{bot} = 6.316 \times 10^6\ mm^3$$

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 5
Subject:			Calc No:
Job No:			File:
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By:	Date: Jan 07	Checked By:	Date:

Plastic section properties Zpe.

Element	Dimension		Area	y from top	A*(y1-y)
	b	d			
Top flange	**14**	**1**	14.00	**0.5**	32.20
Top angles (hor)	**7**	**0.5**	3.50	**1.25**	10.68
Top angles (vert)	**1**	**3**	3.00	**3**	14.40
Web	**0.25**	**29.5**	7.38	**15.75**	
Bottom angles (vert)	**1**	**3**	3.00	**28.9**	92.10
Bottom angles (hor)	**7**	**0.5**	3.50	**30.66**	113.61
Bottom flange	**14**	**0.6**	8.40	**31.2**	277.20
Deduct rivets 1	**-2**	**1.1**	-2.20	**30.75**	-71.61
Deduct rivets 2	**-1.625**	**0.6**	-0.98	**31.2**	-32.18
NET AREA			39.60		
Sum top - sum bottom excl web		8.78			
Ht. axis of EA above mid-height		17.55			
Depth to axis of equal area $= y_1$		-1.80			
Upper web area		-0.7			0.98
Lower web area		8.08			130.41
Upper web centroid		-0.40			
Lower web centroid		14.35			
			Zpe		567.79

except ✓ 29.9

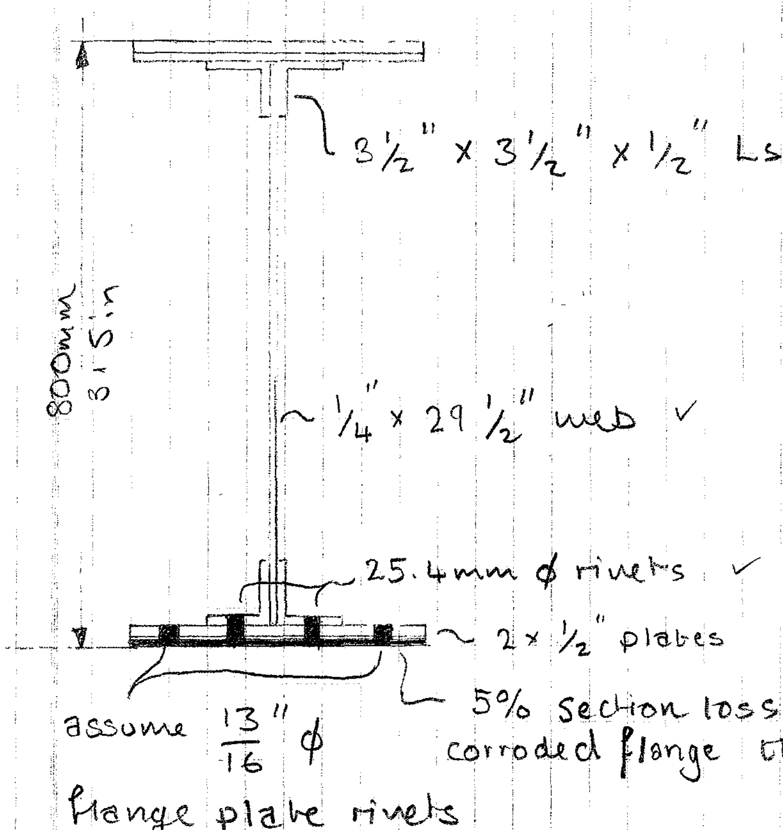
$Z_{pe} = 9.304 \times 10^6\ mm^3$. ✓

CALCULATION SHEET

JE JACOBS

Project Title:		Sheet No: 5a	
Subject:		Calc No:	
Job No: [redacted]		File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Internal girder . 3rd girder from north - mid-span of east span



corroded flange thickness = 24.13 mm ✓

Compactness check

shb 12 $\bar{y}$ depth to neutral axis from compression flange is greater than 300mm ✓

∴ section is non-compact.

Calcsheet1

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 56	
Subject:			Calc No:	
Job No:			File:	
Made By: [redacted]	Date: 9/06	Revised By:		Date:
Checked By: [redacted]	Date: Jan 07	Checked By:		Date:

Element	Dimension b	d	Area	y from top	Ay	A(y-y1)^2	I=bd^3/12
Top flange	**14**	**1**	14.00	**0.5**	7.00	2577.13	1.17
Top angles (hor)	**7**	**0.5**	3.50	**1.25**	4.38	575.02	0.07
Top angles (vert)	**1**	**3**	3.00 ✓	**3**	9.00	367.48	2.25
Web	**0.25**	**29.5**	7.38	**15.75**	116.16	20.87	534.84
Bottom angles (vert)	**1**	**3**	3.00	**28.9**	86.70	660.00	2.25
Bottom angles (hor)	**7**	**0.5**	3.50	**30.66**	107.31 ✓	963.57	0.07
Bottom flange	**14**	**0.95**	13.30 ✓	**31.2**	414.96	3903.79	1.00
Deduct rivets 1	**-2**	**1.45**	-2.90	**30.75**	-89.18	-807.07	-0.51
Deduct rivets 2	**-1.625**	**0.95**	-1.54	**31.2**	-48.17	-453.119	-0.12
NET AREA			43.23		608.16		
GROSS AREA			47.68				
Depth to Neutral Axis y1		14.07 ✓					
					Sum	7807.67	541.03
						Ixx=	8348.70
						Ztop	593.47
						Zbot	480.30

$Z_{top} = 9.725 \times 10^6 \, mm^3$ ✓

$Z_{bot} = 7.871 \times 10^6 \, mm^3$ ✓

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	80.2
Job No:	J24110IS	File:	R9

Project Manager	[redacted]	Subject:	END/709 BD21 Assessment
Designer	[redacted]		Station Road, Southfleet / Gravesend West Branch
Project Group	[redacted]		Dead Loads

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	6	[redacted]	Feb-07	[redacted]	Feb-07				
Rev									
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Rev									
Rev									
Rev									

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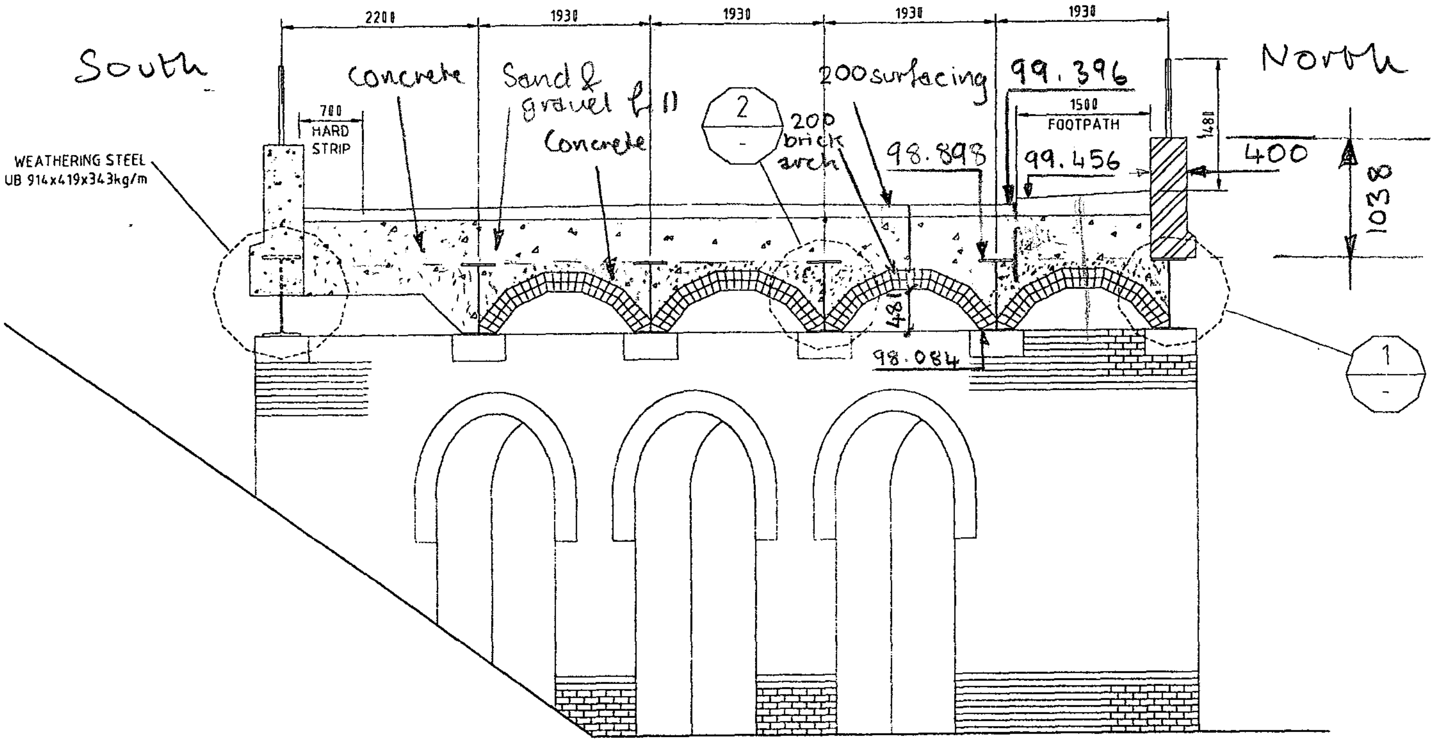
For design criteria, refer to Approval in Principle (Form AA) document

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	6
Subject: END / 709 : Dead Loads		Calc No:	
Job No: J241101S		File:	
Made By: [redacted]	Date: 09/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:



SECTION A
SCALE 1 : 50

Dead Loads on Internal girder.

BD21/01 table 4.1

self wt of beam $= 43 \times 25.4^2 \times 10^{-6} \times 1 \times 75.5$ (area)

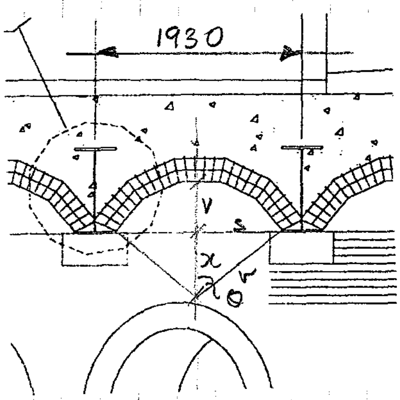
$= 2.3$ kN/m ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 7	
Subject:		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Area of arch:



$$r^2 = (r-v)^2 + s^2$$

$$\cancel{r^2} = \cancel{r^2} - 2rv + v^2 + s^2$$

$$r = \frac{v^2 + s^2}{2v}$$

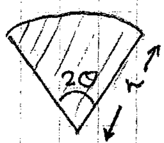
$$= 481^2 + \left(\frac{1930-356}{2}\right)^2 \div 2 \times$$

$$= 884 \text{ mm} \checkmark$$

angle $\theta = \sin^{-1}\left(s/r\right) = \sin^{-1}\left(\frac{787}{884}\right)$ ✓

$$= 63^\circ \checkmark$$

Area of sector $= \frac{2\theta}{360} \times \pi \times r^2$

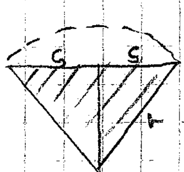


$$= \frac{2 \times 63}{360} \times \pi \times 884^2$$

$$= 0.859 \times 10^6 \text{ mm}^2$$ ✓

Area of triangle $= s(r-v) = 787(884-481)$

$$= 0.317 \times 10^6 \text{ mm}^2$$



Area of void beneath arch $= (0.859 - 0.317) \times 10^6$

$$= 0.542 \times 10^6 \text{ mm}^2$$ ✓

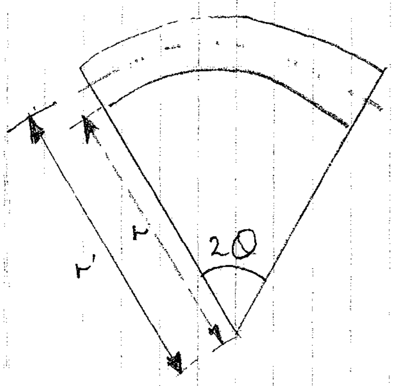
CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 8	
Subject:		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Area of arch barrel = arch circumference × thickness

$= (884+100) \times \frac{2\times 65}{360} \times 2\pi \times 225$ 63° accept ✓



$= 0.502 \times 10^6\ mm^2$ ✓ accept ✓

Area of concrete to top of girder

$= 1944 \times (98.898 - 98.084) \times 10^3$

$- 0.542 \times 10^6 - 0.502 \times 10^6 - 43 \times 25.4^2$ ✓

$= 0.511 \times 10^6\ mm^2$ ✓

Dead Loads on internal beam:

Beam self wt = 2.3 kN/m ✓

BD21/01 table 4.1 — fill $1.93 \times 0.298 \times 2200 \times \frac{9.81}{1000}$ = 12.4 kN/m ✓

Jack arch $0.502 \times 2100 \times \frac{9.81}{1000}$ = 10.34 kN/m ✓

concrete backing $0.511 \times 2300 \times 9.81/1000$ = 11.53 kN/m

surfacing $0.2 \times 1.93 \times 2400 \times 9.81/1000$ = 9.09 kN/m

BD21/01 table 3.1 — Total weight $= 2.3 \times 1.05 + 12.4 \times 1.2$ ✓

$+ 10.34 \times 1.15 + 9.09 \times 1.75$ ✓

$+ 11.53 \times 1.2$ ✓

$= 59$ kN/m ✓

Calcsheet1

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 9	
Subject:		Calc No:	
Job No:		File:	
Made By: ZWC	Date: 9/06	Revised By:	Date:
Checked By: KI	Date: Jan 07	Checked By:	Date:

Edge beam north dead loading

parapet

area = $(400 \times 1038) + 20\% = 0.498 \times 10^6\ mm^2$ ✓

add 20% for outstands and railings

parapet weight = $0.498 \times 2400 \times \frac{9.81}{1000} = 11.72$ kN/m ✓

footpath (dead) loading = $(99\ 456 - 99\ 396) \times 0.865 \times 2400 \times 9.81/1000$

$= 1.22$ kN/m

Total load = $11.72 \times 1.2 + (1.22 + 9.09) \times 1.2$

$\frac{(12.4 + 11.53)}{2} \times 1.2$ (fill) $+ \frac{10.34}{2} \times 1.15$ ref RS, calcs 24.2, p.3

$+ 1.75 \times 1.05$ ✓

$= 48.6$ kN/m conservative accept ✓

effective length of girders on the east span:

clear span = 9.296 m

Girders span onto concrete bedstones at the abutments and the central pier, therefore take bearing length as 1/4 beam depth

file RS Calc no 24.1 sht 3.

$l_e = 9.296 + 2 \times \frac{1}{3} \times \frac{1}{4} \times 0.8 = 9.429$ m. ✓

Ref. RS calcs 24.2 p. 5A

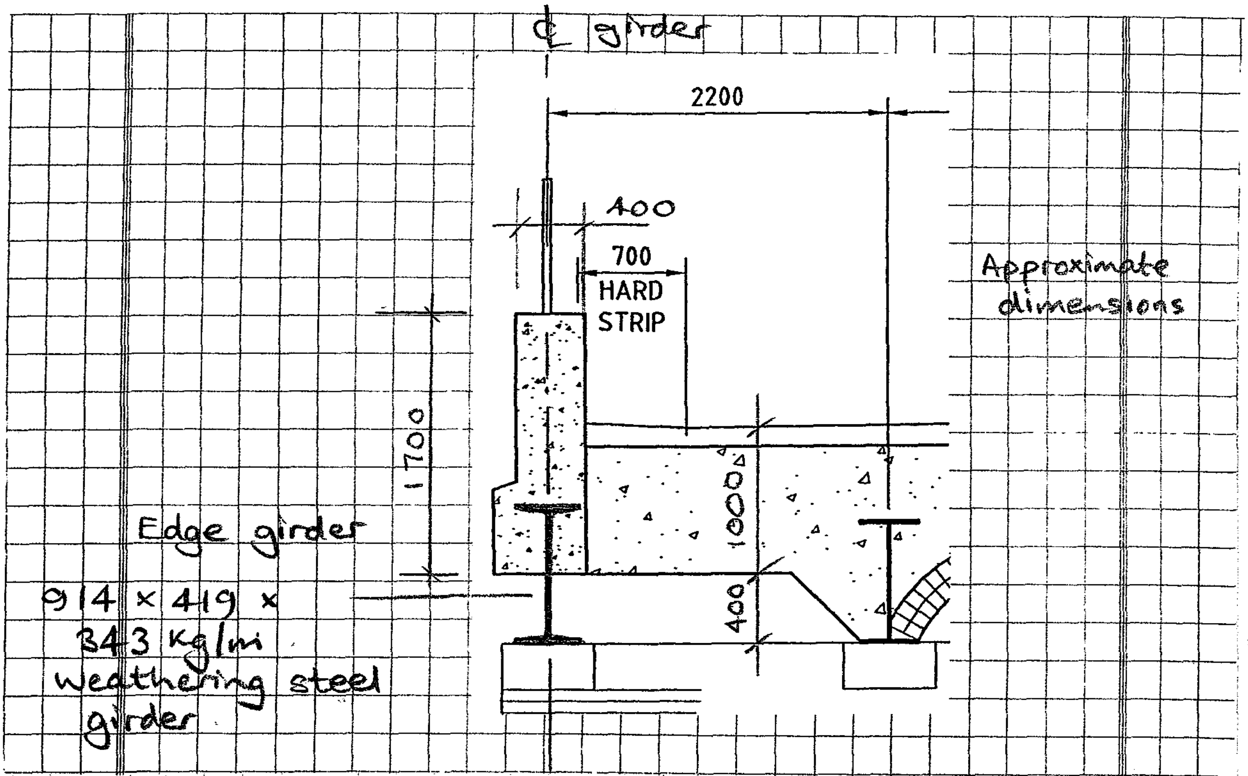
CALCULATION SHEET

JACOBS

Project Title:	Sheet No: 10
Subject:	Calc No:
Job No:	File:

Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By:	Date: JAN 07	Checked By:	Date:

Edge girder south dead loads.



Ref RS calcs 24.9 p. 2

self wt of beam = 3.37 kN/m

Concrete edge beam = 18.5 kN/m

Concrete unit, infill concrete = 19.98 kN/m

Surfacing = 1.62 kN/m

Total Load = 3.37 x 1.05 + (18.5 + 19.98 x 1.15) + 1.62 x 1.75

= 51 kN/m

CALCULATION SHEET

JACOBS

Project Title:	Sheet No: 11
Subject:	Calc No:
Job No:	File:

Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Dead Load effects on internal girder :

Moment $M = 59 \times 9.429^2 \times 1/8 = 656$ KN.m ✓
@ mid-span

conservative

Shear $V = 59 \times 9.429 \times 1/2 = 278$ KN ✓
@ support

Loads [illegible] slightly [illegible] a few amendments

Dead Load effects on edge girder north

9.296 conservative

Shear $V = 48.6 \times 9.429 \times 1/2 = 229$ KN ✓ ace conserv
@ support

Moment $M = 229 \times 4 - 48.6 \times 4^2 \times 1/2$
$= 527$ KN m @ 4m from abutment

Dead Load effects on edge girder south

conservative

Shear $V = 51 \times 9.429 \times 1/2 = 240$ KN ✓

Moment $M = 51 \times 9.429^2 \times 1/8 = 567$ KN.m

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	80.3
Job No: J24110IS		File:	R9
Project Manager	[redacted]	Subject:	END/709 BD21 Assessment
Designer			Station Road, Southfleet / Gravesend West Branch
Project Group	31400		Section Capacites

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

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For design criteria, refer to Approval in Principle (Form AA) document

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 12
Subject: END / 709 : Section Capacities			Calc No:
Job No:			File:
Made By: [redacted]	Date: 09/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Internal girder : 2nd from north

Compression flanges are surrounded by Concrete in fill and therefore girder is restrained against compression flange buckling.

The limiting compressive stress is equal to the yield stress of the material :

BD21/01 cl 4.9 $\sigma_{lc} = \sigma_{yc} = 220\ N/mm^2$

Determine whether section is compact or non-compact :

BD 56/96 9.3.7.2.1 web : $28 t_w \sqrt{\dfrac{355}{\sigma_{yw}}} \not< \bar{y}$

$\bar{y} = 11.8\ in = 300mm$

$28 \times 6.35 \sqrt{\dfrac{355}{220}} = 226mm < 300$ ✓

$\therefore$ Section is non-compact

9.9.1.3 $M_D = \dfrac{Z_{xt}\ \sigma_{yt}}{\gamma_m\ \gamma_{f3}}$

$= \dfrac{6.316 \times 220}{1.2 \times 1.1} = \underline{1053 kN.m}$ ✓

table 2 cl 3.1

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 12a.
Subject:		Calc No:
Job No:		File:

Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By:	Date: Jan 07	Checked By:	Date:

Internal girder : 3rd from north

$$M_D = \frac{Z_{xt}\,\sigma_{yt}}{\gamma_m\,\gamma_{f3}}$$

$$= \frac{7.871 \times 10^{6} \times 220}{1.2 \times 1.1} \times 10^{-6} = \underline{1312 \text{ kN.m}}$$

CALCULATION SHEET

JACOBS

Project Title:				Sheet No: 13	
Subject: END/709 · Section Capacities.				Calc No:	
Job No:				File:	
Made By:	[redacted]	Date: 09/06	Revised By:	Date:	
Checked By:	[redacted]	Date: Jan 07	Checked By:	Date:	

edge girder (north)

The effective length of the girder is given BD56/96 clause 9.6.3 :

$l_e = K_1 K_2 L$

where $K_2 = 1.0 \to 1.2$ depending on the proportion of top flange loading to bottom flange loading.

sht 9 Top flange load = parapet load = $10.76 \times 1.2 = 12.9$ kN/m (11.72, 14.1)

Bottom flange load = AWL + Dead Load − Parapet load

sht 9, sht 21 $= \frac{236}{9.429} + 49.5 - 12.9$ (239, 51, 14.1)

$= 62$ kN/m ✓ accept

$\therefore K_2 = 1 + 0.2 \times \frac{12.9}{(62 + 12.9)} = 1035$ ✓

$K_1 = 0.85$ (compression flange partially restrained by jack arch system and abutments.) ✓

$l_e = 9.296 \times 0.85 \times 1.035 = 8.2$ m

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 14
Subject:			Calc No:
Job No:			File:
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

9.7.2

$$\lambda_{LT} = \frac{l_e}{r_y} K_4 \eta \nu$$

$$K_4 = \left[\frac{4 Z_{pe}^2 \left(1 - \frac{I_y}{I_x}\right)}{A^2 h^2} \right]^{0.25}$$

$$\left[\frac{4 \times (5.813 \times 10^6)^2 \left(1 - \frac{75.5}{2209}\right)}{19134^2 \times 790^2} \right]^{0.25}$$

$$= 0.87$$

D,

Ref RS, calcs 24.2, p.2

$r_y = \sqrt{\frac{I}{A}}$

$$\lambda_F = \frac{l_e}{r_y} \left(\frac{t_f}{D} \right) = \frac{8.2}{0.0628} \left(\frac{18.9}{800} \right)$$

$$= 3.04 < 8 \quad (\text{cl } 9.7.2)$$

mean thickness of top and bot flange $\therefore \frac{\text{top} + \text{bot}}{2} = \frac{12.7 + 6.35}{2} = 9.5\text{ mm}$

Accept since major ... following table and

$$i = \frac{I_c}{I_c + I_t}$$

$6.35 + 12.7 = 19.05$

$$I_t = 184^3 \times 19.05 \times \frac{1}{12} = 9.889 \times 10^6 \text{ mm}^4$$

$$I_c = 381^3 \times 12.7 \times \frac{1}{12} + 184^3 \times 12.7 \times \frac{1}{12}$$

$$= 65.125 \times 10^6 \text{ mm}^4$$

Since $i_c > I_t$ we can conservatively take $\lambda_{LT} = \frac{l_e}{r_y} = \frac{8.2}{0.0628} \Rightarrow$

$\lambda_{LT} = 131$

$$i = \frac{65.125}{9.889 + 65.125} = 0.868$$

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 15	
Subject:		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Table 9 $D = 0.75$

$$\lambda_{LT} = \frac{8.2}{0.0628} \times 0.87 \times 0.75 \times 1.0$$

$$= 85$$

9.8.1 $$\lambda_{LT} \sqrt{\frac{\sigma_{yc}}{355}} = 85 \sqrt{\frac{220}{355}} = 67$$

fig 10 $$\sigma_{li}/\sigma_{yc} = 0.79 \Rightarrow \sigma_{li} = 0.79 \times 220 = 174\ N/mm^2$$

Section is highly corroded and therefore treated as non-compact.

9.8.3 σ_{lc} is the lesser of $\frac{D\sigma_{li}}{2y_c}$ or σ_{yc}

$$\frac{800 \times 174}{2 \times 472} = 147\ N/mm^2 = \sigma_{lc}$$

1 slot λ

9.9.1.3 $$M_D = \frac{Z_{xc}\,\sigma_{lc}}{\gamma_m \gamma_{f3}} = \frac{6.73 \times 147}{1.2 \times 1.1}$$

$$= 749\ kN.m$$

$$M_D = \frac{Z_{xt}\,\sigma_{yc}}{\gamma_m \gamma_{f3}} = \frac{4.68 \times 220}{1.2 \times 1.1} = 780\ kN.m$$

table 3.2

CALCULATION SHEET

JACOBS

Project Title:				Sheet No: 16	
Subject: END / 709 Section capacities.				Calc No:	
Job No:				File:	
Made By: [redacted]	Date: 9/06	Revised By:		Date:	
Checked By: [redacted]	Date: Jan 07	Checked By:		Date:	

South edge girder.

although top half of the girder is surrounded in concrete, take strength of member as based on steel section only as concrete and connection details are not known.

As the compression flange of the girder is surrounded in concrete, it can be assumed that the girder is fully restrained against compression flange buckling. Therefore the limiting compressive stress is equal to the yield stress of the material

CORUS weathering steel bridges p.5

$\sigma_{lc} = \sigma_y = 355\ N/mm^2$

Compactness check:

9.3.7.2.1 web: $28 t_w \sqrt{\frac{355}{\sigma_{yw}}} \not< \bar{y}$

BS4 part1/93 914 x 419 x 343 weathering steel girder.

$\bar{y} = D/2 = \frac{914}{2}$ (911.8) $= 457mm$

28×19.4 (tf ✓) $\times 1 = 543.2 \not< 457$ mm

9.3.7.3.1 flange: $7 t_{fo} \sqrt{\frac{355}{\sigma_{yf}}} \not< b_{fo}$

$b_{fo} = \frac{419}{2} - \frac{19.4}{2} - 24.1 = 176mm$ ✓

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 17
Subject:			Calc No:
Job No:			File:
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

$7 \times 32 \times 1 = 224 < 176$ ✓

$\therefore$ section is compact.

9.9.1.2 $$M_D = \frac{Z_{pe}\,\sigma_{lc}}{\gamma_m\,\gamma_{f3}}$$

$$= \frac{15.48 \times 355}{1.2 \times 1.1} = \underline{4163\ \text{kN.m}}$$ ✓

1547 ✓

Shear force capacity

9.9.2.2 $$V_D = \left[\frac{b_w(d_w - h_n)}{\gamma_m\,\gamma_{f3}}\right]\tau_l$$

Sht 16 $$\lambda = \frac{d_{we}}{b_w}\sqrt{\frac{\sigma_{yw}}{355}} = \frac{914}{19.4}\sqrt{\frac{355}{355}} = 47$$

$$\tau_l/\tau_y = 1.0 \Rightarrow \tau_l = \tau_y = \frac{\sigma_{yw}}{\sqrt{3}} = \frac{355}{\sqrt{3}}$$

$$= 205\ \text{N/mm}$$

table 2 BD56/96 $$V_D = \frac{19.4 \times 914 \times 205}{1.05 \times 1.1} = \underline{3147\ \text{kN}}$$

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 17a	
Subject: END/709. Shear force capacity		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Critical section in shear - internal girder.

9.9.2.2 $$V_D = \left[\frac{t_w (d_w - h_h)}{\gamma_m \gamma_{f3}}\right] \tau_l$$

$t_w = 6.35$ mm

$d_w = 749$ mm - depth of web measured clear betw flanges of a fabricated section $= 800 - 2\times1'' - 2\times1''$ $= 749.3$ mm

$h_h = 0$

τ_l,

$$\lambda = \frac{d_{we}}{t_w}\sqrt{\frac{\sigma_{yw}}{355}}$$

sht 3 $$= \frac{571}{6.35}\sqrt{\frac{220}{355}} = 71$$

sht 3 calc no. 241 file R5 $$\phi = \frac{a}{d_{we}} = \frac{838}{571} = 1.47$$

plate thickness = 15.2mm see p3

$$m_{fw} = \frac{\sigma_{yf}\, b_{fe}\, t_f^2}{2\,\sigma_{yw}\, d_{we}^2\, t_w}$$

$$b_{fe} = \text{either } \frac{b_f}{2} = \frac{356}{2} = 178\text{mm}$$

$$\text{or } 10\, t_f\sqrt{\frac{355}{\sigma_{yf}}} = 10\times 12.7\sqrt{\frac{355}{220}}$$

15.2

$$= 161.3\text{mm}$$

193

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 17b	
Subject:			Calc No:	
Job No:			File:	
Made By: [redacted]	Date: 9/06	Revised By:		Date:
Checked By: [redacted]	Date: Jan 07	Checked By:		Date:

$$M_{fw} = \frac{220 \times 161.3 \times 12.7^2}{2 \times 220 \times 571^2 \times 6.35}$$

198

$= 0.0063 \rightarrow$ Use fig 12 ✓ accept

0.0069

$\tau_x / \tau_y = 1.0$ ✓

$$\therefore \tau_x = \tau_y = \frac{\sigma_{yw}}{\sqrt{3}} = \frac{220}{\sqrt{3}} = 127\ N/mm^2$$

BD21 table 3.2
$\gamma_m = 1.2$
for w.i

$$V_D = \frac{6.35 \times (800 - 0) \times 127}{1.2 \times 1.1}$$

$= 489$ KN. ✓

CALCULATION COVER SHEET

Jacobs
Reading

Project Title: BRB (Residuary) Ltd - Major Works 2004/2007		Calc. No.: 80.4
Job No: J24110IS		File: R9
Project Manager [redacted]	Subject: END/709 BD21 Assessment	
Designer [redacted]	Station Road, Southfleet / Gravesend West Branch	
Project Group 31400	Live Loads	

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

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For design criteria, refer to Approval in Principle (Form AA) document

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 18	
Subject: END / 709 : Live loads.		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9 / 06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Live loads on northern most internal girder:

Carriage way width = 1930 × 4 + 2200 − 1500 − 700 − 400 = 7320 mm

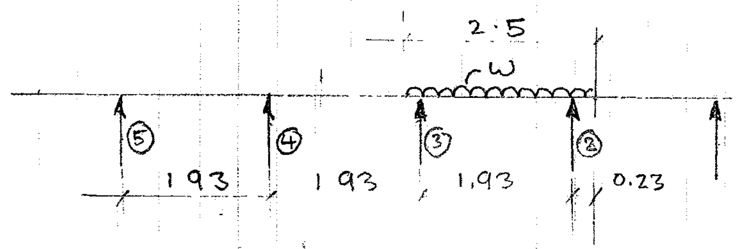
Note: The hard strip 700 mm might need to be taken as part of the carriageway width, since the weathering steel girder is used as part of a widening scheme at the past, therefore width = 7320 + 700 = 8020 mm therefore 3 notional lanes. There is no impact on the following calcs though

Refer clause 5.6 and table 5.1 of BD21.

2 No notional lanes.

width of lane = $\frac{7.32}{2}$ = 3.66 m

The Udl shall occupy a width of 2.5 m within the lane.



w on 2:

$$= \left[\frac{0.23}{2.5} \times \left(1.93 - \frac{0.23}{2}\right) + \left(\frac{1.93}{2.5} \times \frac{1.93}{2}\right)\right] \div 1.93$$

$$= 0.\cancel{467}\ 0.473\ w$$

w on 3 : 2.5 m udl straddling 3

$$= 2 \times \left[\frac{1.25}{2.5} w \times 1.93 - \frac{1.25}{2}\right] \div 1.93$$

$$= 0.676 w \checkmark$$

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 19	
Subject:			Calc No:	
Job No:			File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:	
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:	

5.18 $\quad$ $HA\ udl = 336\left(\frac{1}{L}\right)^{0.67}$

$$= 336\left(1/9.429\right)^{0.67}$$

$$= 75\ kN/m$$

$HA\ kel = 120\ kN$

Adjustment factor $= \frac{3.65}{2.5} = 1.46$ (lane factor = 1.0)

HA adjusted line load effects on internal girder:

$$M = \left(\frac{75 \times 9.429^2}{8} + \frac{120 \times 9.429}{4}\right) \times \frac{0.467}{1.46} \times 1.5$$

0.473 $\quad$ γ_{fL}

AF $\quad$ table 3.1

$= \underline{536\ kN.m}$ (543) @ mid-span

$$V = \left(\frac{75 \times 9.429}{2} + 120\right) \times \frac{0.467}{1.46} \times 1.5$$

0.473

$= \underline{227\ kN}$ (230) @ support

For bridge specific loading line load effects are multiplied by a reduction factor K. For medium HGV flow and good road condition, fig 5.6 gives

$K = 0.79$ for 40 tonnes a.1.1

($M_{a.1.1} = 543 \times 0.79 = 429\ kNm$ → FAIL since capacity = 331 kNm
$V_{a.1.1} = 230 \times 0.79 = 182\ kN$ → PASS since " = 209 kN)

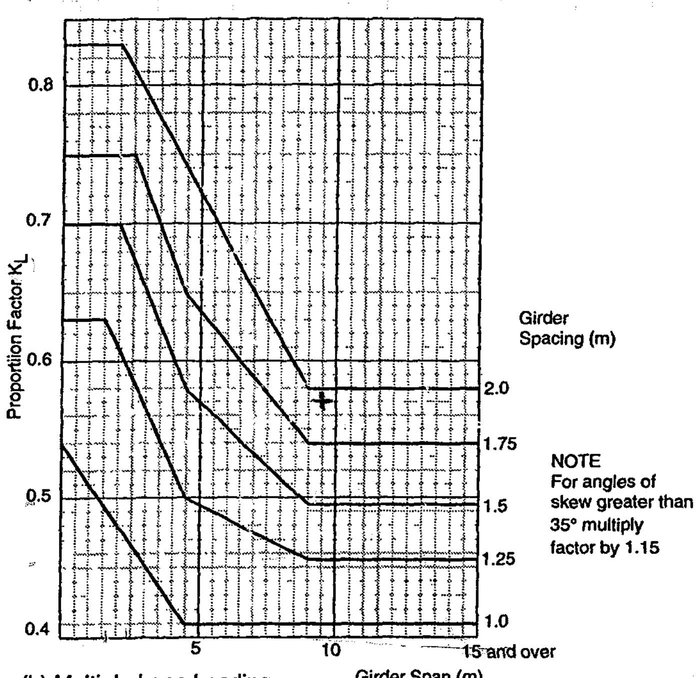
CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 19 A .	
Subject:		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By:	Date: Jan 07	Checked By:	Date:

Internal girders.

Load effects using BA16/97 proportion factors:



(b) Multiple Lane Loading

Girder spacing = 1.93 ✓ Span = 9.429 ✓

Skew ∠ = 43° ✓

$K_L = 0.57 \times 1.15 = 0.655$ ✓

$$M = \left(\frac{75 \times 9.429^2}{8} + \frac{120 \times 9.429}{4}\right) \times \frac{0.655}{1.46} \times \overset{\gamma_{fl}}{1.5}$$

$$= \underline{751.2 \text{ kN.m}}$$

$$S_L = 0.655\left(\frac{75 \times 9.429}{2} \times \frac{1.5}{1.46}\right) + \left(0.5 \times \frac{120}{1.46} \times 1.5\right)$$

$$= 237.9 + 61.6 = \underline{299.5 \text{ kN.m}}$$ ✓

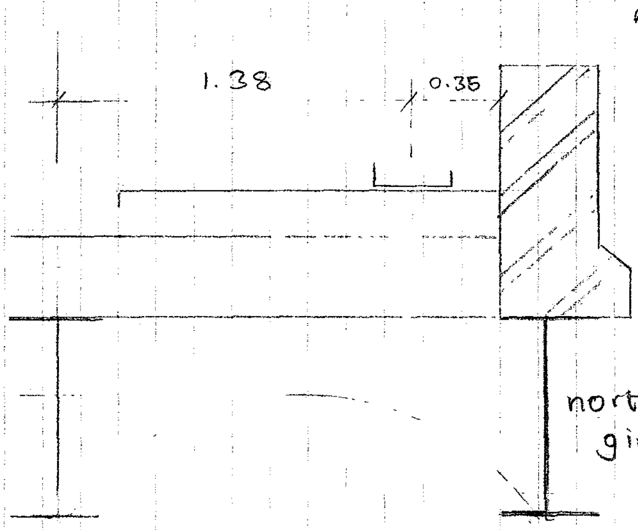
CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 20	
Subject: END / 709 : Live Loads on edge girder north		Calc No:	
Job No:		File:	
Made By: [redacted]	Date:	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Accidental wheel loading with axles selected from BD21 Annex D :

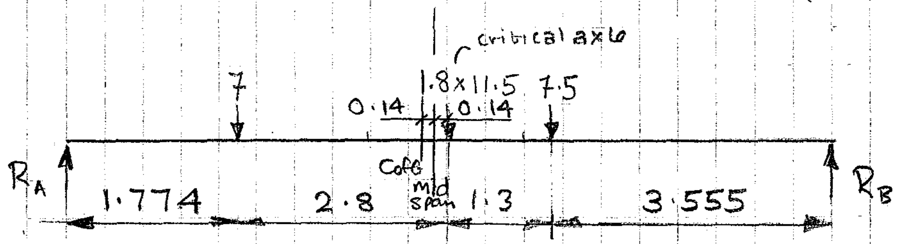
vehicle width = 2.5m
Axle spacing = 1.8m
0.7m / 2 = 0.35 m
distance from wheel to edge of vehicle



proportion of wheel carried to north edge girder

$$= \frac{(1.93 - 0.55)}{1.93} \; \omega = 0.715\,\omega \; ✓$$

for a 9.429m long span : the critical vehicle from BD21 is vehicle 8 (44 tonnes GVW)



$$R_A = (7.5 \times 3.555 + 11.5 \times 1.8 \times 4.855 + 7 \times 7.655) \times \frac{0.715}{9.429 \times 2}$$

$$= 6.853\ t \quad ✓$$

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 21	
Subject:		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9/06	Revised By: JLR	Date:
Checked By:	Date: Jan 07	Checked By:	Date:

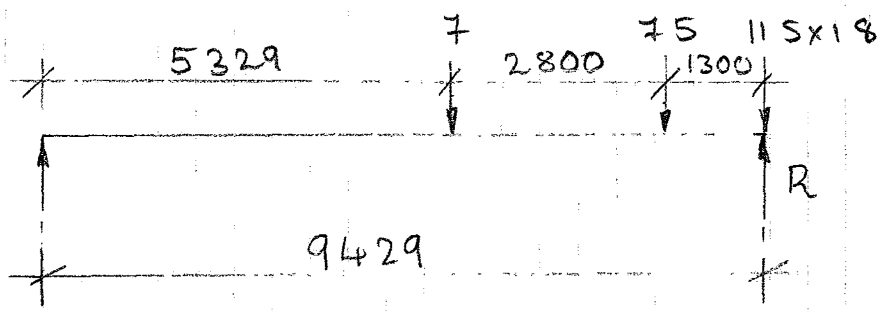
$$M = 6.853 \times 4.728 - \frac{7 \times 0.715}{2} \times 2.8$$

$$= 25.4 \text{ T.m}$$

$$= 249 \text{ kN.m}$$

Factored $= 249 \times 1.5 = 373.5$ kN.m

Shear :

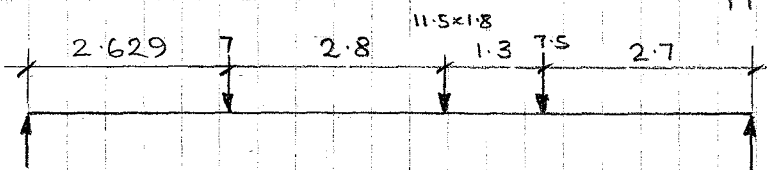


$$\text{Shear} = R = \left(7 \times 5.329 + 7.5 \times 8.129 + 11.5 \times 1.8 \times 9.429\right) \times \frac{0.715}{9.429 \times 2}$$

$$= 31.1 \times 0.715/2$$

$$= 11.1 \text{ t} = \underline{109 \text{ kN}}$$

Maximum moment at 4m from support (pt. of maximum corrosion



$$R_A = (7.5 \times 2.7 + 11.5 \times 1.8 \times 4 + 7 \times 6.8) \times \frac{0.715}{9.429 \times 2} = 5.71 \text{ t}$$

$$M_{4m} = 5.71 \times 5.429 - \frac{7 \times 0.715}{2} \times 2.8 = 23.99 \text{ t.m}$$

$$= 235.4 \text{ kN.m}$$

Factored $235.4 \times 1.5 = 353.1$ kN.m

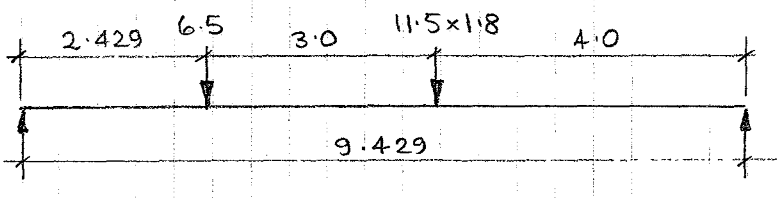
CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 21 A	
Subject: END 1709		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 1/07	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

Find reduced AWL:

26 tonne vehicle RC has near identical effects to 44 tonne 44⁸ – so try 18 tonne RE. ✓



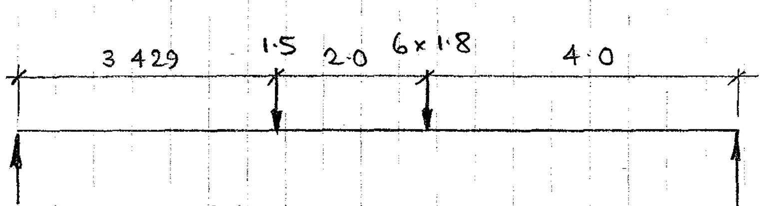
$$R_B = (2.429 \times 6.5 + 11.5 \times 1.8 \times 5.429) \times \frac{0.715}{2 \times 9.429}$$

$$= 4.859\,t$$

$$M_{4m} = 4 \times 4.859 = 19.4\ t.m = \underline{190\ kN.m}$$

$190 \times 1.5 = 285 > 222$ kN.m capacity
Fails

Try 7.5 tonne (RF). ✓



$$R_B = (3.429 \times 1.5 + 6 \times 1.8 \times 5.429) \times \frac{0.715}{2 \times 9.429}$$

$$= 2.418\,t$$

$$M_{4m} = 4 \times 2.418 = 9.67\ t.m = 94.9\ kN.m$$

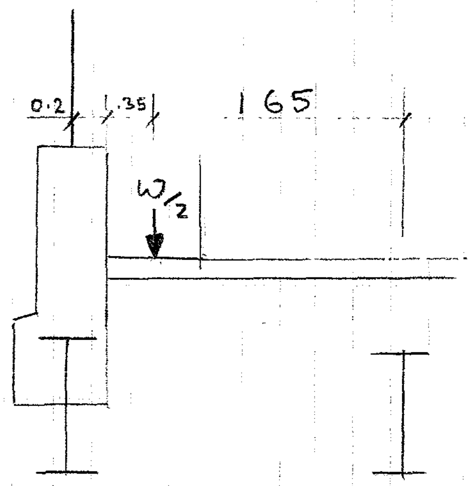
$94.9 \times 1.5 = 142.3 < 222$ kN.m
OK

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 22	
Subject: END / 709 : Live load on south edge girder		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 9/06	Revised By:	Date:
Checked By: [redacted]	Date: Jan 07	Checked By:	Date:

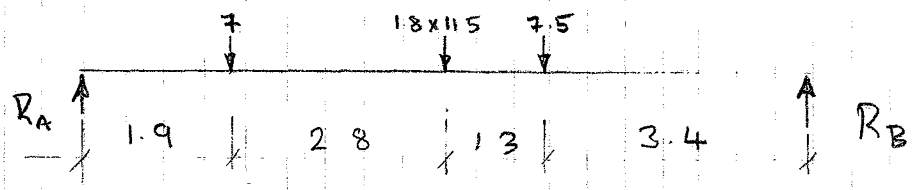
Accidental wheel loading on south edge girder:



proportion of load on girders

$$= \frac{1.65}{2.2 \times 2} = 0.375\,W$$

vehicle 8 (40 tonne GVW).



$$R_A = (7.5 \times 3.4 + 1.8 \times 11.5 \times 4.7 + 7 \times 7.5) \times \frac{0.375}{9.429}$$

$$= 6.97\ T$$

$$M = 6.97 \times 4.7 - 7 \times 0.375 \times 2.8$$

$$= 25.41\ T.m$$

$$= 249\ kN.m \ ✓$$

253

Calcsheet1

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 22a.
Subject:			Calc No:
Job No:			File:
Made By:	Date:	Revised By:	Date:
Checked By:	Date:	Checked By:	Date:

LL shear on south edge girder :

Use vehicle 8 configuration from pg 21

Shear = 31.1 x 0.315

= 9.8 t

= 96.1 kN

CALCULATION COVER SHEET

Jacobs
Reading

Project Title: BRB (Residuary) Ltd - Major Works 2004/2007		Calc. No.: 80.5	
Job No: J24110IS		File: R9	
Project Manager [redacted]	Subject: END/709 BD21 Assessment		
Designer	Station Road, Southfleet / Gravesend West Branch		
Project Group 31400	Girder Summary, Ratings and Bearing Stiffener check		

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	5	[redacted]	Feb-07	[redacted]	Feb-07				
Rev									
Rev									
Rev									
Rev									
Rev									

Superseded by Calculation No. Date

For design criteria, refer to Approval in Principle (Form AA) document

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 23
Subject:			Calc No:
Job No:			File:
Made By:	Date:	Revised By:	Date:
Checked By:	Date:	Checked By:	Date:

Summary of girder results (pass for C > K = 0.79 40 tonn a

north edge girder , Bending moments @ 4m from abut

sht 15 Bending moment capacity = 749 KN.m ✓

sht 11 Dead load moment = 527 KN.m ✓

Line load capacity = 222 KN.m

sht 21 AWL moment (40t) = 353 KN.m (Fail)

21 A AWL moment (7.5t) = 142 KN.m (Pass

south edge girder , Bending Moments @ mid-span

sht 17. Bending moment capacity = 4163 KN.m ✓

sht 11 Dead load moment = 567 KN.m ✓

line load capacity = 3596 KN.m ✓

sht 22 AWL moment = 249 KN.m PASS

northern-most internal girder , BM @ mid-span

sht 12 Bending moment capacity = 1053 KN.m

sht 11 Dead load moment = 656 KN.m

line load capacity = 397 KN.m ✓

sht 19 HA adjusted L.L moment = 543 KN.m ✓

C factor = 0.73 . fails 40T a.1.1

Rating = 18 tonnes. ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 24	
Subject:		Calc No:	
Job No:		File:	
Made By:	Date:	Revised By:	Date:
Checked By:	Date:	Checked By:	Date:

northern most internal girder, SF @ support

sht 17b	Shear force capacity	=	489 kN ✓
sht 11	Dead load shear	=	278 kN ✓
	Live load capacity	=	211 kN. ✓
sht 19	HA adjusted L.L. effect	=	230 kN. ✓
	C factor	=	0.92 PASS ✓

third girder from north

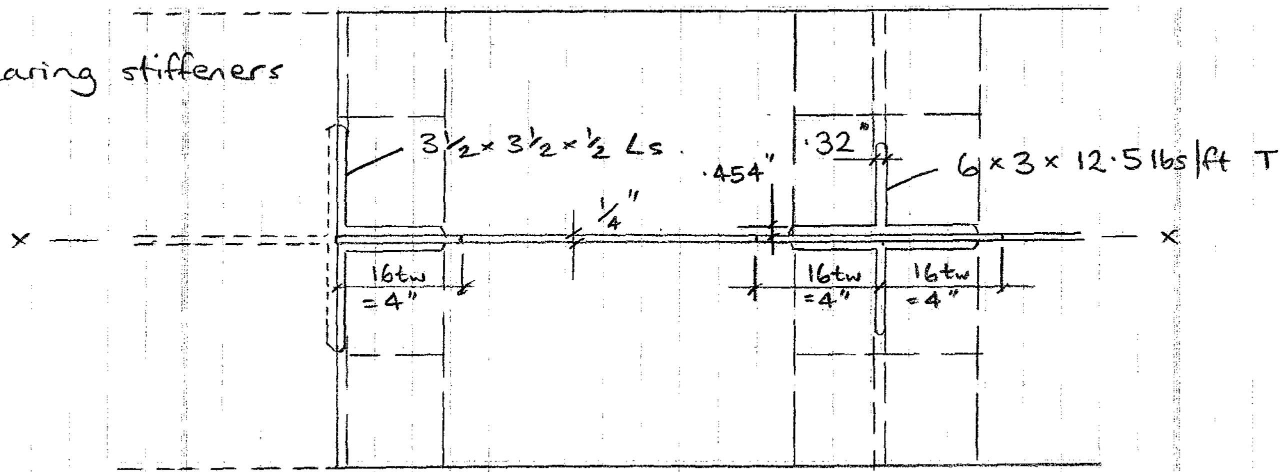
12a	Bending moment capacity	=	1312 kN.m ✓
11	Dead Load moment	=	656 kN.m ✓
	Live load capacity	=	656 kN.m ✓
19.	HA adjusted L.L effect	=	751 kN.m ✓
	C factor	=	0.873 pass. ✓
	Shear force capacity	=	489 kN
	Dead Load shear	=	278 kN
	Live load capacity	=	211 kN
	HA adjusted L.L effect	=	299 kN
	C factor	=	0.705
	rating	=	18 tonnes.

CALCULATION SHEET

JE JACOBS

Project Title:	Sheet No: 25
Subject: END|709: Bearing stiffner check	Calc No:
Job No:	File:
Made By: [redacted] Date: 1/07	Revised By: Date:
Checked By: [redacted] Date: Jan 07	Checked By: Date:

Bearing stiffeners



Check bearing stiffener at end of long span edge girder:

BD 56/96
9.14.2

Take effective stiffener section as Ts and end angles combined:

Effective section:

Dorman Long Handbook
p 206 / p 227

$$A_{se} = 2 \times 20{\cdot}87 \times 10^2 + 2 \times 23{\cdot}7 \times 10^2 + (4 \times 25{\cdot}4) \times 6{\cdot}35 + (8 \times 25{\cdot}4) \times 6{\cdot}35$$

$$= \underline{10849 \text{ mm}^2} \checkmark$$

$$I_{xx} = \frac{\tfrac{1}{2} \times 7\tfrac{1}{4}^3}{12} + \frac{3 \times 1\tfrac{1}{4}^3}{12} + \frac{\tfrac{1}{2} \times \tfrac{1}{4}^3}{12} + \frac{{\cdot}32 \times 6\tfrac{1}{4}^3}{12} + \frac{6 \times 1{\cdot}158^3}{12} + \frac{2 \times \tfrac{1}{4}^3}{12} = 23{\cdot}66 \text{ in}^4$$

$$= \underline{9{\cdot}85 \times 10^6 \text{ mm}^4} \checkmark$$

$$Z_x = \frac{9{\cdot}85 \times 10^6}{(3\tfrac{1}{8} \times 25{\cdot}4)} = 124094 \text{ mm}^3 \checkmark$$

Radius of gyration $r_{se} = \sqrt{I/A} = \underline{30{\cdot}1 \text{ mm}}$ ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 26	
Subject:		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 1/07	Revised By:	Date:
Checked By:	Date: 5Jun07	Checked By:	Date:

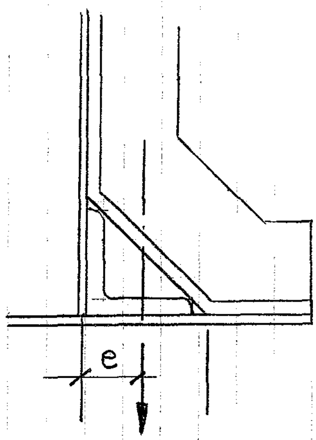
BD 56/96

9.13.5.3 $$\frac{P}{A_{se}\,\sigma_{ls}} + \frac{M_{xs}}{Z_x\,\sigma_{ys}} \leq \frac{1}{\gamma_m \cdot \gamma_{f3}}$$

$P = 229$ kN (dead load) $+ 109$ kN $\times 1.5$ factored

$= 393$ kN ✓

15.3.2 & 15.3.1(b) M_{xs}: is additional bending moment meant to address the shape of the stiffener. For knee stiffeners as here, eccentricity = ½ distance from centroid of stiffener to its point of intersection with the beam flange.



$2e = \frac{1/4''}{2} + 3\frac{1}{2}'' + \frac{1}{2}'' = 4\frac{1}{8}''$

$e = 2\frac{1}{16}'' = 52.4$ mm ✓

$M_{xs} = 393 \times 52.4 = 20593$ kN.mm. ✓

9.13.5.3 σ_{ls}: $\lambda = \frac{l_s}{r_{se}}\sqrt{\frac{\sigma_{ys}}{355}}$

9.13.3.2 l_s = clear distance between beam flanges
$= 800 - 25.4 = 774.6$ mm

$\lambda = \frac{774.6}{30.1}\sqrt{\frac{220}{355}} = 20.25$ ✓

Fig. 23 $\frac{\sigma_{ls}}{\sigma_{ys}} = 0.945$ ✓

$\sigma_{ls} = 0.945 \times 220 = \underline{207.9 \text{ N/mm}^2}$. ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 27	
Subject:		Calc No:	
Job No:		File:	
Made By: [redacted]	Date: 1/07	Revised By:	Date:
Checked By: [redacted]	Date: Jan07	Checked By:	Date:

$$\frac{393 \times 10^3}{10849 \times 207{\cdot}9} + \frac{20{\cdot}593 \times 10^6}{124094 \times 220} \leqslant \frac{1}{1{\cdot}2 \times 1{\cdot}1}$$

$$0{\cdot}174 + 0{\cdot}754 \leqslant 0{\cdot}75$$

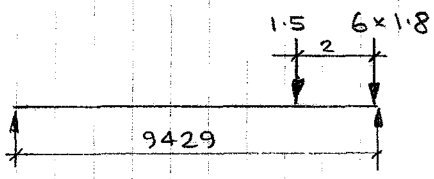
$0{\cdot}928 > 0{\cdot}75$ $\therefore$ Fail for 40 tonnes

Permissible load = $393 \times \frac{0{\cdot}75}{0{\cdot}928} = 317$ KN

Permissible live load = $317 - 229 = 88$ KN

Permissible Nominal live load = $88/1{\cdot}5 = \underline{59 \text{ KN}}$.

Check 7·5 tonne vehicle. (RF)



$$\text{Shear} = \left(\frac{1{\cdot}5 \times 7{\cdot}429}{9{\cdot}429} + 6 \times 1{\cdot}8\right) \times \frac{0{\cdot}715}{2} \times 9{\cdot}81$$

$= 42$ KN. OK ✓

18 tonnes fails by inspection

$\therefore$ Rating = 7·5 tonne A.V.L. ✓

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	80.6
Job No: J24110IS		File:	R9

Project Manager	[redacted]	Subject:	END/709 BD21 Assessment
Designer			Station Road, Southfleet / Gravesend West Branch
Project Group	31400		Jack Arch Assessment

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	4	[redacted]	Feb-07	[redacted]	Feb-07				
Rev									
Rev									
Rev									
Rev									
Rev									

Superseded by Calculation No. Date

For design criteria, refer to Approval in Principle (Form AA) document

PRO FORMA FOR EMPIRICAL ASSESSMENT OF BRICK, MASONRY AND CONCRETE JACK ARCHES AND ASSOCIATED TIES
(To be included with the Assessment Report Calculations)

BRIDGE/LINE NAME:	Southfleet Station Road / Gravesend West Branch
STRUCTURE NO:	END / 709

Assessment should include completion of all three Sections even where Section 1 has shown the bridge deck to be non-compliant.

SECTION 1 CHECKS FOR COMPLIANCE WITH 40 TONNE CONFIGURATION REQUIREMENTS

		Compliant Yes/No
What is maximum clear span of the arch *Non-compliant if greater than 2.0m*	1575 1.549 m	Yes
Do jack arches spring from bottom flanges of beams? *If not, non compliant*	Y	Yes
What is the beam spacing? What is the rise of the arch? Gross aspect ratio *Non-compliant if greater than 10*	$b := 1.930$ m $r_c := 0.500$ m $\frac{b}{r_c} = 3.86$	Yes
What is the arch barrel thickness (including concrete fill above) and how is it derived ie from record drawings or site investigation? *Non-compliant if thickness less than 220*	$d := 300$ mm 225 mm	Ref 24.5, p.2 Yes

accept since 300mm is a better assumption

JDC 09/06

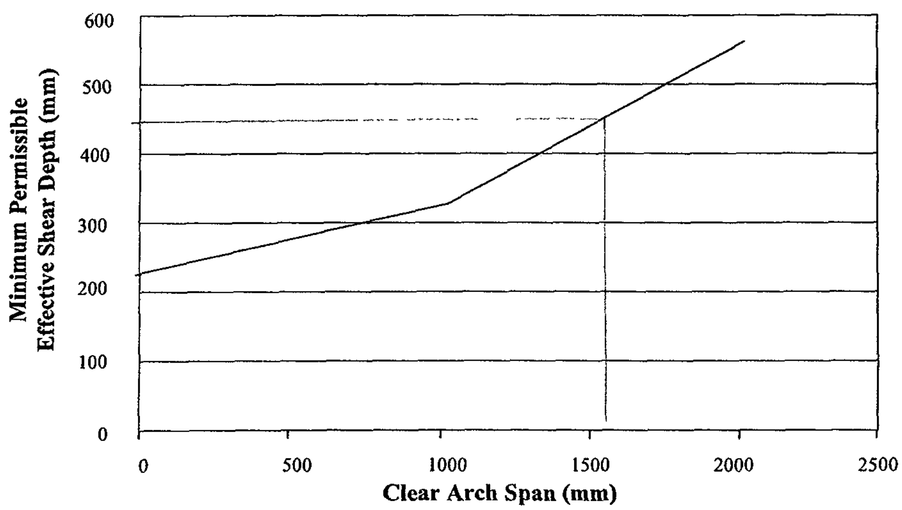
KJ Jan 07

PRO FORMA FOR EMPIRICAL ASSESSMENT OF BRICK, MASONRY AND CONCRETE JACK ARCHES AND ASSOCIATED TIES
(To be included with the Assessment Report Calculations)

BRIDGE/ LINE NAME:	Southfleet Station Road / Gravesend West Branch
RAILTRACK NO:	END / 709

Assessment should include completion of all three Sections even where Section 1 has shown the bridge deck to be non-compliant.

SECTION 2 CHECKS FOR DEFICIENCY

Type No	Deficiency	Pass/ Fail
1	What is the backing material? Is it structural? concrete (friable)	
	Does the structural backing extend to at least the crown level of the arch extrados? Yes *If not, then fail (1) (4)*	Pass
	Height of structural fill above crown $d_f := 298$ mm 150 mm	
	What is effective shear depth of deck? (= arch rise + barrel thickness + depth of structural fill above crown of extrados) $D_s := r_c + d + d_f$ $D_s := 1098$ 800mm = height of girder	
	Is $D_s \geq$ "minimum requirements of Fig 1" Fail if < Fig 1 Ds > fig 1	Pass
	 *Figure 1*	

JDC
09/0

2	Do jack arches span longitudinally (eg in half through girder construction) or transversely between longitudinal girders? ***Transverse Jack Arches*** For longitudinal spanning jack arches, ignore following questions on ties/lateral restraint and state N/A. Are ties provided in edge bays of transversely spanning jack arches? *If yes, go to 3a/3b* *If not, fail unless edge bay is 'hard' (see 5)*	Pass	✓
3a CI	What is the cross sectional area of one tie? (allowing for corrosion losses) Diameter of tie $Dia :=$ ▪ mm Therefore Area $A := \pi \frac{(Dia)^2}{4}$ $A = \cdot mm^2$ What is number of ties per beam length? $n := 2$ What is the clear skew span? $L :=$ ▪ m Specific area of tie $A_s := \frac{(n+1) \cdot A}{L}$ $A_s = \cdot \frac{mm^2}{m}$ NA *Non-compliant if less than 260mm²/m* What is maximum tie spacing? $S :=$ ▪ m *Non-compliant if greater than 2.5m for cast iron*		
3b WI/ST	What is the cross sectional area of one tie? (allowing for corrosion losses) Diameter of tie $Dia := 22.9$ mm Therefore Area $A := \pi \frac{(Dia)^2}{4}$ $A = 411.871 \cdot mm^2$ What is number of ties per beam length? $n := 5$ What is the clear skew span? $L := 9.03$ m Specific area of tie $A_s := \frac{(n+1) \cdot A}{L}$ $A_s = 273.668 \cdot \frac{mm^2}{m}$ *Non-compliant if less than 260mm²/m* What is maximum tie spacing? $S := 1.524$ m *Non-compliant if greater than 3.0m for wrought iron/steel*	✓ Pass Pass	
4	Are ties located within crown of external arch? *If so, then fail CI or possible fail for WI/steel*	Pass	
5	Does external bay construction provide alternative lateral restraint? (ie not soft edge)? *If so, pass.* *If not, are ties provided in first Jack Arch bay? if yes, treat as 3a (or 3b). otherwise fail.*	Pass	TWC 09/0[illegible]

Notes: (1) Results also in loss of D/d (composite action) for cast iron beams
(4) A trial hole should be undertaken to confirm the existence of structural backing if there is any doubt.

K 5 Jan 07

PRO FORMA FOR EMPIRICAL ASSESSMENT OF BRICK, MASONRY AND CONCRETE JACK ARCHES AND ASSOCIATED TIES
(To be included with the Assessment Report Calculations)

BRIDGE/LINE NAME:	Southfleet Station Road / Gravesend West Branch
RAILTRACK NO:	END / 709

Assessment should include completion of all three Sections even where Section 1 has shown the bridge deck to be non-compliant.

SECTION 3 CHECKS FOR DEFICIENCY

Type No	Defect	Empirical Assessment		Pass/ Fail
		CI Decks	WI/Steel Decks	
6	Rotation of supporting beam	Fail	Fail	Pass ✓
7	Horizontal displacement of supporting beam	Fail	Fail	Pass ✓
8	Inadequate support to springings eg corrosion of bottom flange of supporting beam over a significant length, missing bedding mortar	Possible Fail	Possible Fail	Pass * Not Possible fail
9	Transversely bowed bottom flange of supporting beam	Fail	Fail	Pass ✓
10	Cracking at crown of arch owing to spreading of springings (other than 12, 13)	Fail	Fail	Pass ✓
11	Distortion and any associated cracking of jack arch barrel	Fail	Fail	Pass ✓
12	Arch crack resulting in substructure crack	Fail	Fail (5)	Pass ✓
13	Substructure crack or other distress resulting in crack to jack arch	Possible Fail (3)	Possible Fail (3) (5)	Pass ✓

TDC 09/

Notes: (3) 'Substructure renovation' or 'Monitoring' as appropriate; 'Repair of arch' (if appropriate)
(5) Not applicable in general to longitudinally spanning arches.

FJ 30/10/07