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BRB (Residuary) Ltd

Major works programme 2004/2007

VAR9-1423-01

BD21/01 Assessment

Fenton Bridge, Nr. Luffness, East Lothian

BRIDGE REF: AGB/5

March 2006

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Document control sheet Form IP180/B

Client: BRB (Residuary) Ltd
Project: Major works Programme 2004/2007 Job No: J24110HQ
Title: AGB/5 (BD21/01 Assessment)

	Prepared by	Reviewed by	Approved by
ORIGINAL	NAME [redacted]	NAME	NAME
DATE 25 January 2006	SIGNATURE	SIGNATURE	SIGNATURE

REVISION	NAME [redacted]	NAME	NAME
DATE 6 March 2006			

REVISION	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

REVISION	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

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Contents

1 BD21/01 Assessment

This report presents the BD21/01 assessment for Structure AGB/5.

1.1 Location of Structure

Structure AGB/5 is located on the Gullaine to Longniddry disused railway line at Grid Reference NT487808. The structure carries a public road and is known locally as Fenton Public Bridge.

1.2 Construction Type

Half through girder type bridge. The edge girders are slender steel riveted plate girders 6' – 6" (1.981m) deep with unequal flanges. The transverse girders are riveted steel plate girders 15" x 9" (381 x 225 mm). The transverse girders connect to the edge girders with a cleated connection on the inside face, each connection has a gusseted web stiffeners on the outside face and a tee section on the inside face. Buckle plates span between the top angles of the transverse girders supporting the deck construction. The buckle plates are two way spanning connected laterally by tee sections. The bridge was constructed circa 1893.

1.3 Information used to form the Assessment

The assessment was carried out to BD21 on the bridge in its current state. All dimensions and condition factors were obtained from site measurements and reference to historic data. (See Jacobs report "VAR9-830 BE4 Assessment Programme – Assessment and Inspection Report – Bridge Ref.: AGB/5").

Load distribution in the plates and connecting tees was modified in accordance with the recommendations in Jacobs FE analysis of buckle plates (November 2005).

1.4 Results of BD21/01 Assessment

Element: **Parapet girders**

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 = 0.76 for 40 tonne loading (Lg) Low HGV flow, good road condition.

Action	Critical Location	Dead load effect	Adjusted HA live load effect	Assessed resistance	C factor	Live load rating (Lg)
Bending Compression flange buckling	Mid-span	466.7 kN.m	606.3 kN.m	1824 kN.m	2.2	40 tonnes
Shear	Support	216 kN	388 kN	1401 kN	3.0	40 tonnes

Accidental wheel loading from Annex D vehicle D4 (two 10 tonne axles at 1.8m separation)

Action	Critical Location	Dead load effect	Accidental wheel loading	Assessed resistance	C factor	AWL rating
Bending Compression flange buckling	Mid-span	466.7 kN.m	572 kN.m	1824 kN.m	2.3	40 tonnes
Shear	Support	216 kN	132 kN	1401 kN	8.9	40 tonnes

Element: **Transverse girders T1 – T5** (T6 length and applied dead load are reduced due to skew of bridge)

Assessed for critical road vehicles BD21/01 Table D1 (also refer to clause D4 a.) Critical axle wheel loads for various vehicle gross weights

Axle weights (tonnes)	**Vehicle gross weight (tonnes)**				
	Full assessment live loading		Restricted assessment live loading		
axle	44	40	26	18	7.5
W2	**11.5**	11.5	11.5	11.5	1.5
W1				6.5	**6.0**

Capacity factor = Available live load capacity / assessed live load effects (11.5 tonnes axle)

Action	Critical Location	Dead load effect	Live load effect	Assessed resistance	Capacity factor	Live load rating
Bending	Mid-span	135.93 kN.m	473 kN.m	464.7 kN.m	0.695	7.5 tonnes
Shear	Support	68.5 kN	140.2 kN	365 kN	2.11	40 tonnes

Accidental wheel loading from Annex D (single 11.5 tonne axle)

(Bending effect is identical to assessment live load)

Action	Critical Location	Dead load effect	Live load effect	Assessed resistance	Capacity factor	Live load rating
Shear	Support	68.5 kN	252 kN	365 kN	1.17	40 tonnes

Element: **Buckle plates**

Assessed for single wheel loading to BD21/01 Clause 5.30.

40, 26 and 18 tonne loading, single wheel loads for various road surface and HGV flow combinations:

	HGV Flow		
Road Surface	High (H)	Med. (M)	Low (L)
Good (g)	90	86	**82**
Poor (p)	100	95	90

7.5 tonne loading, single wheel loads for various road surface and HGV flow combinations:

	HGV Flow		
Road Surface	High (H)	Med. (M)	Low (L)
Good (g)	46	43	**41**
Poor (p)	50	47	44

Capacity factor = Available live load capacity / assessed live load effects (82 kN wheel)

Action	Location	Dead load effect	Load effect 82kN wheel	Assessed resistance	Capacity factor	Live Load Rating (Lg)
Axial compression strip load	Applied adjacent to tees	29.8 kN/m	517.76 kN/m	701.04 kN/m	1.3	40 tonnes

Element: **Buckle plate riveted connection to transverse girders**

Action	Location	Dead load effect	Load effect 82kN wheel	Assessed resistance	Capacity factor	Live Load Rating (Lg)
Rivets in shear	Buckle plate / main girder	3.0 kN/rivet	52.6 kN/rivet	29.85 kN/rivet	0.51	7.5 tonnes

Element: **Tee sections connecting adjacent buckle plates**

Action	Location	Dead load effect (modified)	Load effect 82kN wheel (modified)	Assessed resistance	Capacity factor	Live Load Rating (Lg)
Tees in bending	Mid-span	0.255 kN.m	3.123 kN.m	1.97 kN.m	0.55	7.5 tonnes

Bending effects in the connecting tees have been derived in accordance with the findings from Jacobs report on the FE analysis of buckle plates (November 2005).

Main assumptions:

- Bridge specific live loading was based on "low" HGV usage and "good" road surface, reflecting the current condition.
- The main girders, tee sections and buckle plates were taken as steel. This was assumed in the BE4 assessment.

- It was assumed that the transverse girders connecting to the main girders will provide lateral restraint to the compression flange of the parapet girders by U –frame action. The flexibility coefficient f used to calculate δ in BD56: Clause 9.6.5 was obtained from RT/CE/C/025 Fig. A42, which presents a greater range of historical connection types than BD56.

- The buckle plates were checked as an arch catenary, calculating the limiting compressive stress as for a strut with effective length extending from the end of the span (the rivet line) to the intersection point with the wheel distribution, as outlined in BA56: clause 15.2. The rivets were checked for the horizontal thrust imposed by the arch action.

1.5 Load Rating

The transverse girders are deficient for 40 tonne assessment live loading in bending. BD21 requires that transverse members failing the 40 tonne loading level and are rated at 7.5 tonnes Assessment Live loading or below, because 26 tonne and 18 tonne vehicles can have 11.5 tonne axles. The rating determined for the bridge was 7.5 tonnes and Fire Engine Group 2. This load corresponds to the loading imposed by two axle critical AW vehicles under the road vehicles (Authorised Weight) regulations 1998.

The main parapet girders are robustly constructed and despite some web corrosion, they have sufficient capacity to carry 40 tonne Assessment Live Loading. They are slender sections with a relatively small compression flange. The most critical load effect is bending producing buckling of the compression flange.

Wheel loading in accordance with BD21 is considerably more onerous than BE4, namely a nominal 100 kN wheel with impact as opposed to a 5 ton (50kN) wheel load in BE4. The plate connections and the supporting tee sections failed to meet the 40 tonne requirements. As with the transverse girders, the next assessment level below 40 tonnes is 7.5 tonnes. The components just passed at this reduced level. It should be noted that if "poor (p)" road surface condition is taken, the rivet connections will technically fail for 7.5 tonnes and would be rated at 3 tonnes.

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Appendix A - Form AA

FORM 'AA' (BRIDGES) GC/TP0356
Appendix: 4
ELR/ Bridge No AGB/5 Issue: 1
Revision: B (Nov 2000)

APPROVAL IN PRINCIPLE FOR ASSESSMENT

Senior Civil Engineer's Comments

Confirmation required that the FE analysis undertaken by Tech. is linear and that its application to limit state CoP is acceptable.

Proposed Category for Independent Check .....

Superstructure I

Substructure ..... I.

Name of Checker suggested if Cat 2 or 3 .....

Category 1

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

Signed .....[redacted]

Title .....

Date 19/12/05

Category 2 and 3

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

Signed .....

Title .....

Date .....

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Appendix B - Form BA and BAA

FORM 'BA' (BRIDGES)

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

ELR/ Bridge No AGB/5

CERTIFICATION FOR ASSESSMENT CHECK

Assessment Group:	**Jacobs Infrastructure**
Bridge/Line Name:	**Fenton Bridge / Aberlady Gullane Branch**
Category Of Check:	1
ELR/ Bridge No:	AGB/5

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 Form AA approved on 20 December 2005.

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

BD 21/01 - "The Assessment of Highway Bridges and Structures"

BD 56/96 – "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 (commenting on the results if appropriate).

None

Category 1

Name	Signature	Date	
[redacted]		25/1/06	Assessor
		25/1/06	Assessment Checker
			Authorised signatory of the firm of Consulting Engineers to whom Assessor/Checker is responsible.

FORM 'BA' (BRIDGES)

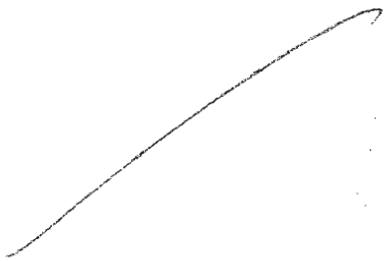
GC/TP0356
Appendix: 4
Issue: 1
Revision: A (Feb 1993)

ELR/ Bridge No AGB/5

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 responsible.

This Certificate is accepted b [redacted] 26/9/07

FORM 'BAA' (BRIDGES)

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

ELR/ Bridge No AGB/5

CERTIFICATION FOR ASSESSMENT CHECK

Name	Signature	Date	
[redacted]		25/1/06	Assessor
		25/1/06	Assessment Checker
		1/2/06	Authorised signatory of the firm of Consulting Engineers to whom Assessor/Checker is responsible.

This Certificate is accepted by [redacted] 26/9/07

FORM 'BAA' (BRIDGES)

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

ELR/ Bridge No AGB/5

CERTIFICATION FOR ASSESSMENT CHECK

Notification of Assessment Check

Assessment Group	Jacobs Infrastructure.
Bridge Name/Road No.	Fenton Bridge / unclassified
Line Name	Aberlady Gullane Branch
ELR Code/Structure No.	AGB/5

The above bridge has been assessed and checked in accordance with Standards which are listed on the [illegible] summary of the results of the [illegible] as follows:-

STATEMENT OF CAPACITY

Transverse Girder: 7.5 tonnes Assessment Live Loading and Fire Engines Group 2. This corresponds to the loading imposed by two axle light goods and public service vehicles (restricted to 7.5 tonnes GVW).

Floor plate connection to transverse girders and connecting tees between buckle plates: 7.5 tonnes Assessment Live Load and Fire Engines Group 2 (as above).

Other assessed components are satisfactory for 40 tonnes Assessment Live Loading.

Recommended Loading Restrictions

7.5 tonnes GVW and Fire Engines Group 2.

Description of Structural Deficiencies and Recommended Strengthening

There is corrosion of the webs of both external girders and slight section loss on several internal girders. The corrosion in the main girder webs should be treated and maintenance painting is required throughout.

Minor masonry repairs and repointing are recommended throughout the structure as well as the removal of the trees behind the NE wingwall. .The vertical fracture at West abutment does not warrant any additional maintenance work, since the pilaster on the top does not show any signs of movement. Although recently resurfaced, the carriageway surfacing is in need of minor maintenance.

The dampness of the abutments and underneath the inverted Tee sections shows that the waterproofing is not effective. Deck re-waterproofing should be considered for the long-term sustainability of the abutment/bridge.

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Appendix C - Calculations

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	68.1
Job No: J24110HQ		File:	R8
Project Manager	[redacted]	Subject:	AGB/5 - BD21/01 assessment
Designer	[redacted]		Fenton Bridge / Aberlady Gullane Branch
Project Group	31400		Section properties

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	6	[redacted]	Jan-06	[redacted]	Jan-06				
Rev									
Rev									
Rev									
Rev									
Rev									

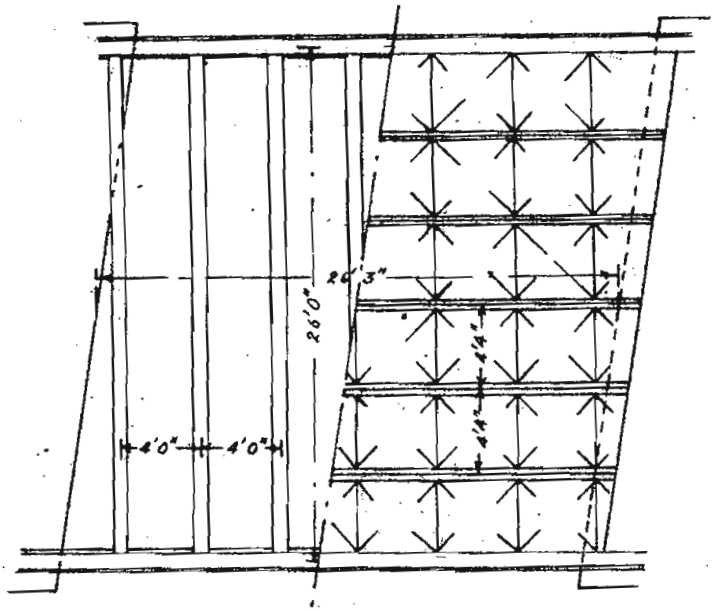
Superseded by Calculation No. Date

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

CULLANE BRANCH

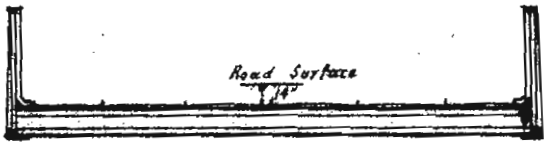
FENTON

BRIDGE No 5



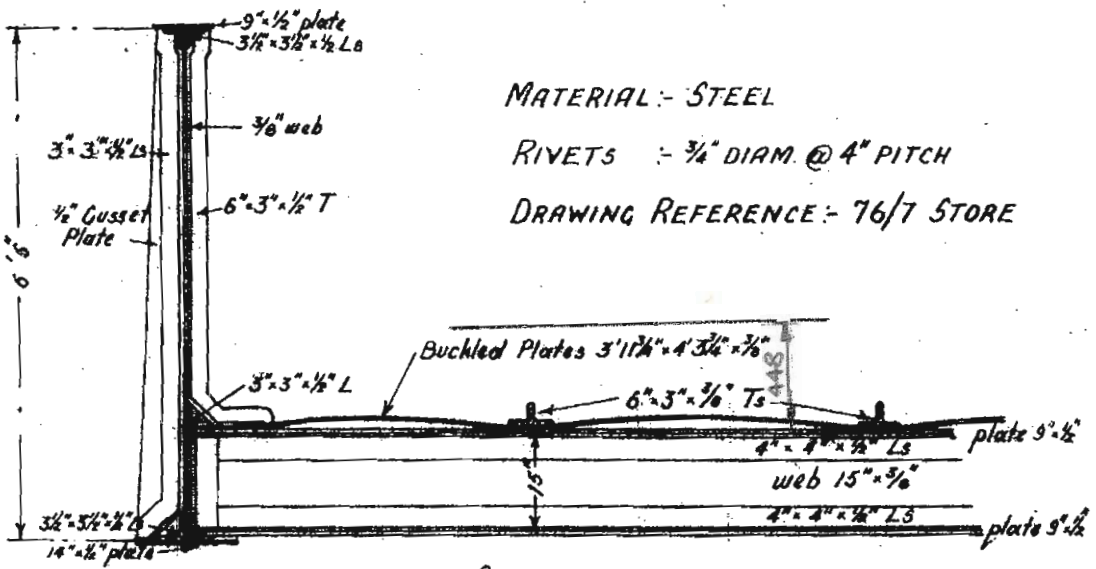
PLAN

SCALE ⅛" = 1'



SECTION

SCALE ⅛" = 1'



MATERIAL :- STEEL

RIVETS :- ¾" DIAM. @ 4" PITCH

DRAWING REFERENCE :- 76/7 STORE

SECTION

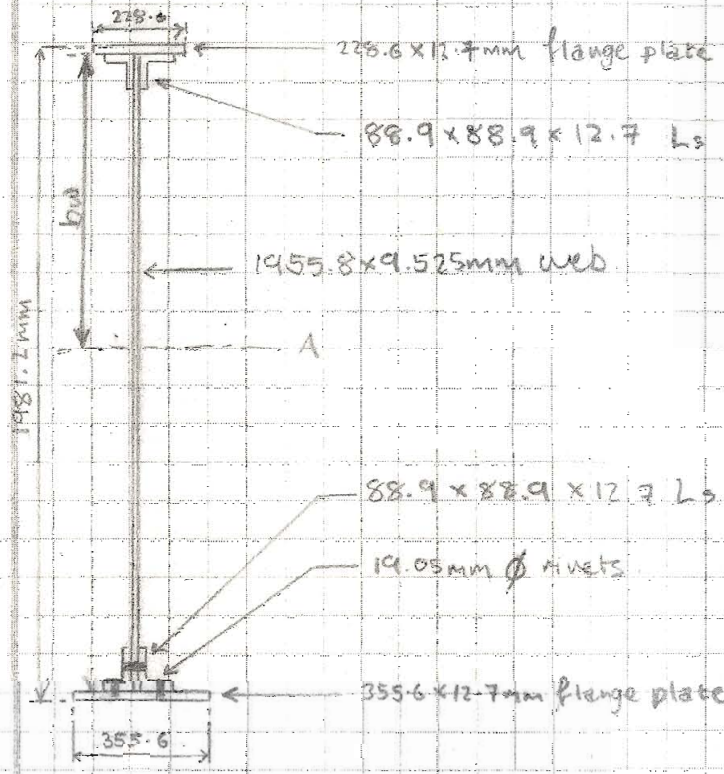
SCALE ½" = 1'

CALCULATION SHEET

JACOBS

Project Title: BRB(Residuary) BD21 Assessment			Sheet No: 1
Subject: AGB/5 ~ Section properties main girder (MG)			Calc No: 68.1
Job No: J24110HQ			File: RB
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By: [redacted]	Date: 1/06	Checked By:	Date:

Main (Parapet) girder (all dims in mm)



p. 7-8 Summary of section properties from BE4 Assessment

$A = 32802.354\ mm^2$ ($34435.415\ mm^2$ with rivets)

$\bar{y} = 989.858\ mm$

$I_{xx} = 19220307480\ mm^4$ 1.922×10^{10}

$I_{yy} = 74814821\ mm^4$ 74.8×10^6

$Z_{bot} = 19417237\ mm^3$

$Z_{top} = 19388170.20\ mm^3$

CALCULATION SHEET

JE JACOBS

Project Title:		Sheet No:	2
Subject:	SECTION PROPERTIES (MG)	Calc No:	68.1
Job No:		File:	R8
Made By: [redacted]	Date: 01/06.	Revised By:	Date:
Checked By:	Date: 1/06	Checked By:	Date:

classification of main girder.

9.3.7.2 web:

$$b_w \not> 28 t_w \sqrt{\frac{355}{\sigma_{yw}}}$$

$t_w = 9.525\,mm$ ✓

BD21/01 4.3 $\sigma_{yw} = 230\ N/mm^2$ ✓

$b_w = 1981.2 - 989.858 - 12.7 = 978.642$ ✓

$$28 \times 9.525 \sqrt{\frac{355}{230}} = 331.34 < b_w$$

∴ Main girder is a non-compact section ✓

9.7.4 Plastic section properties calculated for K_4

Axis of equal area:

Top flange and angles area:-

BEA calcs p.7 $2903.22 + 2 \times (2 \times 967.74 + 161.29)$

$= 7096.76\ mm^2$

Bottom flange and angles area (less rivets)

$4516.12 + 2 \times (2 \times 967.74 + 161.29) - 2(483.87) - 665.321$

$= 7076.6\ mm^2$

Web area $= 18628.995\ mm^2$ ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 3
Subject:	SECTION PROPERTIES (MG)	Calc No: 68.1
Job No:		File: R8
Made By: [redacted]	Date: 01/06	Revised By: Date:
Checked By: [redacted]	Date: 1/06	Checked By: Date:

Balance position.

$709676 - 7076.6 = 20.161\ mm^2$

$\frac{20.161}{2} \div 9.525 = 1.058$ mm above mid height

$= 1981.2/2 + 1.058$

$= 991.658$ mm above bottom.

Z_{pe} is 1st moment of area about plastic N.A.

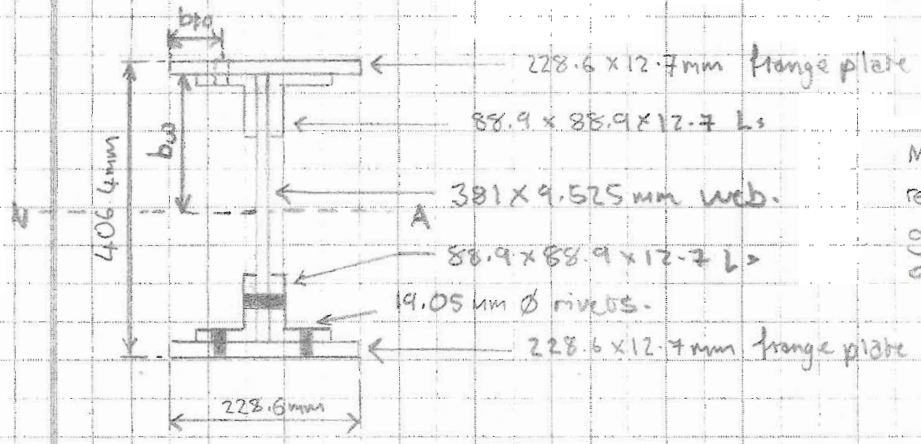
Element	A (mm^2)	y (mm)	Ay ($\times 10^6\ mm^3$)
Top flange	2903.22	983.192	2.854
Top Ls hor	2260.6	970.492	2.194
Top Ls ver	1935.48	932.392	1.805
web (upper)	9304.42	488.421	4.544
web (lower)	9324.57	495.3	4.618
bottom Ls ver	1935.48	928.158	1.796
bottom Ls hor	2260.6	972.608	2.199
bottom flange	4516.12	985.308	4.450
Deduct			
flange rivets	-2×483.87	978.958	-0.956
web rivets	-665.321	972.608	-0.647
			22.857 mm^3

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	4
Subject:	SECTION PROPERTIES Transverse girder (TG)	Calc No:	68.1
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By:	Date: 1/06	Checked By:	Date:

Transverse girder



Minimal section loss reported. Site measureme. give flange thickness as 13mm :- Use original ½" (12.7mm) plate thickness.

p. 14-15 Summary of section properties from BEL Assessment.

$A = 17479.806 mm^2$ ✓ ($19112.865 mm^2$ with rivets) ✓

$\bar{y} = 218.822 mm$ ✓

$I_{xx} = 476063577 mm^4$ ✓

$I_{yy} = 4630554.3 mm^4$ ✓

$Z_{top} = 2537950 mm^3$ ✓

$Z_{bot} = 2175575 mm^3$ ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	5
Subject:	SECTION PROPERTIES (TG)	Calc No:	68.1
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By:	Date: 1/06	Checked By:	Date:

Plastic section properties

find axis of equal area

Top flange + angles area = 2903.22 + 4838.7
= 7741.92 mm²

Bottom flange + angles - rivets = 7741.92 - 967.74
-665.322
= 6108.858 mm²

web = 3629.025 mm²

7741.92 - 6108.858 = 1633.062 mm²

$\frac{1633.062}{2} \div 9.525 = 85.73$ mm above mid height

$\frac{406.4}{2} + 85.73 = 288.93$ mm above bottom.

Z_{pe} is 1st moment of area about axis of equal area.

Element	A (mm²)	y (mm)	Ay ($\times 10^6$ mm³)
Top flange	2903.22	111.12	0.323
Top Ls hor	2260.6	98.42	0.222
Top Ls vert	1935.48	53.97	0.104
web (upper)	1665.72	87.439	0.146
web (lower)	1963.31	103.061	0.202
bot Ls ver	1935.48	155.322	0.300
bot Ls hor	2260.6	199.772	0.452
bottom flange	2903.22	212.472	0.617
Deduct			
flange rivets	-967.74	206.122	0.199
web rivet	-665.321	155.322	0.103
Σ			2.667 $\times 10^6$ mm³

CALCULATION SHEET

JE JACOBS

Project Title:		Sheet No:	6
Subject:	SECTION PROPERTIES (TG)	Calc No:	68.1
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By:	Date: 1/06	Checked By:	Date:

Classification of transverse girder

9.3.7.2 web

$$b_w \geq 28 t_w \sqrt{\frac{355}{\sigma_{yw}}} = 28 \times 9.525 \sqrt{\frac{355}{230}}$$

$$= 331.3$$

$b_w = 406.4 - 218.822 - 12.7 = 174.878 \not\geq 331.3$

9.3.7.3 flange (compression)

$$b_{fo} \geq 7 t_{fo} \sqrt{\frac{355}{\sigma_{yf}}} = 7 \times 12.7 \sqrt{\frac{355}{230}}$$

$$= 110.45$$

$b_{fo} = 228.6/2 - 12.7 - (88.9 - 12.7)/2 = 63.5\ mm \not\geq 110.45$

∴ TRANSVERSE GIRDER IS A COMPACT SECTION ✓

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	68.2
Job No:	J24110HQ	File:	R8
Project Manager	[redacted]	Subject:	AGB/5 - BD21/01 assessment
Designer			Fenton Bridge / Aberlady Gullane Branch
Project Group	31400		Section capacities

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	10	[redacted]	Jan-06	[redacted]	Jan-06				
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:	7
Subject: AGB/5 ~ SECTION CAPACITIES (MG)		Calc No:	68.2
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By: [redacted]	Date: 1/06	Checked By:	Date:

Main (parapet) girder

U-frame action is provided at gusset plate connections only, which is applicable to every connection @ 1.219 c/cs

restraint to compression flange is provided by a deck connected to a stiffened web, therefore BD56/96 9.6.5 and BD56/96 9.12.2 apply.

BD56/96 9.6.5 $l_e = K_5 K_3 (E I_c l_u \delta)^{0.25}$ but not less than l_u

$K_5 = 1$ for unrestrained beams at supports.

BEU calcs p.9 $I_c = 12.64 \times 10^6 + 2 \times 3.455 \times 10^6 = 19.55 \times 10^6 \text{ mm}^4$

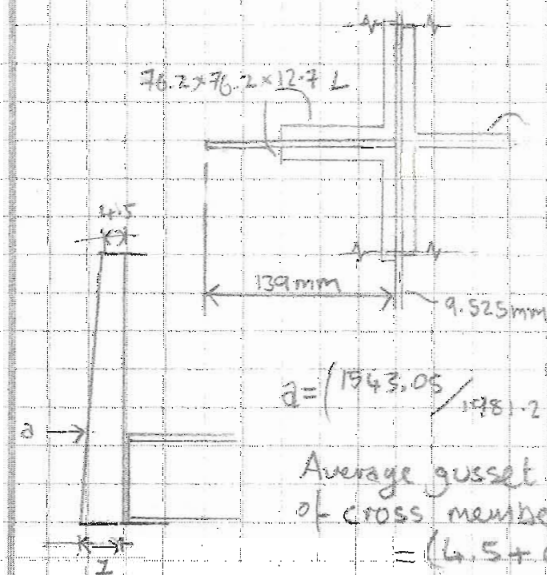
$l_u = 1219 \text{ mm}$

$$\delta = \frac{d_1^3}{3EI_1} + \frac{uBd_1^2}{EI_2} + f d_2^2$$

$d_1 = \left(78 - \frac{1}{4} - 16 - \frac{1}{2} - \frac{1}{2}\right) \times 25.4 = 1543.05 \text{ mm}$

$d_2 = \left(78 - \frac{1}{4} - \frac{16}{2} - \frac{1}{2} - \frac{1}{2}\right) \times 25.4 = 1746.25 \text{ mm}$

I_1 :



$a = \left(1543.05 / 1778.2 \times 2.5\right) + 4.5 = 6.45$

Average gusset projection between top of cross member and compression flange

$= (4.5 + 6.45)/2 = 5.47'' = 139 \text{mm}$

CALCULATION SHEET

JE JACOBS

Project Title:		Sheet No: 8
Subject: (MG)		Calc No: 68.2
Job No:		File: R8
Made By: [redacted]	Date: 01/06	Revised By: [redacted] Date: 02/06
Checked By [redacted]	Date: 1/06	Checked By: [redacted] Date: 3/06

$I_1 = (152.4 \times 34.925^3)/12 + (12.7 \times 139^3)/3$

$+ (25.4 \times 76.2^3)/3 + (12.7 \times 76.2^3)/3$

$= 541019.56 + 11369120.43$

$+ 3746082.8 + 1873041.415$

$= 17.53 \times 10^6 \text{ mm}^4$

No concrete deck present

p.12

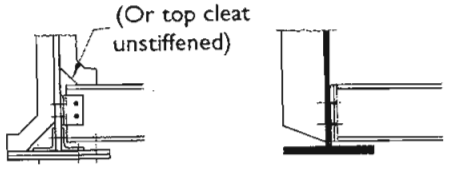
$\therefore I_2 = 476 \times 10^6 \text{ mm}^4$

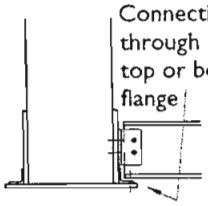
$\mu = 0.5$

$B = 26' = 7924.8 \text{ mm}$

$f = 0.5 \times 10^{-4} \text{ rad/kN m} = 0.5 \times 10^{-10} \text{ rad/N mm}$

RT/CE/C/025
fig. A42





f $\times 10^{-4}$ RAD/kNm.
0.5

$\delta = \frac{1543.05^3}{3 \times 205 \times 17.53 \times 10^9} + \frac{0.5 \times 7924.8 \times 1746.25^2}{205 \times 476 \times 10^9}$

$+ 0.5 \times 10^{-4} \times 1746.25^2$

$\delta = 0.000341 + 0.000124 + 0.000152 = 0.000617$

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 9
Subject:	M.G		Calc No: 68.2
Job No:			File: R8
Made By: [redacted]	Date: 01/06	Revised By: [redacted]	Date: 02/06
Checked By: [redacted]	Date: 1/06	Checked By: [redacted]	Date: 3/06

$\delta = 0.000617$ mm/N

$l_e = \pi \times 1.0 \times (205000 \times 19.55 \times 10^6 \times 1219 \times 0.000617)^{0.25}$

$= 4146$ mm

9.9.1.3 $M_D = \dfrac{Z_{xc}\sigma_{xc}}{\gamma_m \gamma_{f3}}$ or $\dfrac{Z_{xt}\sigma_{yt}}{\gamma_m \gamma_{f3}}$ (lesser of the two)

σ_{xc})

9.7.2 $\lambda_4 = \dfrac{l_e}{r_y} K_4 \eta \nu$

$l_e =$

SWT1 $r_y = \sqrt{\dfrac{I_{yy}}{A}} = \sqrt{\dfrac{74.8 \times 10^6}{34435.415}} = 46.6$ mm

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

$= \left[\dfrac{4 \times (22.857 \times 10^6)^2 \left(1 - \frac{7.48}{1922}\right)}{34435.4^2 \times 1968.5^2}\right]^{0.25}$

$= 0.819$

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	10
Subject: (MG)		Calc No:	68.2
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By: [redacted]	Date: 02/06
Checked By [redacted]	Date: 1/06	Checked By: [redacted]	Date: 3/06

$\eta = 1.0$

D,

$$\lambda_F = \frac{\ell_e}{r_y}\left(\frac{t_f}{D}\right)$$

$$= \frac{4146}{46.6}\left(\frac{22.6}{1981.2}\right) = 1.02$$

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

$I_t = 47589126\ mm^4$, $I_c = 12643030\ mm^4$

$$\iota = 12643030 / 60232156$$

$$= 0.21 \quad \checkmark$$

Table 9 $\quad \nu = 1.5$

$$\lambda_{LT} = \frac{4146}{46.6} \times 0.819 \times 1.0 \times 1.5$$

$$= 109.3$$

$\sigma_{yc} = 230\ N/mm^2$

$$\lambda_{LT}\sqrt{\frac{\sigma_{yc}}{355}} = 109.3\sqrt{\frac{230}{355}} = 87.98 \quad \checkmark$$

CALCULATION SHEET

JE JACOBS

Project Title:				Sheet No: 11	
Subject: (NG)				Calc No: 68.2	
Job No:				File: R8	
Made By: [redacted]	Date: 01/06	Revised By: [redacted]		Date: 02/06	
Checked By: [redacted]	Date: 1/06	Checked By: [redacted]		Date: 3/06.	

figure 10 $\sigma_{zi} / \sigma_{yc} = 0.54$ ✓

$\sigma_{zi} = 0.54 \times 230 = 124.2 \text{ N/mm}^2$ ✓

983 $D\sigma_{zi} / 2\gamma_t = 1981.2 \times 124.2 / 2 \times 989.858$

$= 124.2 \text{ N/mm}^2 < \sigma_{yc} \therefore = \sigma_{zi}$ ✓

BD21 3.10 $\gamma_{f3} = 1.1$

table 2 $\gamma_m = 1.2$ (compression) $= 1.05$ (tension)

$$M = \frac{19388170 \times 124.2}{1.2 \times 1.1} \times 10^{-6}$$

$= 1824 \text{ kN.m}$ ✓

$$M = \frac{19417237 \times 230}{1.05 \times 1.1} \times 10^{-6}$$

$= 3866 \text{ kN/m}$ ✓

$M_D = 1824 \text{ kN.m}$ ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	12.
Subject: (MG)		Calc No:	68.2
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By:	Date: 1/06	Checked By:	Date:

Shear capacity

9.2.2 $V_D = \left[\frac{t_w(d_w - h_n)}{\gamma_m \gamma_{13}}\right] \tau_t$

$t_w = 9.525\ mm$

$d_w = 1955.8\ mm$

$h_n = 0$

τ_t $\tau_y = \frac{\sigma_{yw}}{\sqrt{3}} = \frac{230}{\sqrt{3}} = 132.79\ N/mm^2$

$\phi = a/d_{we}$ $d_{we} = 1955.8 - (2 \times 89) = 1777.8\ mm$

$a = 4 \times 12 \times 25.4 - 2 \times 82.55 = 1054.1\ mm$

$\phi = 1054.1 / 1777.8 = 0.59$

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

$b_{fe} = 10 t_f \sqrt{\frac{355}{\sigma_{yf}}} = 10 \times 12.7 \sqrt{\frac{355}{230}} = 157.78\ mm$

or $228.6/2 = 114.3\ mm$ ✓

Use smallest value $= 114.3\ mm$ ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 13
Subject: (MG)		Calc No: 68.2
Job No:		File: R2
Made By: [redacted]	Date: 01/06	Revised By: Date:
Checked By:	Date: 1/06	Checked By: Date:

$$M_{fw} = \frac{230 \times 114.3 \times 12.7^2}{2 \times 230 \times 1803.2^2 \times 9.525} = 0.00029$$

$$\lambda = \frac{d_{we}}{t_w}\sqrt{\frac{\sigma_{yw}}{355}} = \frac{1777.8}{9.525}\sqrt{\frac{230}{355}} = 150.24$$

Use figure 11 $M_{fw} = 0$

$$\tau_u/\tau_y = 0.78$$

$$\tau_e = 0.78 \times 132.79 = 103.58 \ N/mm^2$$

BEL calcs p.43.

$h_n = 80mm$

$$V_D = \left[\frac{9525(1955.8-80)}{1.2 \times 1.1}\right] 103.58 \times 10^{-3}$$

$$= \underline{1401 kN}$$

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	14
Subject:	TG	Calc No:	68.2
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By:	Date: 1/06	Checked By:	Date:

Internal girder (transverse)

9.9.1.3 $M_D = \dfrac{Z_{pc}\,\sigma_{lc}}{\gamma_m\,\gamma_{f3}}$

σ_{lc},

9.7.2 $\lambda_{LT} = \dfrac{l_e}{r_y} K_4 \eta_2$

Top flange is fully restrained by buckle plates therefore $l_e = 0$

figure 10 $\sigma_{l1}/\sigma_{yc} = 1.0 \Rightarrow \sigma_{l1} = 230 \times 1.0 = 230$

9.8.2 $\therefore \sigma_{lc} = \sigma_{l1} = 230$

$$M_D = \frac{2.667 \times 10^6 \times 230}{1.2 \times 1.1} \times 10^{-6}$$

$$= \underline{464.7\ \text{kN.m}}$$

CALCULATION SHEET

JE JACOBS

Project Title:		Sheet No:	15
Subject:	TG-	Calc No:	68.2
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By: [redacted]	Date: 1/06	Checked By:	Date:

Internal girder - shear force capacity.

9.9.2.2

$$V_D = \left[\frac{t_w(d_w - h_n)}{\gamma_m \gamma_{fe}}\right] \tau_e$$

$t_w = 9.525\,mm$
$d_w = 381\,mm$
$h_n = 0$

τ_e

$$\tau_y = \frac{\sigma_{yw}}{\sqrt{3}} = \frac{230}{\sqrt{3}} = 132.79\,N/mm^2$$

$$\phi = a/d_{we} \qquad d_{we} = 381 - (2 \times 101.6) = 177.8\,mm$$

$$a = (323'' \times 25.4) - (2 \times 76.2) = 8051.8\,mm$$

$$\phi = 8051.8/177.8 = 45.29 \text{ / conservative}$$

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

$$b_{fe} = 10 b_f \sqrt{\frac{355}{\sigma_{yf}}} = 10 \times 12.7 \sqrt{\frac{355}{230}} = 157.76\,mm$$

or $228.6/2 = 114.3\,mm$

Use smallest value $= 114.3\,mm$

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	68.3
Job No:	J24110HQ	File:	R8
Project Manager	[redacted]	Subject:	AGB/5 - BD21/01 assessment
Designer			Fenton Bridge / Aberlady Gullane Branch
Project Group	31400		Dead loads

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	3	[redacted]	Jan-06	[redacted]	Jan-06				
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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:	16
Subject:	TG	Calc No:	68.2
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By:	Date: 1/06	Checked By:	Date:

$$m_{fw} = \frac{230 \times 114.3 \times 12.7^2}{2 \times 230 \times 177.8^2 \times 9.525} = 0.031$$

$$\lambda = \frac{d_{we}}{t_w}\sqrt{\frac{\sigma_{yw}}{355}} = \frac{177.8}{9.525}\sqrt{\frac{230}{355}} = 15$$

Figure 14 $\Rightarrow \tau_L/\tau_y = 1.0$

$\therefore \tau_L = \tau_y = 132.79\ N/mm^2$

$$V_D = \left[\frac{9.525(381-0)}{1.2 \times 1.1}\right] \times 132.79$$

$= \underline{365\ kN}$

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	17
Subject: AGB/S :- DEAD LOADS. (MG)		Calc No:	68.3
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By: [redacted]	Date: 1/06	Checked By:	Date:

Dead loads - Transverse girder

BE4 calcs p.10 & p.42

self weight of girder	=	1.545 kN/m
verge self weight	=	1.604 kN/m
Carriageway self weight	=	1.103 kN/m
fill self weight	=	10.811 kN/m
T-section self weight	=	0.206 kN
Buckle plate self weight	=	0.894 kN/m

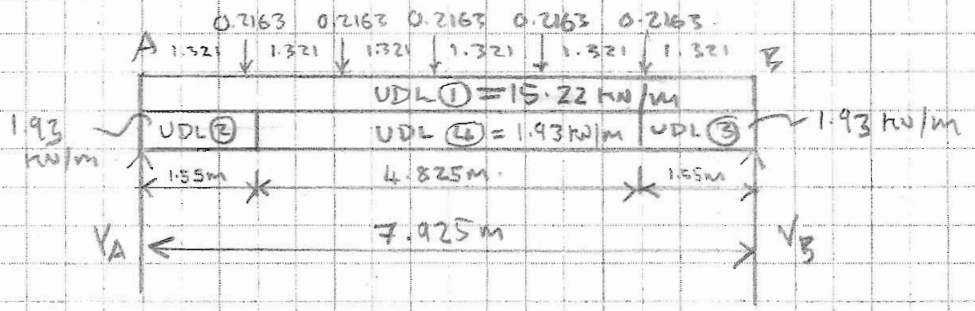
BD21/01 table 3.1 Apply $\gamma_{f1} = 1.05$ (Steel girder + T-section + Buckle plate)
$\gamma_{f1} = 1.2$ (fill and verge)
$\gamma_{f1} = 1.75$ (macadam)

factored dead load:

$(1.545 + 0.894) \times 1.05 + 10.811 \times 1.2$
$= 15.22$ kN/m (UDL ①)

$1.604 \times 1.2 = 1.9248$ kN/m (UDLs ② & ③)
$1.103 \times 1.75 = 1.93$ kN/m (UDL ④)
} taken as 1 whole UDL

$0.206 \times 1.05 = 0.2163$ kN (PL ① + ⑤)



Expected max BM at mid-span due to symmetry.

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	18
Subject:		Calc No:	68.3
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By:	Date: 1/06	Checked By:	Date:

Dead load moment at mid-span due to symmetry

$$= \frac{15.22 \times 7.925^2}{8} + \frac{1.93 \times 7.925^2}{8} + \frac{5 \times 0.2163 \times 7.925}{4}$$

$$- 0.2163 (1.321 + 2.642)$$

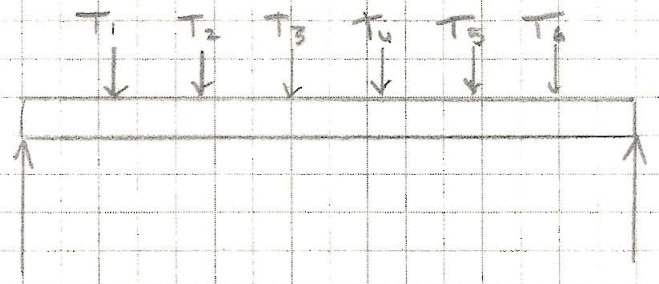
$$= 135.925 \text{ kN.m}$$

Max shear at support

$$= \frac{(15.22 + 1.93) \times 7.925}{2} + \frac{5 \times 0.2163}{2}$$

$$= 68.5 \text{ kN}$$

Dead load effects - external girder

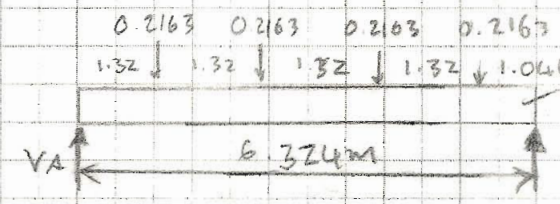


BEL calcs p.17 because of skew, length of transverse girder 6. is reduced to 6.324m

CALCULATION SHEET

JE JACOBS

Project Title:		Sheet No:	19
Subject:		Calc No:	68.3
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By: [redacted]	Date: 1/06	Checked By:	Date:



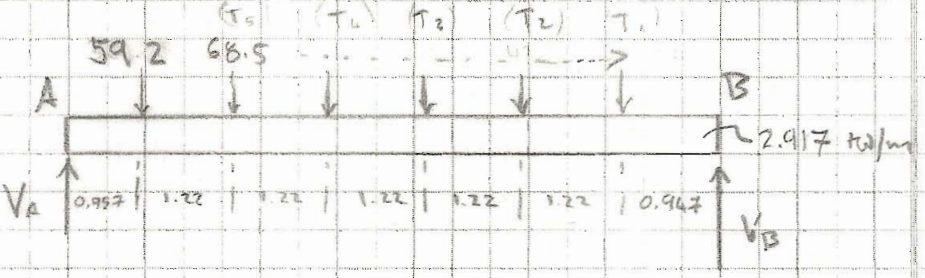
point load applied on external girder = V_A

$V_A \times 6.324 = (15.22+1.93) \times \frac{6.324^2}{2} + 0.2163 \times (1.044+2.364+3.684+5.0)$

$V_A = 59.2\ kN = T_6$

BS8 cals p 10 cl 6.3 self wt of external girder = 2.917 kN/m.

effective length = L x 1.0 x 1.0 = 8.00m



Max BM expected at T_3.

Reaction V_A

$V_A = [2.917 \times 8^2/2 + 59.2 \times 7.043 + 68.5(0.947+2.167+3.387+4.607+5.827)] \div 8$

$V_A = 209\ kN$

$M = V_A \times 4.617 - 59.2 \times 3.66 - 68.5 \times (2.66+1.22) - 2.917 \times 4.617^2/2$

$= 466.48\ kN.m$

Max shear at support B

$V_B = 2.917 \times 8 + 59.2 + 5 \times 68.5 - 209 = 216.0\ kN$

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	68.4
Job No: J24110HQ		File:	R8
Project Manager	[redacted]	Subject:	AGB/5 - BD21/01 assessment
Designer			Fenton Bridge / Aberlady Gullane Branch
Project Group	31400		Live loads

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	4	[redacted]	Jan-06	[redacted]	Jan-06				
Rev									
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Rev									
Rev									

Superseded by Calculation No. Date

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

CALCULATION SHEET

JACOBS

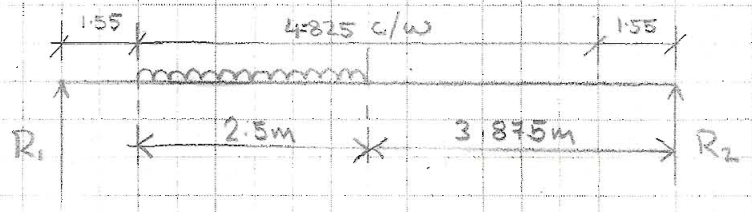
Project Title:		Sheet No: 20
Subject: AGB/5 - Live loading : External girder.		Calc No: 68.4
Job No:		File: R8

Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By [redacted]	Date: 1/06	Checked By:	Date:

Carriageway width = 7.925 - 2×1.55 = 4.825m

table 5.1 1 Notional lane is applied

Notional lane width = 2.5m



$$R_1 = \frac{w\left(3.875 + \frac{2.5}{2}\right)}{7.925} = 0.65w$$

Edge girder 1 takes up to 65% of live load

Loaded length = effective span = 8000mm

HA UDL = $336\left(\frac{1}{8}\right)^{0.67}$ = 83.42 kN/m

HA KEL = 120 kN

Adjustment factor = 3.65/2.5 = 1.46

Adjusted HA load effect (bending)

$$= \left(\frac{83.42 \times 8^2}{8} + \frac{120 \times 8}{4}\right) \times \frac{1}{1.46} = 621.85 \text{ kN.m}$$

fig 5.7 Load reduction factor K for low HGV flow and good road condition = 0.76

Bridge specific HA load effect with KEL at mid-span

$$= \left(\frac{83.42 \times 8^2}{8} + \frac{120 \times 8.0}{4}\right) \times \frac{0.76}{1.46} = 472.6 \text{ kN.m}$$

CALCULATION SHEET

JE JACOBS

Project Title:		Sheet No:	21
Subject:		Calc No:	68.4
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By: [redacted]	Date: 02/06
Checked By: [redacted]	Date: 1/06	Checked By:	Date:

Factored live load

Table 3.1 = 472.6 × 1.5 = 708.9 kNm

65% is carried by each edge girder

708.9 × 0.65 = 460.79 kN m

= Ultimate live load moment.

Adjusted HA live load effect for edge girder
= 460.79 / 0.76
= 606.3 kN.m

Maximum shear force

$$= \left(\frac{83.42 \times 8}{2} + 120\right) \times 0.76 \times 0.57 \times 1.5$$

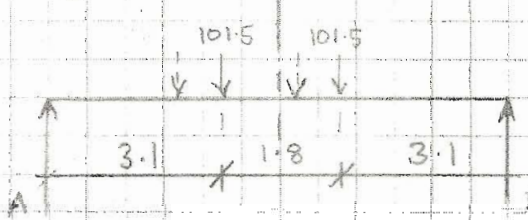
= 294.8 kN

Adjusted HA L L shear for edge girder
= 294.8 / 0.76
388 kN

live loadings : Transverse girder

Table D1 11.5 tonne axle ⇒ 11.5 × 9.81 = 112.8 kN (critical axle)

D4 Apply impact factor of 1.8 to critical axle ⇒ 1.8 × 112.8 = 203.04 kN



$F_A = 1.0$

$$M = \left(\frac{101.5 \times 3.1 \times 4.9}{7.925} \times \frac{2 \times 3.9625}{4.9}\right) \times 1.5$$

= 472 kN.m at midspan

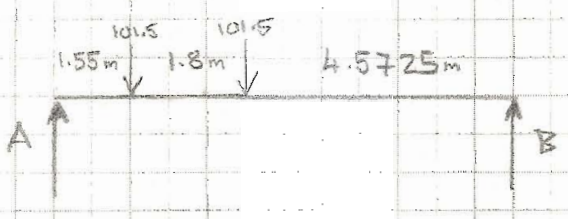
Max LL BM offset 0.45 from ℄ = 473.8 kN.

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 22
Subject:		Calc No: 684
Job No:		File: R8
Made By: [redacted]	Date: 01/06	Revised By: [redacted] Date: 02/06
Checked By: [redacted]	Date: 1/06	Checked By: Date:

Shear:



Shear force at A

$$V = 101.5 \times \left[\frac{(7.925-1.55)}{7.925} + \frac{(7.925-3.35)}{7.925}\right]$$

$= 140.24$ kN.

Main (parapet) girder

p.11 Bending	section capacity	=	1824 kN.m
p.19	Dead load moment	=	466.48 kN.m
	Live load capacity	=	1358 kN.m
p.21	Applied 40t a.l.l effect	=	460.79 kN.m
p.16 Shear	section capacity	=	1401 kN.
p.19	Dead load shear	=	216.0 kN
	Live load capacity	=	1185 kN
p.21	Applied 44t a.l.l effect	=	294.8 kN
	live load rating: Bending	=	40 tonnes.
	Shear	=	40 tonnes.

CALCULATION SHEET

JE JACOBS

Project Title:		Sheet No: 22A
Subject:		Calc No: 684
Job No:		File: R8
Made By: [redacted]	Date: 01/06	Revised By: [redacted] Date: 02/06
Checked B [redacted]	Date: 1/06	Checked By: Date:

Internal (Transverse) girder

p.14 Bending

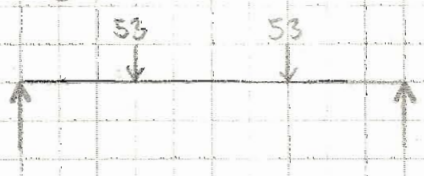
Section capacity	=	464.7 kN.m
Dead load moment	=	135.925 kN.m
Live Load capacity	=	328.775 kN.m
p.21 Applied 40 t a.1.1 effect	=	472 kN.m see below

Shear: Section capacity	=	365 kN
Dead load shear	=	68.5 kN
Live load capacity	=	296.5 kN
Sht 16. Applied 40 a.1.1 effect	=	140.24 kN.

live load rating = 40 tonnes

Table D2 A.L.L level of 7.5 tonnes gives axle load of 6.0 tonnes

⇒ Apply impact factor = $6.0 \times 9.81 \times 1.8 = 105.948$ kN



$$M = \left(\frac{53 \times 3.1 \times 4.9}{7.925} \times \frac{2 \times 3.9625}{4.9} \right) \times 1.5$$

$= 246.45$ kN.m < 328.775

∴ Live load rating for transverse girder in bending = 7.5 tonnes

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007		Calc. No.: 68.5
Job No: J24110HQ			File: R8
Project Manager	[redacted]	Subject:	AGB/5 - BD21/01 assessment
Designer			Fenton Bridge / Aberlady Gullane Branch
Project Group	31400		Buckle plate and rivets check

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	4	[redacted]	Jan-06	[redacted]	Jan-06				
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Rev									

Superseded by Calculation No. Date

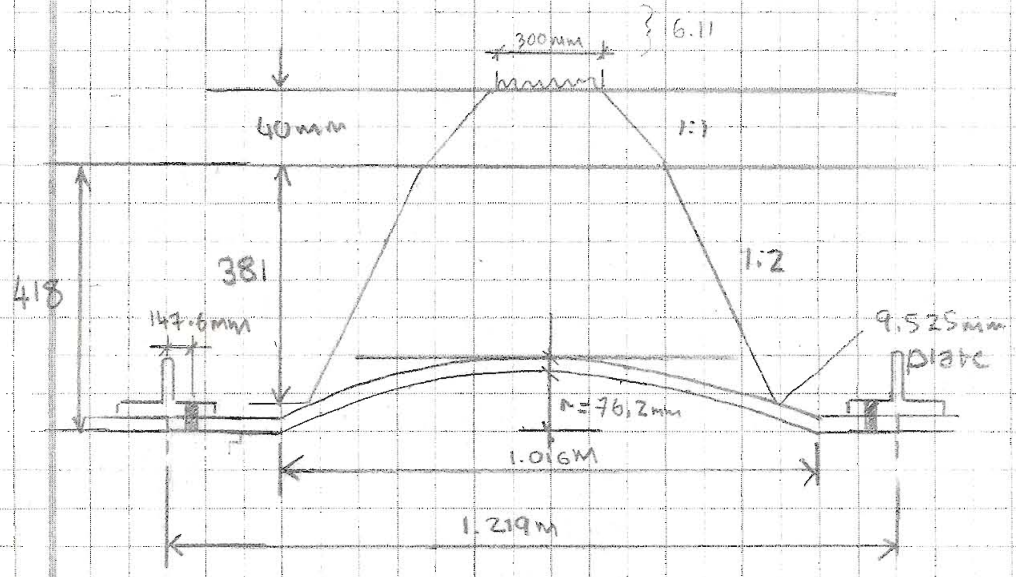
For design criteria, refer to Approval in Principle (Form AA) document

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	23.
Subject: AGB/S : Buckle plate check		Calc No:	68.5
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By: [redacted]	Date: 1/06	Checked By:	Date:

Buckle plate check (values taken from BFU cols 30.2)



BD 21/01 Table 5.3.2

Nominal single wheel loading = 82 kN

foot print area = 0.3 x 0.3 = 0.09 m²

BA 56 15.2

Take 1:1 dispersed through surface, 1:2 through fill

Dispersed length = 300 + 80 + 381 = 761 mm

Intensity of wheel pressure (+ impact)

$$= \frac{1.0 \times 1.5 \times 82}{0.761^2} = 212.39 \text{ kN/m}^2$$

Dead Load

= 0.481 x 21.21 x 1.2 = 12.24 kN/m²

Total = 224.63 kN/m²

CALCULATION SHEET

JE JACOBS

Project Title:				Sheet No: 24
Subject:				Calc No: 68.5
Job No:				File: R8
Made By: [redacted]		Date: 01/06	Revised By:	Date:
Checked By: [redacted]		Date: 1/06	Checked By:	Date:

BA56 15.2 Take intensity of wheel pressure at the plate as occuping the full span of the plate for calculation of thrust.

$$\text{Thrust} = \frac{wL^2}{8r} = \frac{226.63 \times 1.219^2}{8 \times 0.0762}$$

$$= 547.6 \text{ KN/m} \quad \left.\begin{matrix}\\\\\end{matrix}\right\} \begin{matrix}517.76 \text{ Live} \\ 29.8 \text{ Dead}\end{matrix}$$

Take plate to be acting as a strut with effective length extending from the end of the span to the intersection point with the wheel distribution

$$l_e = \frac{1.016 - 0.761}{2} = 0.128 \text{m}$$

Radius of gyration for plate:

BE4 calcs 30.2 $r = 0.108 \text{ in} = 2.7432 \text{ mm}$

Slenderness ratio

$$l/r = \frac{128}{2.7432} = 46.66$$

BD56 10.6.1 $$P_D = \frac{A_e \sigma_c}{\gamma_m \gamma_{13}}$$

$$A_e = \sum k_c \left(k_n A_c\right)$$

Figure 36 k_c

$$\lambda = \frac{b}{t}\sqrt{\frac{\sigma_y}{355}} =$$

$b = 1.219 - (2 \times 0.1476) = 0.924 \text{m}$

$t = 9.525 \text{mm}$

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 25
Subject:		Calc No: 685
Job No:		File: R8
Made By: [redacted]	Date: 01/06	Revised By: Date:
Checked By:	Date: 1/06	Checked By: Date:

$$\lambda = \frac{924}{4.525}\sqrt{\frac{230}{355}} = 78.08$$

Using curve 1 $\Rightarrow K_c = 0.48$

$A_c = 0.375\ in^2/in = 9.525\ mm^2/mm\ run$

$K_m = 1.0$

$$A_e = 0.48(1.0 \times 9.525) = 4.572\ mm^2/mm\ run$$

Table 2 $\quad \gamma_m = 1.2, \quad \gamma_{f3} = 1.1$

σ_c,

$$\lambda = 46.66 \times \sqrt{\frac{230}{355}} = 37.56$$

$$r/y = 2.7432/4.7625 = 0.576 \quad \therefore \text{use curve B.}$$

$$\sigma_c/\sigma_y = 0.88$$

$$\therefore \sigma_c = 0.88 \times 230 = 202.4\ N/mm^2$$

$$P_b = \frac{202.4 \times 4.572}{1.1 \times 1.2} = 701.04\ N/mm\ run$$

$$= 701.04\ kN/m\ run.$$

$701.04 > 547.6$

$\therefore$ plate is satisfactory for 40 tonnes

CALCULATION SHEET

JE JACOBS

Project Title:		Sheet No:	26
Subject:	AGB/5 : Buckle plate rivets check	Calc No:	68.5
Job No:		File:	R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By [redacted]	Date: 1/06	Checked By:	Date:

Check rivets connecting Buckle plate and tee sections:

Thrust from plate = 547.6 kN/m

Bencales P63 — rivet spacing = 6" = 0.1016 m

shear on rivet = 547.6 × 0.1016 = 55.64 kN { 52.6 Live, 3.0 Dead

Rivet diameter = 19.05 mm

14.5.3.4

$$\tau = \frac{V}{n A_{eq}} \not> \frac{\sigma_q}{\gamma_m \gamma_{f3} \sqrt{2}}$$

V = 55.64 kN

n = 1

$A_{eq} = \pi \times 19.05^2/4 = 285\ mm^2$

$\sigma_q = 0.85 \sigma_y = 0.85 \times 230 = 195.5\ N/mm^2$ (Assuming hand driven rivets)

$$\tau = \frac{55.64 \times 10^3}{285} = 195.23\ N/mm^2$$

$$\frac{\sigma_q}{\gamma_m \gamma_{f3} \sqrt{2}} = \frac{195.5}{1.1 \times 1.2 \times \sqrt{2}} = 104.73\ N/mm^2$$

$= 29.85$ kN/rivet

195.23 > 104.73 rivets fail in shear for 40 tonne loading

Max thrust = 104.73 × 285 = 29.85 kN/rivet

= 29.85 / 0.1016 = 293.78 kN/m

Total load = 293.78 × 8 × 0.0762 / 1.219² = 120.52 kN/m²

Total load − Dead load = 120.52 − 12.24 = 108.28 kN/m²

Nominal single wheel loading = 108.28 × 0.761² / 1.5 = 41.8 kN

CALCULATION SHEET

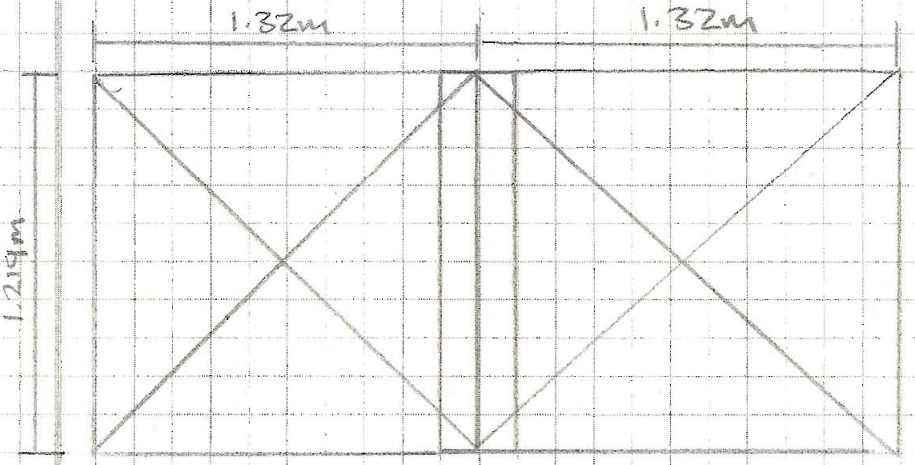
JACOBS

Project Title:			Sheet No: 27
Subject: AGB/5 : Tee section check			Calc No: 68.5
Job No:			File: R4
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By:	Date: 1/06	Checked By:	Date:

Table S.3.2

41 tw A.L.L effect for 7.5 tonne loading { 26.3 Live, 3.0 Dead.

Connecting Ts (152.4 × 76.2 × 9.525 mm)



Applied dead load = 12.24 kN/m² × ½ × 1.219 × 1.32

= 9.85 kN

BEAcalcs p.11

Self weight = 76.996 × 0.002 × 1.219 = 0.188 kN

Wheel load = 1.5 × 82 = 123 kN

As udl $M = \frac{(9.85 + 123 + 0.188)}{8} \times 1.219 = 20.27$ kNm.

(1.53 Dead, 18.74 live)

Assume section is Non-compact

BEAcalc 30.2 A4

$Z_{xx} = Z_{top} = 0.69 in^3 = 11.31 \times 10^3 mm^3$

$Z_{bottom} = 1.75 / 0.56 = 3.125 in^3 = 51.2 \times 10^3 mm^3$

CALCULATION SHEET

JE JACOBS

Project Title:			Sheet No: 28
Subject:			Calc No: 68.5
Job No:			File: R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By:	Date: 1/06	Checked By:	Date:

9.9.1.3 $M_D = \frac{Z_{xc}\,\sigma_{lc}}{\gamma_m\,\gamma_{f3}}$ or $\frac{Z_{xt}\,\sigma_{yc}}{\gamma_m\,\gamma_{f3}}$

M_D is the lesser of the two

Trees are riveted into buckle plates and are surrounded by foil

$\therefore \lambda_e = 0$

$\Rightarrow \lambda_{LT} = 0$

$\Rightarrow \sigma_{li} / \sigma_{yc} = 1.0$

$\Rightarrow \sigma_{li} = 230\ N/mm^2$

9.8.3 $\frac{D\sigma_{li}}{2Y_t} = \frac{3.1 \times 25.4 \times 230}{2 \times 0.56 \times 25.4} = 636.64 \not< \sigma_{yc} = 230$

$\therefore \sigma_{lc} = 230\ N/mm^2$

$M_D = \frac{51.2 \times 10^3 \times 230}{1.1 \times 1.2} = 8.92\ kN.m$

or

$M_D = \frac{11.31 \times 10^3 \times 230}{1.1 \times 1.2} = 1.97\ kN.m$ ✓

SO $M_D = \underline{1.97\ kN.m}$

Modifying moment applied in accordance with the recommendations of Jacobs FE analysis of buckle plates (Nov 05)

revised moment = $20.27/6 = 3.38\ kN.m$

$1.97 < 3.38$ ∴ Not OK ⇒ back calculate

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 29.
Subject:			Calc No: 685
Job No:			File: R8
Made By: [redacted]	Date: 01/06	Revised By:	Date:
Checked By: [redacted]	Date: 1/06	Checked By:	Date:

Max reversed moment = 1.97 kN.m

M = 6 × 1.97 = 11.82 kN.m

Max wheel load = $\frac{11.82 \times 8}{1.219} - 9.85 - 0.188 = 67.53$ kN (= 10.3 kN.m)

Max nominal wheel load = 45 kN

Table 5.3.2 A.A.L of 7.5 tonnes for a 41 kN nominal single wheel load.

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	68.6
Job No:	J24110HQ	File:	R8
Project Manager	[redacted]	Subject:	AGB/5 - BD21/01 assessment
Designer	[redacted]		Fenton Bridge / Aberlady Gullane Branch
Project Group	31400		Addendum calculations: Accidental Wheel loading

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	2	[redacted]	Feb-06	[redacted]	Feb-06				
Rev									
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Rev									
Rev									
Rev									

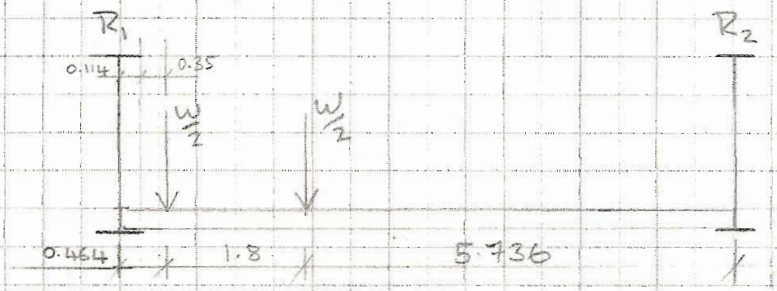
Superseded by Calculation No. Date

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

CALCULATION SHEET

JACOBS

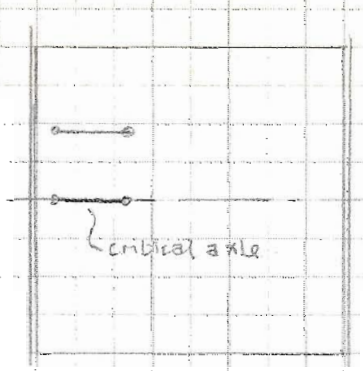
Project Title:			Sheet No:
Subject: AGB/5 : Accidental vehicle loading			Calc No: Addendum 68
Job No: J24110HQ			File: R8
Made By: [redacted]	Date: 02/06	Revised By:	Date:
Checked By:	Date: 3/06	Checked By:	Date:



% load to R_1

$$R_1 = \frac{W}{2} \times \frac{(5.736 + 7.536)}{7925} = 0.837$$

Plan view of axle loads on deck:



BD21 Annex D4 8.

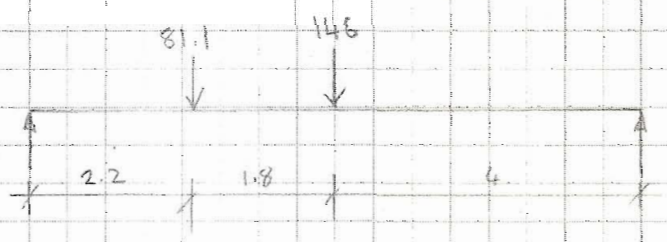
$W = 10 \times 9.81 \times 0.837 \times 1.8 = 146$ kN (critical axle)

$W = 10 \times 9.81 \times 0.837 = 81.8$ kN

CALCULATION SHEET

JE JACOBS

Project Title:			Sheet No: 2
Subject: AGB/5 Accidental vehicle loading			Calc No: Addendum 68
Job No: J24110HQ			File: R8
Made By: [redacted]	Date: 02/06	Revised By:	Date:
Checked By: [redacted]	Date: 3/06	Checked By:	Date:



$M_{mid\text{-}span} = \frac{146 \times 8}{4} + \frac{81.1 \times 2.2 \times 5.8}{8} \times \frac{4}{5.8} \times 1.5$ (table 3.1)

$= 572$ kN.m

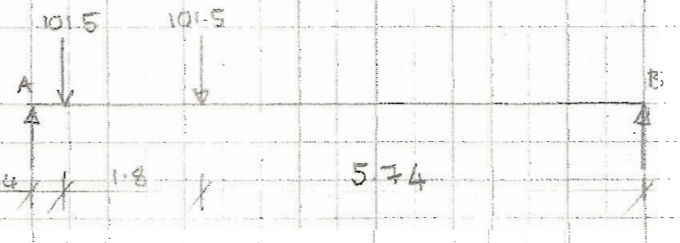
calc No 68 Sht 22 $572 < 1358$ ∴ OK @ 40 tonnes

Shear.

$V_{support} = 81.1 \times \frac{5.8}{8} + 146 \times \frac{1}{2} = 132$ kN

Transverse girder shear check

Sht 21 11.5 tonne critical axle = 203.04 kN $(11.5 \times 9.81 \times 1.8)$ impact



Shear force at A

Sht 22A $V_A = 101.5 \times \left(\frac{7.461}{7.925} + \frac{5.661}{7.925}\right) = 168.1 \times 1.5 = 252$ kN < 296.5 ∴ OK