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BRB (Residuary) Ltd

Major works programme 2004/2007

VAR9/1423-01

BD21/01 Assessment

Luffness Mains Bridge, Nr. Luffness, East Lothian

BRIDGE REF: AGB/3

April 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 - AGB/3
Title: AGB/3 (BD21/01 Assessment)

	Prepared by	Reviewed by	Approved by
ORIGINAL	NAME [redacted]	NAME	NAME
DATE 02 August 2006	SIGNATURE	SIGNATURE	SIGNATURE
REVISION 1	NAME [redacted]	NAME	NAME
DATE 04 Sept 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/3.

1.1 Location of Structure

Structure AGB/3 is situated on the Gullane to Longniddry disused railway line at Grid Reference NT483797. The structure carries a public road and is named Luffness Mains 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/3").

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	604 kN.m	865 kN.m	1824 kN.m	1.41	40 tonnes
Shear	Support	209 kN	333 kN	1401 kN	3.58	40 tonnes

Accidental wheel loading from Annex D vehicle 5 (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	604 kN.m	776 kN.m	1824 kN.m	1.57	40 tonnes
Shear	Support	209 kN	320 kN	1401 kN	3.73	40 tonnes

Element: **Transverse girders 4 – 7** (for transverse girders 1 -3 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	118 kN.m	474 kN.m	464.7 kN.m	0.73	7.5 tonnes
Shear	Support	66 kN	145.3 kN	365 kN	2.06	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

3 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)	22	21	**19**
Poor (p)	25	22	21

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	26.6kN/m	612.4 kN/m	1228 kN/m	1.96	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	2.7 kN/rivet	62.2 kN/rivet	29.85 kN/rivet	0.44	3 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	0.23 kN.m	3.125 kN.m	1.97 kN.m	0.56	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 transverse girders 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 with a larger contact area 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 however also failed to meet 7.5 tonne requirements and were subsequently rated at 3 tonnes and Fire Engines group 2.

The overall bridge rating is governed by the weakest component of the bridge; therefore the bridge is rated at 3 tonnes and Group 2 Fire Engines.

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Appendix A - Form AA

FORM 'AA' (BRIDGES)

GC/TP0356
Appendix: 4
Issue: 1
Revision: B (Nov 2000)

ELR/ Bridge No AGB/3

APPROVAL IN PRINCIPLE FOR ASSESSMENT

Bridge/Line Name: Luffness Mains Bridge / Aberlady Gullane Branch

ELR/Bridge No. AGB/3

Brief Description of Existing Bridge:

(a) Span Arrangement

Single span, simply supported bridge, clear skew span of parapet girders is 33' – 6" (10.21). Skew angle is about 27°. Transverse girders span between edge girders at 4'–0" (1.219m) intervals. Separation of the edge girders is 26'-0" (7.92m).

(b) Superstructure 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.

(c) Substructure Type

The abutments and wingwalls are constructed in coursed sandstone masonry.

(d) Planned highway works/modifications at this site

None known.

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

The bridge carries a single carriageway unclassified road. Carriageway width is 4.577m (15'-0"), with soft verges of 1.4m and 2.1m wide on each side. It is unlikely to be a heavy load route.

(f) Any other requirements

The bridge has passed BE4 assessment for full C&U loading and is now being checked to BD21.

FORM 'AA' (BRIDGES)

GC/TP0356
Appendix: 4
Issue: 1
Revision: B (Nov 2000)

ELR/ Bridge No AGB/3

APPROVAL IN PRINCIPLE FOR ASSESSMENT

Assessment Criteria

(a) Loadings and Speed

Dimensions and condition factors obtained from site measurements and reference to historic data. (See Jacobs report "VAR9-830 BE4 Assessment Programme – Assessment and Inspection Report – Bridge Ref.: AGB/3"). Assessment live loading obtained from and applied in accordance with BD21/01, assuming low HGV flow and good road condition. The bridge is assessed for up to 40/44 tonne live loading, with reduced loading being determined where this capacity is not reached.

(b) Codes to be used

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

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

(c) Proposed Method of Structural Analysis

Vehicle loading (kel and udl components) will be applied to the main girders by simple statics. Transverse members will be considered under appropriate single axle loads. Buckle plates will be examined under single wheel loads.

Capacities of the plate girders will be calculated using measurements of the reduced section sizes where corrosion is present. Consequently, a general condition factor is not applied.

It is 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 will be obtained from RT/CE/C/025 Fig. A42, which presents a greater range of historical connection types than BD56.

The buckle plates will be 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 will be checked for the horizontal thrust imposed by the arch action. Load distribution in the plates and connecting tees will be modified in accordance with the recommendations in Jacobs FE analysis of buckle plates (November 2005).

FORM 'AA' (BRIDGES)

GC/TP0356
Appendix: 4
Issue: 1
Revision: B (Nov 2000)

ELR/ Bridge No AGB/3

APPROVAL IN PRINCIPLE FOR ASSESSMENT

Director Structures' Comments

.....

.....

.....

.....

Proposed Category for Independent Check ....1....

Superstructure ....1....

Substructure ....1....

Name of Checker suggested if Cat 2 or 3 ....N/A....

Category 1

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

Signed [redacted]

Title ....CIVIL ENGINEER....

Date ....24/7/06....

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/3

CERTIFICATION FOR ASSESSMENT CHECK

Assessment Group: **Jacobs Infrastructure**

Bridge/Line Name: **Luffness Mains Bridge / Aberlady Gullane Branch**

Category Of Check: **1**

ELR/ Bridge No: **AGB/3**

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 24 July 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:

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]		4/9/06	Assessor
		4/9/06	Assessment Checker
		4/9/06	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/3

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 by [redacted] 7/2/08

FORM 'BAA' (BRIDGES)

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

ELR/ Bridge No AGB/3

CERTIFICATION FOR ASSESSMENT CHECK

Notification of Assessment Check

Assessment Group	Jacobs Infrastructure.
Bridge Name/Road No.	Luffness Mains Bridge / unclassified
Line Name	Aberlady Gullane Branch
ELR Code/Structure No.	AGB/3

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

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 Gross Vehicle Weight).

Floor plate connection to transverse girders and connecting tees between buckle plates: 3 tonnes Assessment Live Load and Fire Engines Group 2.

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

Recommended Loading Restrictions

3 tonnes Gross Vehicle Weight 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.

FORM 'BAA' (BRIDGES)

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

ELR/ Bridge No AGB/3

CERTIFICATION FOR ASSESSMENT CHECK

Name	Signature	Date	
[redacted]		4/9/06	Assessor
		4/9/06	Assessment Checker
		4/9/06	Authorised signatory of the firm of Consulting Engineers to whom Assessor/Checker is responsible.

This Certificate is accepted by.. [redacted] ..(7/2/08).....

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Appendix C - Calculations

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	73.1
Job No:	J24110IS	File:	R9
Project Manager	[redacted]	Subject:	AGB/3 BD21 Assessment
Designer			Luffness Mains Bridge / Aberlady Gullane Branch
Project Group	31400		Section Properties

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

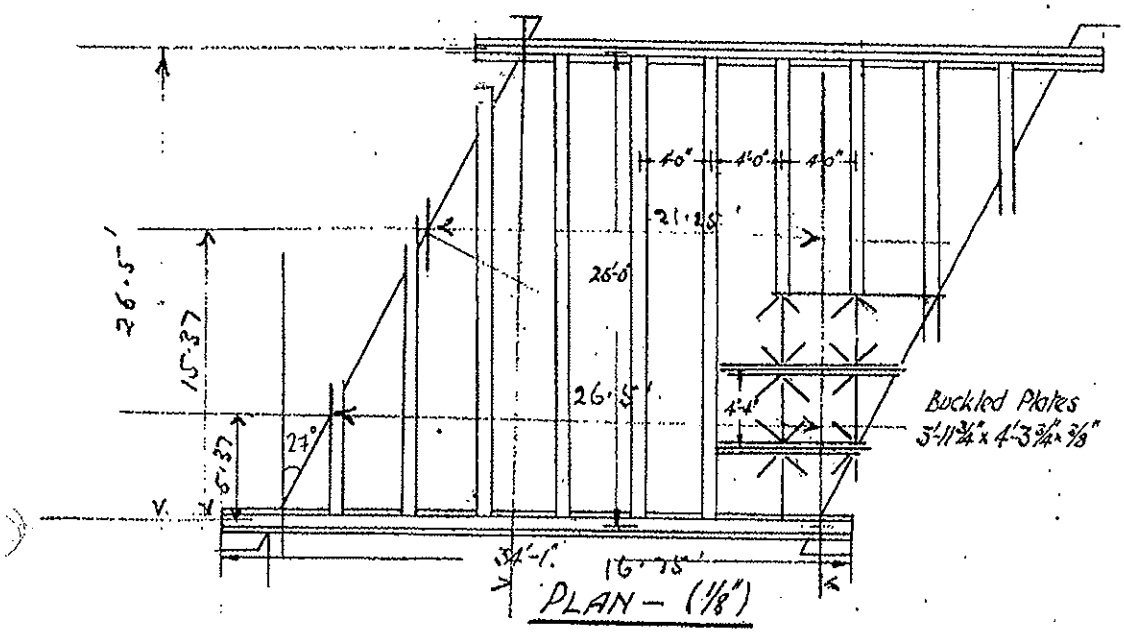
Superseded by Calculation No. Date

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

GULLANE BRANCH

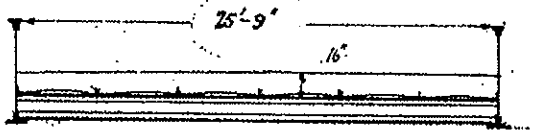
BRIDGE No 3

LUFFNESS MAINS

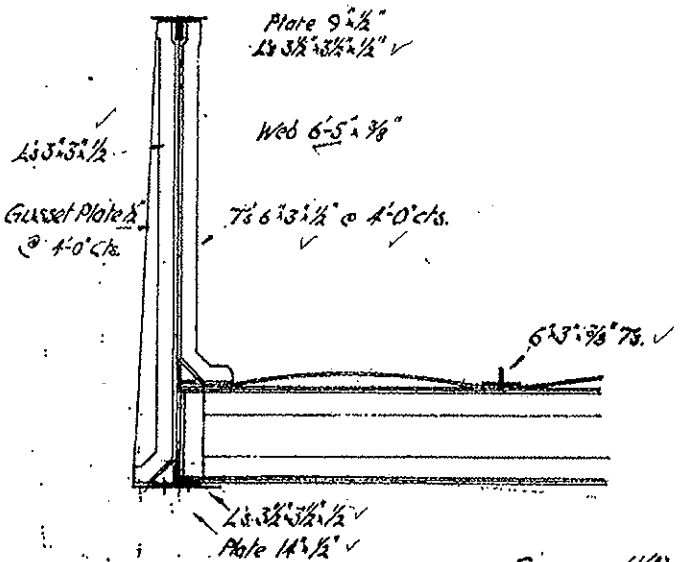


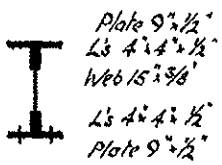
PLAN – (1/8")

2



SECTION – (1/8")





SCALE – (1/2")

Drawings 76/T Store.

¾" Rivets @ 4" Pitch

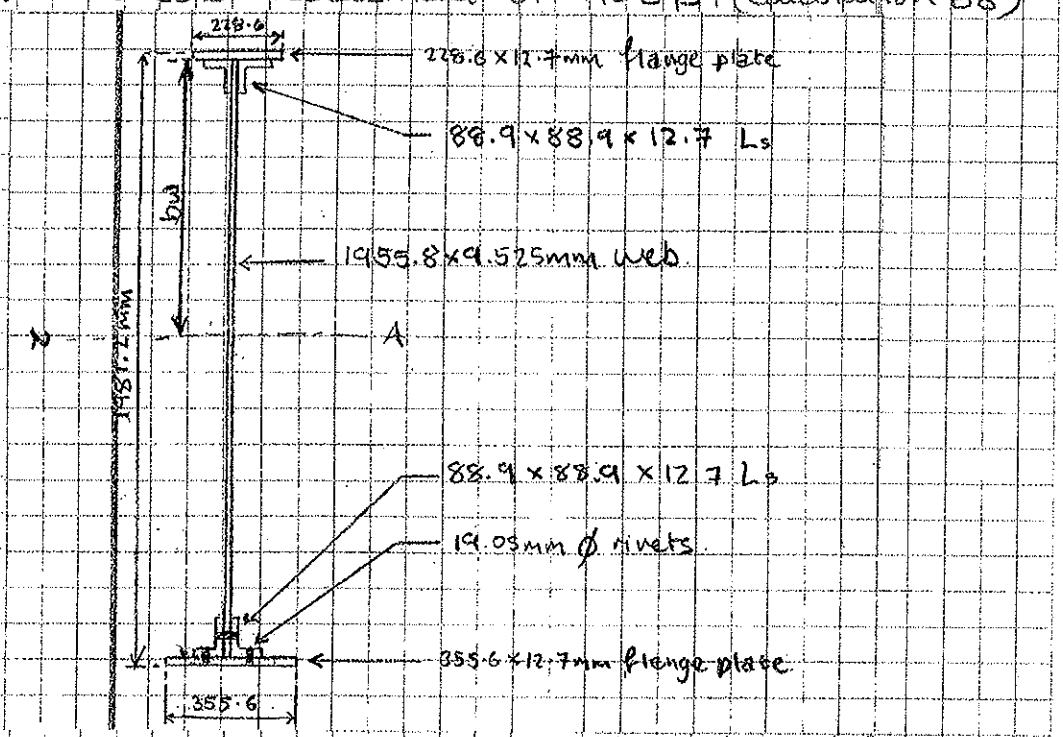
CALCULATION SHEET

JACOBS

Project Title: BRB (Residuary) BD21 Assessments		Sheet No: 1	
Subject: AGB/3 : Section properties.		Calc No: 73.1	
Job No: J24110IS		File: R9	
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06	Checked By:	Date:

Main girders and transverse girder are identical to corresponding girders in AGB/5 (calc No. 68) the angle of skew is slightly increased

- Geometrical and section properties can be obtained from the BE4 assessment of AGB/3 (Calculation 31)
- BD21 loadings and section capacities can be obtained from the BD21 assessment of AGB/5. (Calculation 68)



For detailed derivation of section properties refer to BD21 assessment of AGB/5. Calc 68/ Sht 1. which itself refers to the BE4 calcs for AGB/3 and AGB/5

$A = 32.8 \times 10^3 \text{ mm}^2$ (net) $34.4 \times 10^3 \text{ mm}^2$ (gross)

$\bar{y} = 989.86 \text{ mm}$

Main girder is a non-compact section

$I_{xx} = 1.922 \times 10^{10} \text{ mm}^4$

$Z_{p.e} = 22.86 \times 10^{-6} \text{ mm}^3$

$I_{yy} = 74.8 \times 10^6 \text{ mm}^4$

$Z_{bot} = 19.42 \times 10^6 \text{ mm}^3$

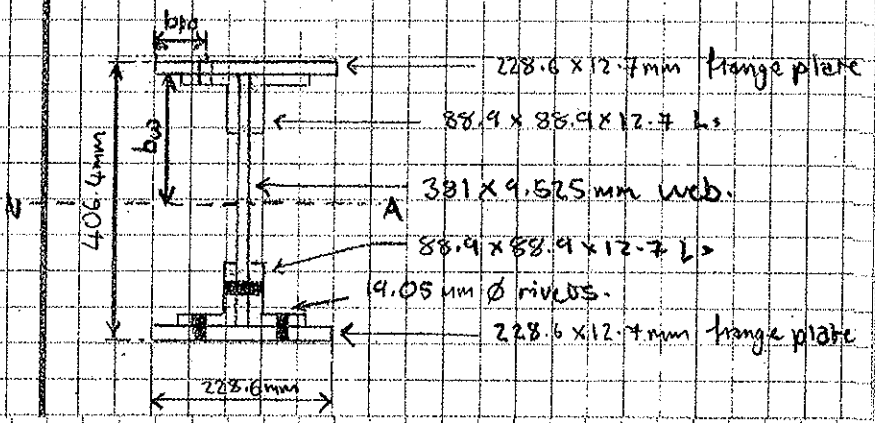
$Z_{top} = 19.39 \times 10^6 \text{ mm}^3$

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 2.	
Subject:		Calc No: 73.1	
Job No:		File:	
Made By: JDC	Date: 04/06	Revised By:	Date:
Checked By: JKR	Date: 6/06	Checked By:	Date:

Transverse girder



See AGB|S calcs Sht 4

$A = 17.5 \times 10^3 \text{ mm}^2$ net $19.1 \times 10^3 \text{ mm}^2$ gross

$\bar{y} = 218.8 \text{ mm}$

$I_{xx} = 476 \times 10^6 \text{ mm}^4$

$I_{xy} = 46.31 \times 10^6 \text{ mm}^4$

$Z_{top} = 2.54 \times 10^6 \text{ mm}^3$

$Z_{bot} = 2.18 \times 10^6 \text{ mm}^3$

Girder is a compact section

$Z_{pc} = 2.667 \times 10^6 \text{ mm}^3$

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	73.2
Job No:	J24110IS	File:	R9
Project Manager	[redacted]	Subject:	AGB/3 BD21 Assessment
Designer			Luffness Mains Bridge / Aberlady Gullane Branch
Project Group	31400		Dead Loads

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	5	[redacted]	Aug-06	[redacted]	Aug-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:	3
Subject: AGB/3 : Dead Loads - transverse girder		Calc No:	73.2
Job No: J24110IS		File:	R9
Made By: [redacted]	Date: 04/06.	Revised By:	Date:
Checked By: [redacted]	Date: 6/06	Checked By:	Date:

Dead loads obtained from AGB/3 BE4 calcs. (31) Shts 10 & 15

self wt of girder = 1.545 kN/m ✓

Macadam = 1.379 kN/m

Fill = 8.949 kN/m

T-section = 0.206 kN

Buckle plate = 0.894 kN/m

Verge = 4.5 kN/m

BD21/01 table 3

Apply $\gamma_f = 1.05$ (girder, Buckle plate, T-section)

$\gamma_f = 1.2$ (fill and verge)

$\gamma_f = 1.75$ (macadam)

Factored dead loads

udl ① = $(1.545 + 0.894) \times 1.05 + 8.949 \times 1.2$ ✓ ✓

① = 13.3 kN/m

udl ② = 1.2×4.5 = 5.4 kN/m

udl ③ = 1.75×1.379 = 2.41 kN/m

PL ① → ⑤ = 0.206×1.05 = 0.216 kN

CALCULATION SHEET

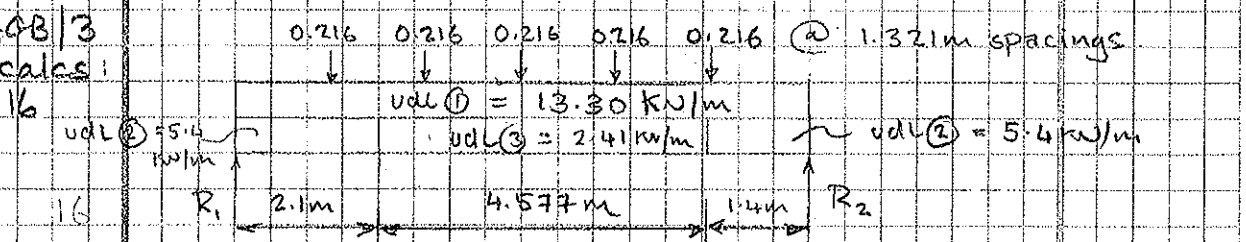
JACOBS

Project Title:		Sheet No: 4	
Subject:		Calc No: 73.2	
Job No:		File:	
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06	Checked By:	Date:

Transverse girders ④ → ⑦

Length of transverse girder = 8.077 m

See ACB/3 BE4 calcs: 31 Sht. 16



Max BM is near mid-span

$$R_1 = 0.216 \times 5/2 + 13.3 \times 8.077/2 + \left(5.4 \times 1.6 \times 1.4/2 + 2.41 \times \left(1.4 + 4.577/2\right) + \left(1.4 + 4.577 + 2.1/2\right) \times 5.4 \times 2.1\right) \div 8.077$$

$$= 54.25 + 11.62$$

$$V = 65.87 \text{ KN} \Rightarrow \text{Max shear}$$

$$M = 71.62 \times \frac{8.077}{2} - 5.4 \times 2.1 \times \left(\frac{8.077}{2} - \frac{2.1}{2}\right) - 13.3 \times 8.077^2/8 - 2.41 \times \frac{\left(\frac{8.077}{2} - 2.1\right)^2}{2} - 0.216 \times (1.321 + 2.642)$$

$$289 - 33.89 - 108.46 - 4.53 - 0.86$$

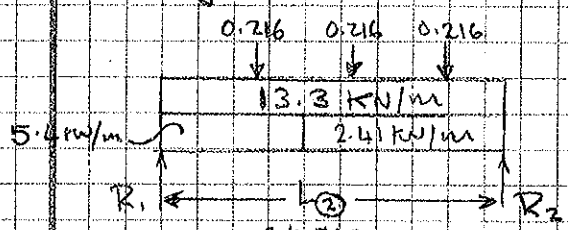
$$M = 11.8 \text{ KN m}$$

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 5	
Subject:		Calc No: 73.2	
Job No:		File:	
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06	Checked By:	Date:

Transverse girder (2)

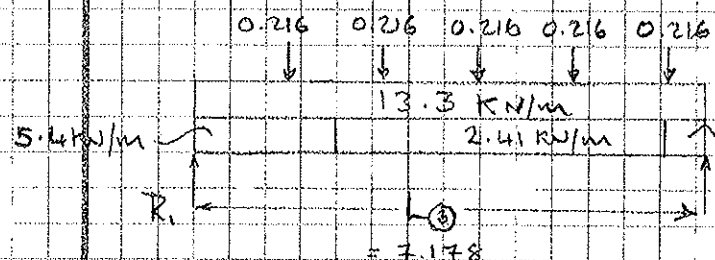


$$R_1 = \left(2.41 \times 2.642^2 \times \tfrac{1}{2} + 5.4 \times 2.1 \times \left(\frac{2.1}{2} + 2.642\right) + 13.3 \times 4.742^2 \times \tfrac{1}{2} + 0.216 \times \left(3 \times 0.779 + 2 \times 1.321\right)\right) \div 4.742$$

$$= \left(8.41 + 41.87 + 150 + 1.075\right) \div 4.742$$

$$= 42.46 \text{ KN}$$

Transverse girder (3)



$$R_1 = 2.41 \times 5.078^2 \times \tfrac{1}{2} + 5.4 \times 2.1 \times \left(\frac{2.1}{2} + 5.078\right) + 13.3 \times 7.178^2 \times \tfrac{1}{2} + 0.216 \times \left(5 \times 0.573 + 4 \times 1.321\right) \div 7.178$$

$$= \left(31.1 + 69.5 + 342.63 + 1.76\right) \div 7.178$$

$$= 62 \text{ KN}$$

CALCULATION SHEET

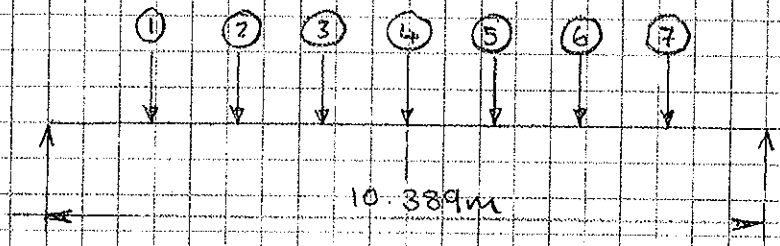
JACOBS

Project Title:		Sheet No: 6	
Subject: AGB/3 . Dead Loads : Main girder & effective length		Calc No: 73.2	
Job No:		File:	
Made By: [redacted]	Date: 04/06.	Revised By:	Date:
Checked By: [redacted]	Date: 6/06.	Checked By:	Date:

length of girder = 34.083 ft = 10.389 m

BD56 9.6.3 effective length = 1.0 x 1.0 x 10.389

= 10.389 m



Transverse girders ① → ③ are reduced in length due to skew

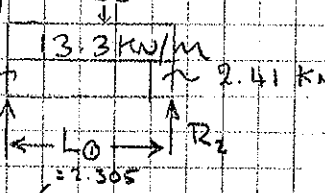
See AGB/3 BE4 calcs:—

31 sht 19 $L_{①}$ = 2.305 m

" " 18 $L_{②}$ = 4.742 m

" " 17 $L_{③}$ = 7.178 m

Transverse girder ①



$$R_1 = \left(2.4 \times 0.205^2 \times \tfrac{1}{2} + 5.4 \times 2.1 \times \left(\tfrac{2.1}{2} + 0.205\right) + 13.3 \times 2.305^2 \times \tfrac{1}{2} + 0.216 \times 0.984\right) / 2.305$$

$$\approx 21.63 \text{ kN}$$

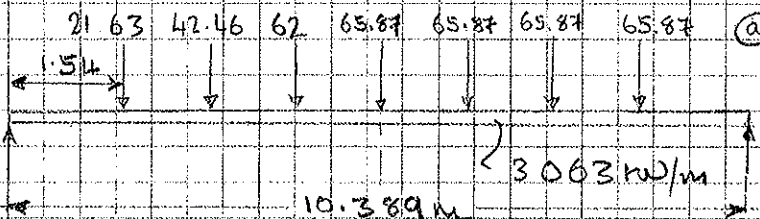
CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 7
Subject: AGB/3 : Dead Load Main girder.			Calc No: 73.2
Job No:			File:
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06	Checked By:	Date:

Main Girder

girder self wt = 2.917 x 1.05 = 3.063 kN/m



R_B = Maximum shear.

3+4+5+6 = 18

$$= \left(21.63 \times 1.54 + 42.46 \times (1.54 + 1.219) + 62 \times (1.54 + 2 \times 1.219) + 65.87 \left(4 \times 1.54 + 18 \times 1.219 \right) + \frac{10.389^2 \times 3.063}{2} \right) \div 10.389$$

$$= \left(33.3 + 117 + 3.978 + 185.1 + 165.3 \right) \div 10.389$$

$V = 209$ kN

point of max moment is close to mid-point

$M = 209 \times 10.389/2 - 65.87 \times 1.219 \times 6$

$M = 604$ kN.m

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	73.3
Job No:	J24110IS	File:	R9
Project Manager	[redacted]	Subject:	AGB/3 BD21 Assessment
Designer			Luffness Mains Bridge / Aberlady Gullane Branch
Project Group	31400		Section Capacites

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	1	[redacted]	Aug-06	[redacted]	Aug-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: 8
Subject: AGB/3 : Section capacities			Calc No: 73.3
Job No: J24110IS			File: R9
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06	Checked By:	Date:

See AGB/5 3D21 calcs for derivation of section capacities.

U-frame action between transverse and main girders provides some restraint to the compression flange on the main girders. Dimensions of U-frame are identical to AGB/5

68.2 sht 11 $M_D = 1824$ kN.m

Shear capacity :

68.2 sht 13 $V_D = 1401$ kN

Transverse girders are restrained by buckle plates as they are in AGB/5 :

68.2 sht 15 $M_D = 464.7$ kN.m

Shear capacity :-

68.2 sht 16 $V_D = 365$ kN

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007		Calc. No.: 73.4
Job No: J24110IS			File: R9
Project Manager	[redacted]	Subject:	AGB/3 BD21 Assessment
Designer			Luffness Mains Bridge / Aberlady Gullane Branch
Project Group	31400		Live Loads

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	3	JDC	Aug-06	JLR	Aug-06				
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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

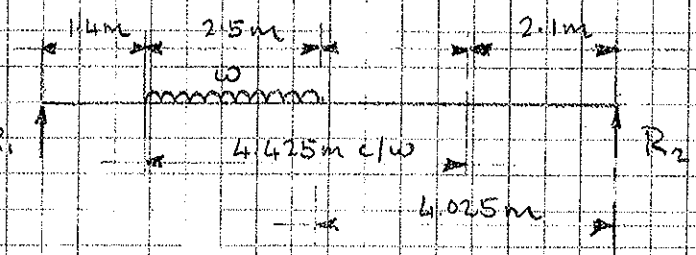
Project Title:		Sheet No: 9	
Subject: AGB/3 : Live loads		Calc No: 73.4	
Job No: J24110IS		File: R9	
Made By: [redacted]	Date: 04/08	Revised By:	Date:
Checked By [redacted]	Date: 6/06	Checked By:	Date:

Carriageway width = 7.925 − 2.1 − 1.4

= 4.425m

BD21 table 5 | Notional lane applied

Notional lane width = 2.5m



$$R_1 = \frac{\omega \times \left(4.025 + \frac{2.5}{2}\right)}{7.925} = 0.67\omega$$

Edge girder 1 takes up to 67% of the load

Loaded length = effective span = 10.389m

HA UDL = $336\left(1/10.389\right)^{0.67}$ = 70.02 kN/m

HA KEL = 120 kN.

Adjustment factor = 3.65/2.5 = 1.46

Adjusted HA load effect (in bending) (factored)

Table 3.1

$$= \left(\frac{70.02 \times 10.389^2}{8} + \frac{120 \times 10.389}{4}\right) \times \frac{1.5}{1.46} \times 0.67$$

= 865 kN.m

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 10	
Subject:		Calc No: 73.4	
Job No:		File:	
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06	Checked By:	Date:

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

$= 865 \times 0.76$

$= 657.4 \text{ kN.m} = M$ ✓

Shear:

Adjusted HA Line load for edge girder 1

$= \left(\frac{70.02 \times 10.389}{2} + 120 \right) \times \frac{1.5}{1.46} \times 0.67$ ✓

$= 333 \text{ kN}$

Bridge specific HA load effect Kel @ support.

$= 333 \times 0.76$

$= 253 \text{ kN} = V$ ✓

CALCULATION SHEET

JACOBS

Project Title:			Sheet No: 11
Subject: AGB / 3 : Live Loads · Transverse girder			Calc No: 73.4
Job No:			File:
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06.	Checked By:	Date:

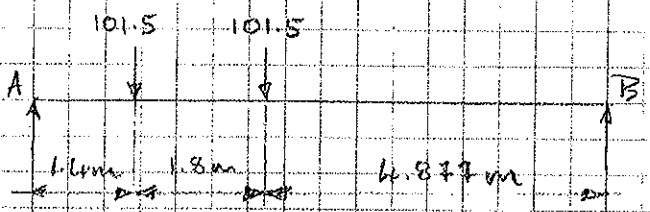
See AGB/5 BD21 scales for derivation of transverse live load effects

As per AGB/5, an 11.5 tonne Critical axle is applied to determine transverse effects

68.4 sht 21 $M = 473.8$ kN.m

Shear:

68.4 sht 21



Shear force V @ A

$= 101.5 \times (4.877 + 6.687) + 8.077$

$V = 145.32$ kN

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007	Calc. No.:	73.5
Job No: J24110IS		File:	R9
Project Manager	[redacted]	Subject:	AGB/3 BD21 Assessment
Designer			Luffness Mains Bridge / Aberlady Gullane Branch
Project Group	31400		Summary, Ratings, Accidental Wheel Loading check

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	4	[redacted]	Aug-06	[redacted]	Aug-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: 12	
Subject:		Calc No: 73.5	
Job No:		File:	
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06	Checked By:	Date:

Summary

Main girder

sht 8	Bending capacity	=	1824	kN.m
sht 7	Dead Load moment	=	604	kN.m
	Live Load capacity	=	1220	kN.m
sht 10	Applied 40t a.l.l	=	657	kN.m
sht 8	shear force capacity	=	1401	kN
sht 7	Dead Load shear	=	209	kN
	Live Load capacity	=	1192	kN
sht 10	Applied 40t a.l.l	=	253	kN

Transverse girder

sht 8	Bending capacity	=	464.7	kN.m
sht 4	Dead Load moment	=	118	kN.m
	Live Load capacity	=	346.7	kN.m
sht 11	Applied 40t a.l.l	=	473.8	kN.m *
sht 8	shear force capacity	=	365	kN
sht 4	Dead Load shear	=	65.9	kN
	Live Load capacity	=	299.1	kN
sht 11	Applied 40t a.l.l	=	145.3	kN

* see next pg for reduced rating.

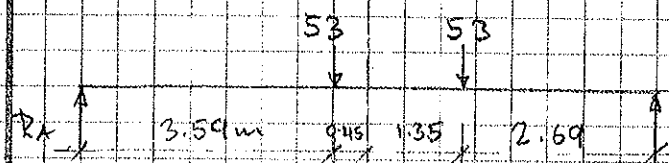
CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 13	
Subject:		Calc No: 735	
Job No:		File:	
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06	Checked By:	Date:

Table D2 — 4.1.1 level of 7.5 tonnes gives max axle load of 6.0 tonnes

68 Sht 22A — Impact axle = $6.0 \times 9.81 \times 1.8 = 106$ kN



$R_A = 53 \times (2.69 + 4.49) \div 8.077 = 47.1$ kN

$M = (47.1 \times 4.04 - 53 \times 0.45) \times 1.5$

$= 250$ kN.m $<$ 346.7 kN.m

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

FE group 2 : Dodge. 7.5 tonnes gross axle wt has a maximum axle weight of 5.08 tonne

∴ passes for FE group 2

CALCULATION SHEET

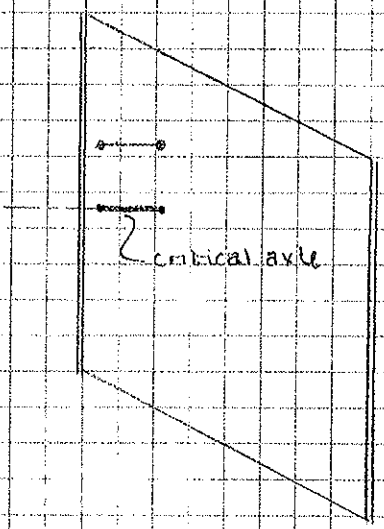
JACOBS

Project Title:		Sheet No: 13a	
Subject: AGB/3 : Accidental wheel check		Calc No: 735	
Job No:		File:	
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06.	Checked By:	Date:

Principal aspects of Accidental Vehicle loading are considered in the addendum to the BD21 AGB/5 calculation (68)

Addendum 68 Sht 1 — % load on Edge girder = 0.837 W

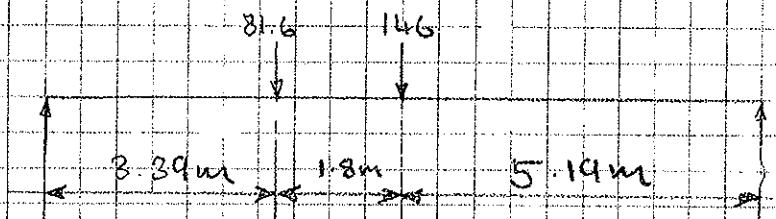
Plan view of axle loads on deck



BD21 Annex D — vehicle 5 with two 10 tonne axles at 1.8m spacings

W = 10 × 9.81 × 0.837 × 1.8 = 146 kN (critical axle)

W = 10 × 9.81 × 0.837 = 81.8 kN



$$M_{mid\text{-}span} = \left(\frac{146 \times 10.389}{4} + \frac{81.6 \times 3.39 \times 6.99}{10.389} \times \frac{5.19}{6.99} \right) \times 1.5$$

Table 3.1

Sht 8 = 776 kN.m < 1824 ∴ ok @ 40 tonnes a 1.1.

CALCULATION SHEET

JACOBS

Project Title:				Sheet No:	13b
Subject: AGB/3 : Accidental wheel loading				Calc No:	73.5
Job No:				File:	
Made By: [redacted]		Date: 06/06	Revised By:		Date:
Checked By:		Date: 6/06	Checked By:		Date:

Shear.

Sht 8

$$V_{support} = \left(146 + 81.1 \times \frac{8.589}{10.389}\right) \times 1.5 = 320\ kN$$

$< 1401\ kN$

For transverse shear accidental wheel loading refer to Addendum 68 sht 2

CALCULATION COVER SHEET

Jacobs
Reading

Project Title:	BRB (Residuary) Ltd - Major Works 2004/2007		Calc. No.: 73.6
Job No: J24110IS			File: R9
Project Manager	[redacted]	Subject:	AGB/3 BD21 Assessment
Designer	[redacted]		Luffness Mains Bridge / Aberlady Gullane Branch
Project Group	31400		Buckle plate and components (rivets and tees)

	Total Sheets	Made by	Date	Checked by	Date	Reviewed by	Date		
Original	6	JDC	Aug-06	JLR	Aug-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

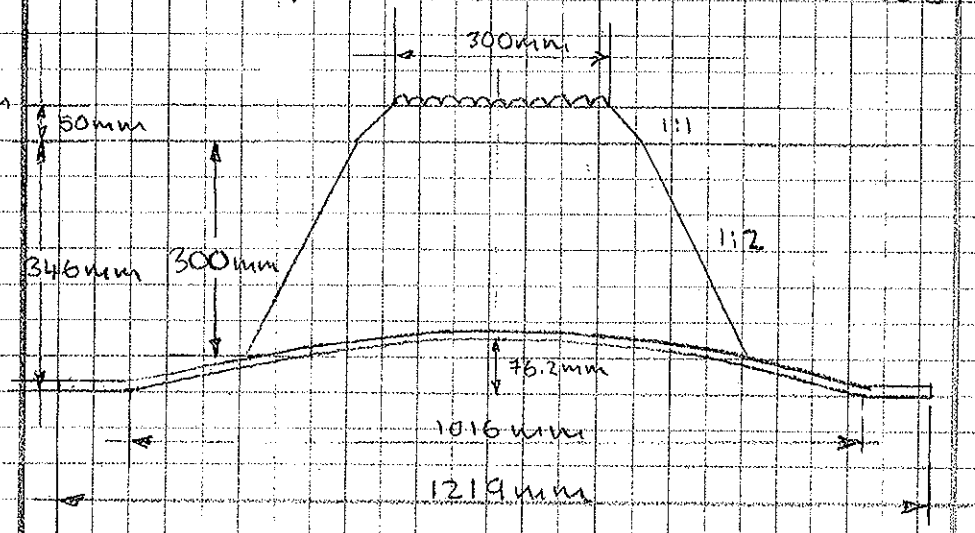
JACOBS

Project Title:			Sheet No: 14
Subject: AGB/3 : Buckle plate check			Calc No: 73.6
Job No: 241101S			File:
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06	Checked By:	Date:

Dimensions of buckle plate are same as AGB/5.

Geometry obtained from BE4 calcs.

calc 31 sht 56



BD21/01 table 5.3.2

Nominal single wheel load = 82 kN

Footprint area = 0.3 × 0.3 = 0.09 m²

Dispersed length = 300 + 100 + 300 = 700mm

Intensity of wheel pressure (+ impact)

$= \frac{82}{0.7^2} \times 1.5 = 251 \text{ kN/m}^2$ ✓

Dead load

calc 31 sht 10 & BD21/01 table 4.1

= 0.346 × 21.20 × 1.2

+ 0.05 × 24. × 1.75 = 10.9 kN/m²

Total (LL + D.L) = 262 kN/m² ✓

CALCULATION SHEET

JACOBS

Project Title:		Sheet No:	15
Subject:		Calc No:	73.6
Job No:		File:	
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By: [redacted]	Date: 6/06.	Checked By:	Date:

BA56 15.2 Assume intensity of wheel pressure at the plate, as occupying the full span of the plate for calculation of thrust

$$\text{Thrust} = \frac{WL^2}{8r} = \frac{262 \times 1.219^2}{8 \times 0.0762}$$

$$= 639 \text{ kN/m} \quad \begin{pmatrix} 26.6 \text{ Dead} \\ 612.4 \text{ Live} \end{pmatrix}$$

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

$$l_e = \frac{1.061 - 0.7}{2} = 0.181 \text{ m}$$

radius of gyration of plate

BD2 sht A2 $r = 0.108 \text{ in} = 2.74 \text{ mm}$

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

BD21 Table 2 $\gamma_m = 1.2$, $\gamma_{fs} = 1.1$

$A_e = A_l = 9.525 \text{ mm}^2/\text{mm}$ width of plate

σ_c

$$\frac{l_e}{r} \sqrt{\frac{\sigma_y}{355}} = \frac{181}{2.74} \sqrt{\frac{230}{355}} = 53.17$$

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 16	
Subject:		Calc No: 13.6	
Job No:		File:	
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By:	Date: 6/06	Checked By:	Date:

$r/x = 2.74/4.76 = 0.576$ ∴ use curve B

fig 37 $\sigma_c/\sigma_y = 0.74$

∴ $\sigma_c = 230 \times 0.74 = 170.2\ N/mm^2$

$P_b = \dfrac{170.2 \times 9525}{1.2 \times 1} = 1228\ N/mm$ width of plate

$= 1228\ kN/m$

$1228 > 639$

∴ Plate is satisfactory for 40 tonnes

CALCULATION SHEET

JACOBS

Project Title:		Sheet No: 17	
Subject: AC83/3 : Buckle plate rivets check		Calc No: 73.6	
Job No:		File:	
Made By: [redacted]	Date: 04/06	Revised By:	Date:
Checked By:	Date: 6/06	Checked By:	Date:

Thrust from plate = 639 kN/m

31 sht 60 rivet spacing = 4" = 0.1016 m

shear on rivet = 639 × 0.1016 = 65 kN

31 sht 61 rivet diameter = 0.019 m

(2.7 Dead, 62.2 Live)

BD56 14.5.3.4

$$\tau = \frac{V}{n A_{eq}} \leq \frac{\sigma_q}{\gamma_m \gamma_{f3} \sqrt{2}}$$

V = 65 kN

n = 1

$A_{eq} = \pi \times 19^2 \times 1/4 = 283.5$

$\sigma_q = 0.85 \sigma_y = 0.85 \times 230 = 195.5 \text{ N/mm}^2$

Assuming hand driven rivets

$$\tau = \frac{65 \times 10^3}{283.5} = 229.3 \text{ N/mm}^2$$

$$\frac{\sigma_q}{\gamma_m \gamma_{f3} \sqrt{2}} = \frac{195.5}{1.1 \times 1.2 \times \sqrt{2}} = 104.73 \text{ N/mm}^2 = 29.85 \text{ kN/rivet}$$

229.3 > 104.73 rivets fail in shear for 40 tonne a.1.1

Max thrust = 104.73 × 283.5 = 29.7 kN/rivet

= 29.7 / 0.1016 = 292.2 kN/m

TOTAL LOAD = 292.2 × 8 × 0.0962 / 1.219^2 = 120

total load − Dead load = 120 − 10.9 = 109.1 kN/m²

Allowable Nominal single wheel loading = 109.1 × 0.7^2 / 1.5 = 35.6 kN

19 kN wheel load for 3 tonne a.1.1 and FE group 2 4 (table 5.4)

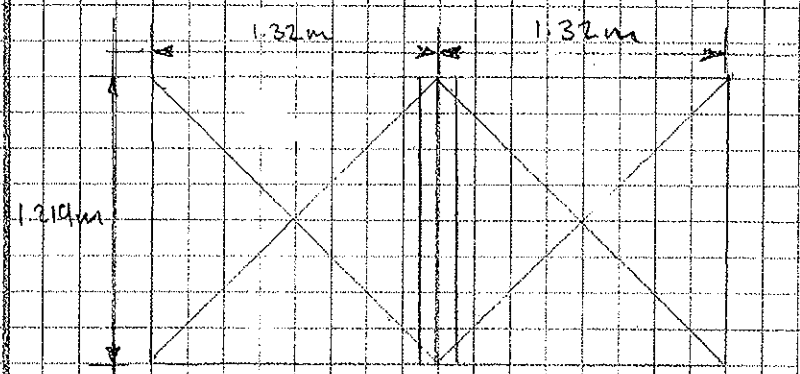
(2.7 Dead, 32.9 Live)

CALCULATION SHEET

JACOBS

Project Title:				Sheet No:	18
Subject:				Calc No:	735
Job No:				File:	
Made By:	[redacted]	Date: 6/06	Revised By:		Date:
Checked By:	[redacted]	Date: 6/06	Checked By:		Date:

Connecting T's



Applied dead load = $10.9 \times \frac{1}{2} \times 1.32 \times 1.219$

= 8.77 kN

68.5 sht 27 self weight = 0.188 kN

Table 5.3.2 wheel load = $1.5 \times 82 = 123$ kN

As UdL $M = \left(\frac{8.77 + 0.188 + 123}{8}\right) \times 1.219$

= 20.11 kN.m (1.36 Dead / 18.75 Live)

Tees are identical to Tees in AGB 15.

68.5 sht 28 M_D = 1.97 kN.m

Moment modification in accordance with Jacobs FE analysis of buckle plates (Nov 05)

revised moment = 20.11/6 = 3.35 kN.m

1.97 < 3.35 ∴ Not OK ⇒ back calculate

CALCULATION SHEET

JACOBS

Project Title:				Sheet No:	19
Subject:				Calc No:	735
Job No:				File:	
Made By: [redacted]	Date: 04/06	Revised By:		Date:	
Checked By: [redacted]	Date: 6/06	Checked By:		Date:	

Max revised moment = 1.97

$M = 6 \times 1.97 = 11.82$ kN.m

Max wheel load $= \frac{11.82 \times 8}{1.219} - 8.77 - 0.188$

$= 68.6$ kN

Table 5.3.2 Max nominal wheel load = 41 kN

3.1.1 of 7.5 tonnes for 41 kN wheel.