

BRB (Residuary) Ltd

Major Works Programme 2009 - 2012

VAR9/3299 ASSESSMENT PROGRAMME

BE4 ASSESSMENT AND INSPECTION REPORT

**Montgreenan, Benslie
North Ayrshire**

BRIDGE REF: DAK/81



October 2011

Project: BRB (Residuary) Ltd
Client: Major Works Programme 2009/2012 Project No: B12360BN
Document title: VAR9/3299 Assessment Programme – BE4 Assessment: DAK/81
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1.1 Introduction

Jacobs was appointed by BRB(R) to conduct the site survey at DAK/81 in sufficient detail to provide data for BE4 assessment work.

Site intrusive investigations were not included within the survey; details regarding hidden elements such as the depth of the arch barrel are to be obtained from available historical information.

1.2 Location and General Description

Bridge DAK/81 carries an unclassified road over the track bed of the former Dalry to Kilmarnock railway line approximately 700m north east of Benslie.

The road is a single carriageway 4.325m wide at the centre of the span. There is a grass verge to the north side of the carriageway, approximately 0.410m wide (Photographs 2 and 3). Refer to the plan at road level in Appendix F for the verge dimensions. Overall width between parapets is 4.725m.

The road is quiet with occasional HGV use.

The OS grid reference is NS341433.

Historical information states the bridge was constructed in 1843.

1.3 Construction type

The bridge is a skewed single span masonry arch overbridge. The clear skew span is 8.995 (32' – 10"), square span is 8.534m giving a skew angle of 19°.

The arch barrel is elliptical constructed from ashlar sandstone blocks.

The arch barrel rise is approximately 1.957m (6' - 5") at midspan and 1.795m (5' – 11") at the quarter points. The thickness of the arch barrel was taken from the available historical information as a minimum of 381mm (15"); refer to historical information in Appendix G.

The arch is supported up on gravity type abutments constructed from large, regularly sized, hammer finished coursed stone blocks. The spandrel walls are also constructed in the type of same stone.

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

2 Existing Information Search

2.1 Services Search

A services search was not required as site intrusive investigations were not within the scope of the survey.

2.2 SI Results

None. Historical information regarding the geometry of hidden elements is included in Appendix G.

2.3 Existing Drawings

A previous Road and Rail Traffic act assessment undertaken in 1938 contains a general arrangement drawing showing details of the bridge, see Appendix G.

3.1 General

The level survey and inspection for BE4 assessment were undertaken on Wednesday 14th September 2011. Weather conditions were wet with a temperature of 11°C.

Parking was available on the northern grass verge, approximately 115m south west of the bridge.

Access to the formation was gained via the embankment to the south east of the bridge.

3.2 Structure condition

3.2.1 Arch Barrel

The arch barrel is generally in fair condition with no distortion of the profile. Two significant longitudinal cracks were observed within the arch barrel. The first towards the north east springing level, 1mm wide x 2000mm long; the second towards the centre of the arch crown, 1mm wide by 1250mm. As the cracks are less than 3mm wide and not in close proximity to each other, the effects of the arch barrel splitting into sections will not be considered. The arch is constructed from ashlar sandstone blocks, a ring factor of 1.4 is considered appropriate for this material (table 3 of BE4). The sandstone blocks are subject to algae and damp staining throughout the arch barrel face (Photograph 4). There are localised areas of water ingress throughout the arch barrel, with the majority of the barrel found to be wet during the inspection.

Intrusive investigations were not included within the survey; archive information suggests a constant arch thickness throughout the structure. The thickness of the arch barrel was taken from the available historical information as a minimum of 381mm (15”), refer to historical information is Appendix G. No details of structural backing material were specified on the drawing.

The carriageway construction over the arch shows no significant settlement or tracking therefore well compacted material will be assumed to make up the arch backing material. A fill factor of 0.7 is conservatively taken (see Table 4 and Note 2 of BE4) for this material.

The joints appear to be well filled, a joint depth factor of 1.0 would normally be applicable; however, widespread areas of damp suggest there is active water ingress through the arch barrel. A depth factor of 0.95 (table 6 of BE4) is taken as a conservative estimate to account for hidden areas of insufficient filling due to mortar washout. The mortar appears to be in fair condition; therefore a mortar factor of 1.0 is appropriate (table 7 of BE4). The joints are less than 6mm wide, giving a width factor of 1.0 (table of 5 BE4).

With two significant cracks noted and no signs of spandrel separation, a general condition factor of 0.8 is considered appropriate.

3.2.2 Abutments

Both abutments appear to be in fair condition, the lower southern corners of the abutment faces are concealed by the embankment slope of the infilled south formation. The remaining exposed area of the east abutment face is subject to damp staining, originating from the water ingress from the arch barrel (Photograph 5). The east abutment face was found to be wet at time of inspection. The remaining exposed area of the west abutment is subject to algae staining and minor open joints throughout (Photograph 6).

3.2.3 Spandrels

Both the north and south spandrel walls appear to be in fair condition, with minor spalling to the edges of the stringcourses (Photographs 7, 8, 11 and 12). There is a sapling growing from the south string course, towards the west pilaster (Photograph 12). No associated defects or signs of movement were noted during the inspection.

3.2.4 Wingwalls

The north east wingwall appears to be in fair condition, the embankment in front of the north east wingwall is largely overgrown with vegetation. No associated defects or signs of movement were noted during the inspection (Photograph 9).

The north west wingwall is in fair condition with minor spalling and mortar loss throughout the lower areas. There are two areas of deep spalling to the wingwall, approximately 1000mm x 1000mm x 200mm deep and 1500mm x 1000mm x 150mm deep (Photograph 10).

Both the south east and south west wing walls appear to be in good condition. There are a number of large trees growing close to the base of the south east wing wall. No associated defects or signs of movement were noted during the inspection (Photograph 13). There are localised areas of mortar loss to the lower areas of the south west wing wall, and minor spalling to the string course (Photograph 14).

3.2.5 Parapets

The parapets are in fair condition. They are constructed from regular courses of large hammer dressed stone blocks with large masonry copings. Both parapets are subject to widespread areas of loose mortar and open joints throughout all faces. There are a number of localised areas where brick repairs have been made to the parapets; the repairs appear to have been originally faced in mortar however the mortar has largely spalled away.

Evidence of vehicle impact damage was observed towards the midpan area of the southern parapet. Two blocks of the external course appear to be displaced out of plane. One block was noted as missing from the north elevation of the southern parapet (Photographs 15 and 16). The mortar within the affected area was found to be loose with the adjacent block work unsecured at the time of inspection.

3.2.6 Formation

The formation to the south of the bridge has been infilled and the ground level raised by about 1.650m with the land used to form the rear of a local resident's garden. To the north, the formation has become overgrown with vegetation. The infill on the south side slopes steeply down under the bridge. There is a low fence at the along the centre line of the bridge at the base of the slope.

3.2.7 Road surface

The road surface is in good condition with some areas of superficial wear (Photographs 2 and 3). The vertical alignment of the road is such that the humped profile restricts the vision of oncoming traffic.

4 Assessment to BE4

4.1 Methodology

The following table summarises the condition/modifying factors that were applied in the MEXE analysis in accordance with BE4: Part III. The factors represent the general condition of the elements of the structure.

Description	Modifying Factor
Ring Factor, F_r	1.4
Fill Factor, F_f	0.7
Width of Joint factor, F_w	1.0
Depth Factor, F_d	0.95
Mortar Factor, F_m	1.0
General condition factor of bridge, F_{cm}	0.8

Table 1: Factors used for MEXE analysis

4.2 Results

4.2.1 MEXE analysis

Element: **Arch barrel (MEXE assessment)**

Arch span	Modified axle load	BE4 assessment result
Skew span 8.995m	15 tons	Pass

The minimum modified axle load obtained from the MEXE analysis was 15 tons. A rating of more than 9 tons means that the bridge has sufficient capacity to carry a tandem 9 ton axle load and is therefore unrestricted for all vehicles complying with construction and use Reg. (1967).

Element: **Substructure**

By qualitative assessment, the sub structure appears to be satisfactory for Full C&U loading. The defects observed are considered in significant and pose minimal structural implications to substructure elements.

The arch of this structure has sufficient capacity for full BE4 loading as determined by this MEXE assessment. A rating in excess of the required tandem 9 ton axles is indicated.

Assignment of a general condition factor for the assessment is somewhat subjective and has a large influence on the result. Within this assessment the effects of the arch barrel splitting into sections were not considered due to the size and locations of the two longitudinal cracks. If the two cracks are found to be active and deteriorate over time, these effects should be accounted for via a reduction in the general condition factor. A significant reduction of the condition factor may lead to the necessity of mitigation/repair works. The condition of the two longitudinal cracks in the arch barrel should be monitored as part of all future inspection works.

It is recommended that repair works are carried out throughout both parapets. Where possible the displaced blocks are to be realigned, with all areas of loose mortar being repointed securing all block work within the parapet. Damaged block work is to be replaced with brickwork repairs similar to those noted during the inspection. Existing brick repairs should be re-faced where the mortar is seen to have spalled away.

If parapet repair works are proposed, it may be beneficial to incorporate minor vegetation removal and re-pointing to the substructure and arch barrel respectively as part of the same works.

Consideration should be given to brickwork patch repair works to the north west wingwall. These works are considered desirable rather than necessary as the current condition of the wingwall poses no immediate cause for concern. In general, the substructure does not give cause for concern and has sufficient capacity for BE4 loading by qualitative assessment. The condition of all substructure elements should continue to be monitored as part of future inspection works.

Appendix A Photographs



Photo 1 – North Elevation



Photo 2 – View over bridge looking east



Photo 3 – View over bridge looking west



Photo 4 – Arch barrel (looking east)



Photo 5 – East Abutment



Photo 6 – West Abutment



Photo 7 – North spandrel wall and pilaster (east)



Photo 8 – North spandrel wall and pilaster (west)



Photo 9 – North east wingwall



Photo 10 – North west wingwall



Photo 11 – South spandrel wall and pilaster (east)



Photo 12 – South spandrel wall and pilaster (west)



Photo 13 – South east wingwall



Photo 14 – South west wingwall



Photo 15 – Vehicle impact to north elevation of south parapet



Photo 16 – Two blocks displaced out of plane with south elevation of south parapet due to vehicle impact

Appendix B Services Search

A services search was not required as intrusive site investigations were not within the scope of the survey.

Appendix C Trial Pit Log

Intrusive site investigations were not included within the survey; historical information regarding geometry of hidden elements included in Appendix G.

Appendix D Form AA

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

ELR/ Bridge No DAK/81

Appendix: 4

Issue: 1

Revision: B (Nov 2000)

APPROVAL IN PRINCIPLE FOR ASSESSMENT**Bridge/Line Name: Montgreenan, Benslie / Dalry to Kilmarnock****ELR/Bridge No. DAK/81****Brief Description of Existing Bridge:****(a) Span Arrangement**

The bridge is a skewed single span masonry arch overbridge. The clear skew span is 8.995 (32' - 10"), square span is 8.534m giving a skew angle of 19°.

(b) Superstructure Type

The arch barrel is elliptical constructed from ashlar sandstone blocks. The rise is approximately 1.957m (6' - 5") at midspan and 1.795m (5' - 11") at the quarter points. The thickness of the arch barrel was taken from the available historical information as a minimum of 381mm (15"); refer to historical information in Appendix G.

(c) Substructure Type

The arch is supported up on gravity type abutments constructed from large, regularly sized, hammer finished coursed stone blocks. The spandrel walls are also constructed in the same type of stone.

(d) Planned highway works/modifications at this site

None

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

Bridge DAK/81 carries an unclassified road over the track bed of the former Dalry to Kilmarnock railway line approximately 700m north east of Benslie. The road is a single carriageway 4.325m wide at the centre of the span. There is a grass verge to the north side of the carriageway, approximately 0.410m wide. Overall width between parapets is 4.725m. The road is quiet with occasional HGV use.

(f) Any other requirements

None

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

ELR/ Bridge No DAK/81

Appendix: 4

Issue: 1

Revision: B (Nov 2000)

APPROVAL IN PRINCIPLE FOR ASSESSMENT**Assessment Criteria**

(a) Loadings and Speed

Dimensions and condition factors are obtained from site measurements and inspection. (See Jacobs report "VAR9-3299 Assessment Programme – Assessment and Inspection Report – Bridge Ref.: DAK/81" – October 2011). The final allowable axle load obtained by calculation will be compared to the 9 ton axle load permitted by BE4.

(b) Codes to be used

BE4 - "The Assessment of Highway Bridges for Construction and Use Vehicles" Ministry of Transport, 1967 (with amendments to 1969).

(c) Proposed Method of Structural Analysis

It is proposed to use the modified MEXE method of assessment as outlined in Part III of BE4.

The following factors are proposed indicating the condition of the arch for the MEXE assessment:

Ring factor	F_r	1.4
Fill Factor	F_f	0.7
(Joint) width factor	F_w	1.0
(Joint) depth factor	F_d	0.95
Mortar factor	F_m	1.0
Condition factor	F_{cm}	0.8

The substructure will be assessed qualitatively.

FORM 'AA' (BRIDGES)

GC/TP0356

ELR/ Bridge No DAK/81

Appendix: 4

Issue: 1

Revision: B (Nov 2000)

APPROVAL IN PRINCIPLE FOR ASSESSMENT

Senior Civil Engineer's Comments

None

.....
.....
.....
.....
.....

Proposed Category for Independent Check 1

Superstructure 1

Substructure 1

Name of Checker suggested if Cat 2 or 3 ... Not Applicable

Category 1

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

Signed [Redacted]
[Redacted]
[Redacted]

Category 2 and 3

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

Signed
Title
Date

Signed
Title
Date

Appendix E Form BA

FORM 'BA' (BRIDGES)

GC/TP0356

ELR/ Bridge No DAK/81

Appendix: 4

Issue: 1

Revision: A (Dec 2005)

CERTIFICATION FOR ASSESSMENT CHECK

Assessment Group: Jacobs Engineering UK Ltd

Bridge/Line Name: Montgreenan, Benslie/ Dalry to Kilmarnock

Category of Check: 1

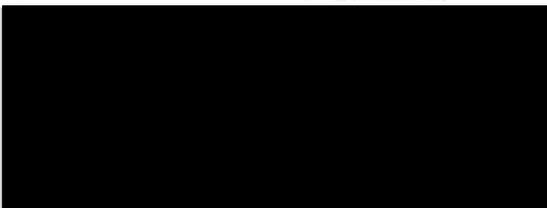
ELR/ Bridge No: DAK/81

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 principles recorded in the accompanying Form AA.
- (2) It has been checked for compliance with the following principal British Standards, Codes of Practice, BRB (Residuary) Limited technical notes and Assessment standards:
 - BE4 - "The Assessment of Highway Bridges for Construction and Use Vehicles" Ministry of Transport, 1967 (with amendments to 1969).

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

None

Category 1NameSignatureDate

.....18/10/11..... Assessor

.....18/10/11..... Assessment Checker

.....20.10.11.....
 Authorised signatory of the
 firm of Consulting
 Engineers to whom
 Assessor/Checker is
 responsible.

FORM 'BA' (BRIDGES)

GC/TP0356

ELR/ Bridge No DAK/81

Appendix: 4

Issue: 1

Revision: A (Dec 2005)

CERTIFICATION FOR ASSESSMENT CHECK

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

(a) Assessment

<u>Name</u>	<u>Signature</u>	<u>Date</u>	
.....	Assessor
.....	Assessment Checker
.....	Authorised signatory of the firm of Consulting Engineers to whom Assessor/Checker is responsible.

(b) Check

<u>Name</u>	<u>Signature</u>	<u>Date</u>	
.....	Assessor
.....	Assessment Checker
.....	Authorised signatory of the firm of Consulting Engineers to whom Assessor/Checker is responsible.

This Certificate is accepted by.....

..... 8

..... 14:09:30

..... +01'00'

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

ELR/ Bridge No DAK/81

Appendix: 4

Issue: 1

Revision: A (Dec 2005)

CERTIFICATION FOR ASSESSMENT CHECK**Notification of Assessment Check**

Assessment Group	Jacobs Engineering UK Ltd
Bridge Name/Road No.	Montgreenan, Benslie/ Unclassified Road
Line Name	Dalry to Kilmarnock
ELR Code/Structure No.	DAK/81

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

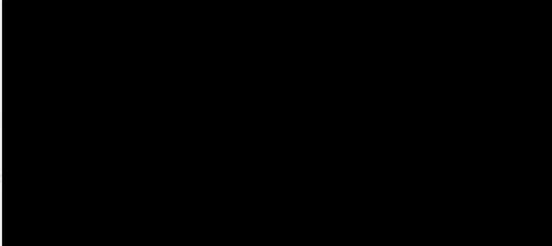
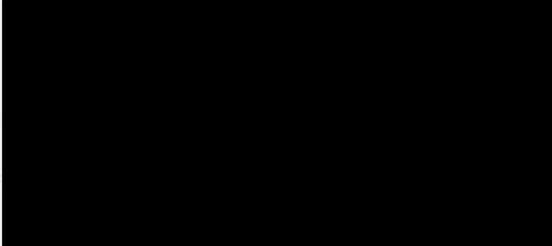
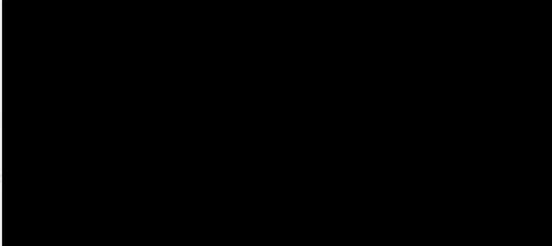
Masonry arch (MEXE)	Full C&U vehicle loading to BE4 – tandem 9 ton axles.
Substructure:	Full C&U loading by qualitative assessment.

Recommended Loading Restrictions

None

Description of Structural Deficiencies and Recommended Strengthening

The bridge is in fair condition and requires little maintenance other than re-pointing works to the arch barrel face to prevent future water ingress.

<u>Name</u>	<u>Signature</u>	<u>Date</u>	
		18/10/11.....	Assessor
		18/10/11.....	Assessment Checker
		18-10-11.....	Authorised signatory of the firm of Consulting Engineers to whom Assessor/Checker is responsible.

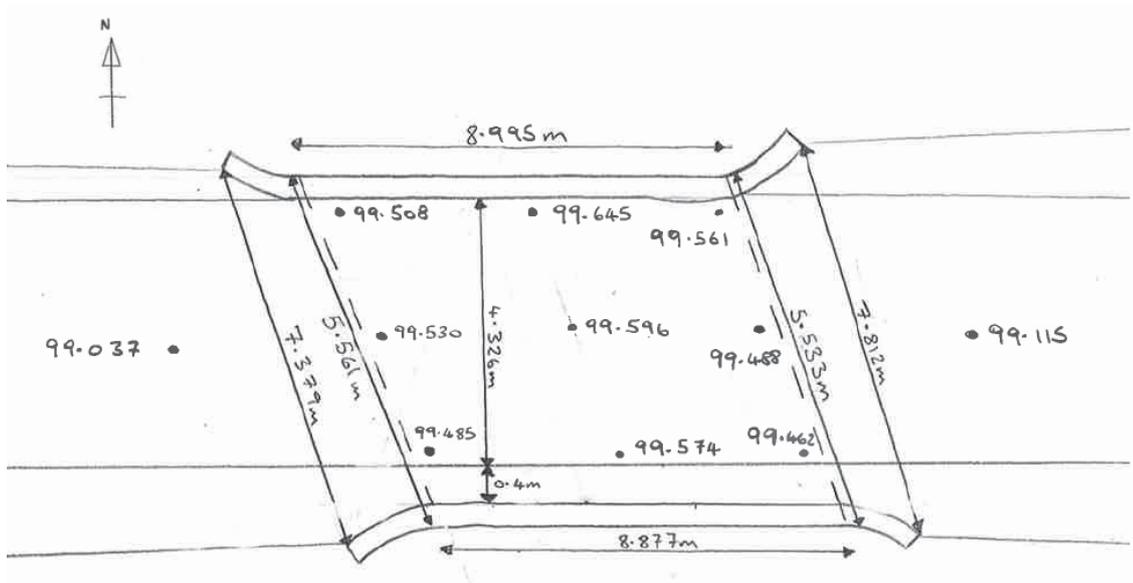
This Certificate is accepted by 

2011.10.28

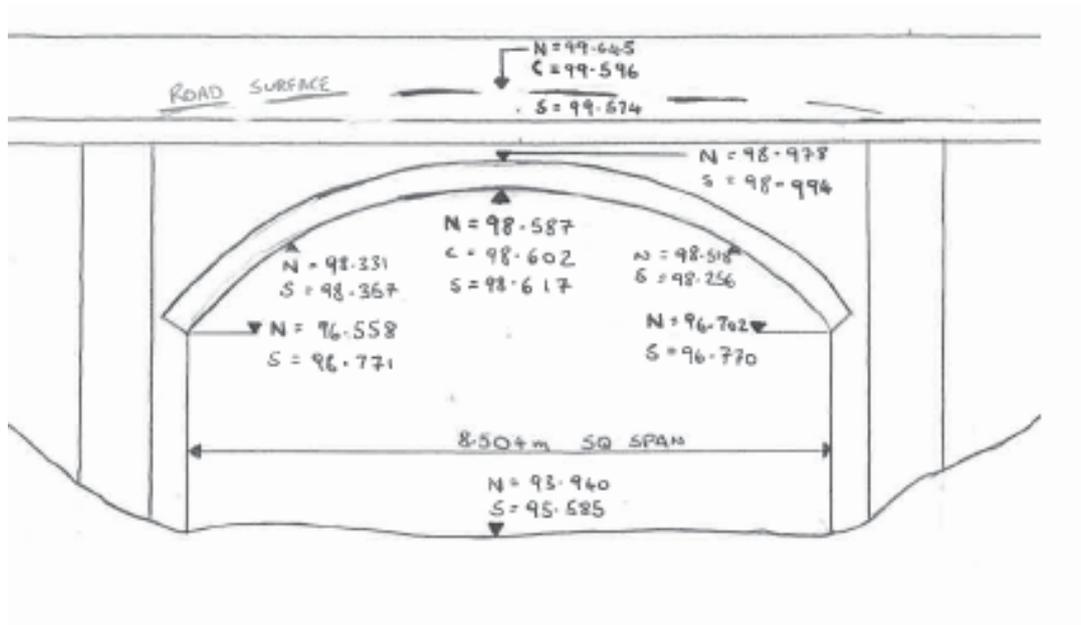
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Appendix F Calculations



Plan at road level

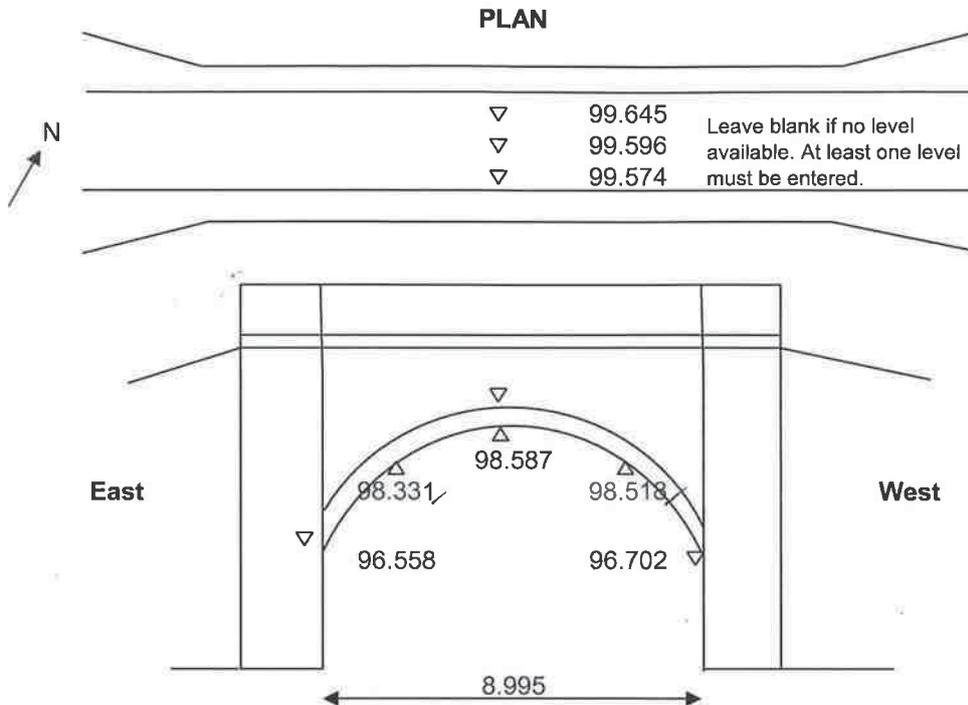


North elevation

CALCULATION SHEET

JACOBS

Project Title : BRB (Residuary) Ltd - 2010/11 assessment programme		Sheet No :	1
Subject : DAK/81		Calc No :	
Job No : B12360BN		File :	
Made by :	[REDACTED]	Date : 18/10/2011	Revised by :
Checked by :	[REDACTED]	Date : 18/10/11	Checked by :



Dimensions taken from site measurements / Desk study

Span	L =	8.995 m
Rise of arch barrel at crown	rc =	1.957 m
Rise of arch barrel at 1/4 pts	rq =	1.795 m
Thickness of arch barrel adjacent to keystone	d =	0.381 m
Av depth of fill bet. road surface & arch barrel at crown	h =	0.6370 m

Notes: North face of bridge
 The thickness of the arch barrel was taken from historical information as of 381mm (15")
 Arch is elliptical.

The factors represent the general condition of the soffit of the arch.

Note:-All measurements are in metres.

Structure Ref DAK/81

Assessment of Masonry Arch by the Modified MEXE Method

Span L (m) 8.995
 Rise of arch barrel at crown r_c (m) 1.957
 Rise of arch barrel at 1/4 pts r_q (m) 1.795
 Thickness of arch barrel adjacent to keystone d (m) 0.381
 Av depth of fill between road surface & arch barrel at crown h (m) 0.637

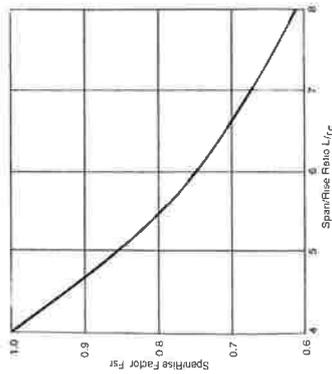


Fig 7

PAL 44.108852
 PAL **44.1089**

Span/Rise Ratio 4.5963
 Span/Rise factor F_{sr} 0.9061366

Profile factor F_p 0.51676
 Profile factor F_p **0.5167558**

Barrel factor Fr 1.4
 Fill factor Ft 0.7

Material Factor F_m **0.96**

Width factor F_w 1

Depth Factor F_d 0.95

Mortar factor F_m 1

Joint Factor F_j **0.95**

Condition factor F_{cm} 0.8 ✓

Span factor due to pier flexibility 1.000

MODIFIED AXLE LOAD **15.10**
 (formula = F_{sr} · F_p · F_m · F_j · F_{cm} · PAL)

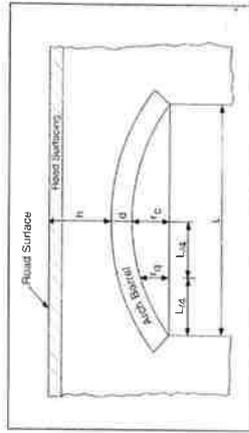


Figure 3/2 Arch Dimensions

(max = 70)
 (formula = (740[d+h]²)/L³)

(4 or less = span/rise factor = 1)

(Max = 1)
 (formula = 2.3[(r_c - r_q)/r_c]^{0.6})

(table 3 BE4)
 (table 4 BE4)

(formula = [(fr · d) + (ft · h)] / (d + h))

(table 5 BE4)

(table 6 BE4)

(table 7 BE4)

(formula = F_w · F_d · F_m)

(0 = poor, 1 = good condition)

Prep

Check

Table 3

Granite, whinstone and built-in-course masonry, with large shaped voussoirs	Fr	1.5
Concrete or engineering bricks		1.2
Limestone, good random masonry and building bricks in good condition		1.0
Masonry of (any kind) or brickwork in poor condition (many voussoirs flaking or badly		0.7

Table 4

Concrete slab or saddle	Ft	1.0
Grouted materials (other than those with clay content)		0.9
Well compacted materials		0.7
Weak materials evidenced by tracking of the carriageway surface		0.5

Table 5

Joint with widths up to 6mm	Fw	1.0
Joints with widths between 6mm and 12.5mm		0.9
Joints with widths over 12.5mm		0.8

Table 6

Pointed joints in good condition	Fd	1.0
unpointed joints, pointing in poor condition and joints with up to 0.5in from edge insufficiently		0.9
Joints with from 0.5in to 1 tenth of the thickness of the ring insufficiently filled		0.8
Joints insufficiently	AI	Engineer's

Table 7

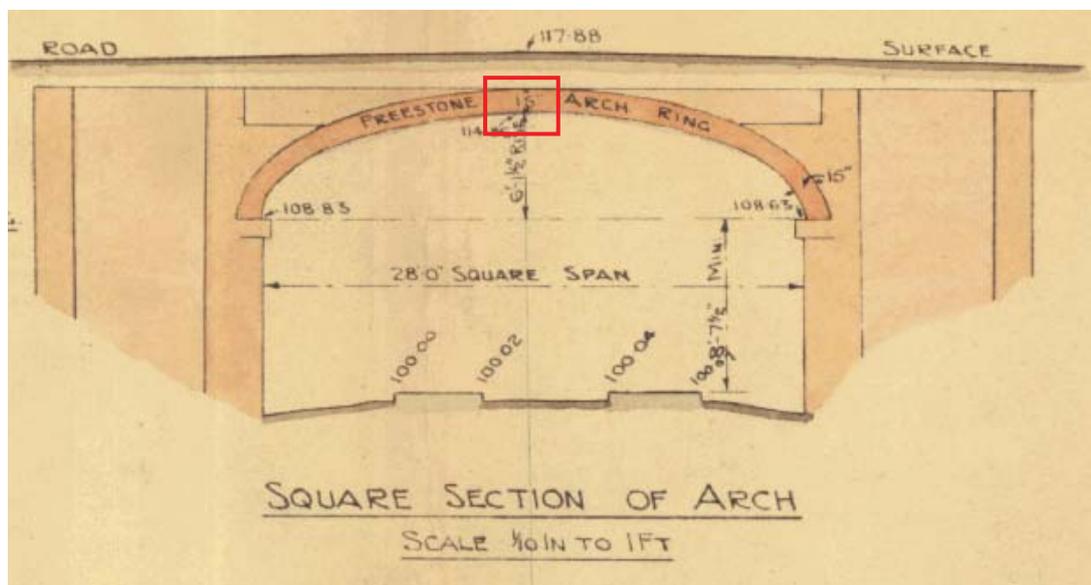
Mortar in good condition	Fm	1.0
Loose or friable mortar		0.9

Span factor (from RTICE/CIH's Section 5.2.5.9)

Arch supported on one abutment and one pier		0.9
Arch supported on two piers		0.8
Arch supported on abutments or two massive type piers		1.0

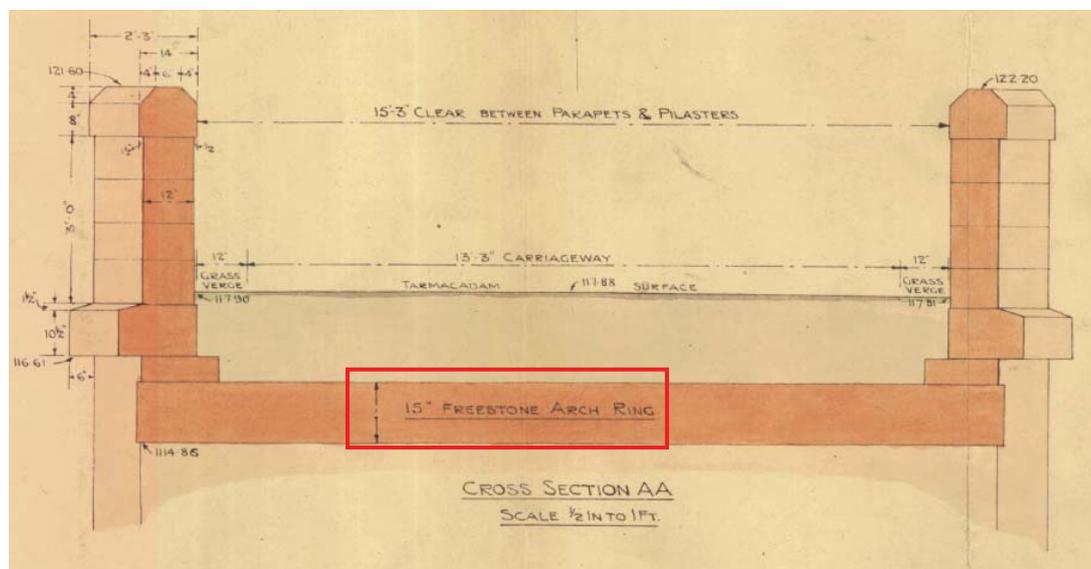
According to Part III (Assessment of masonry and brick arch bridges-clause 2) a rating of >9 Tons means that the bridge is capable carrying vehicles with tandem 9 ton axes, and since a such bridge is also capable of carrying vehicles with a single 11 ton axle, it follows that the arch bridge with final assessment of >9 Tons is unrestricted for all vehicles complying with Construction and Use Regulations (1967) issue.

Appendix G Historical Information



Elevation

Taken from general arrangement within 'Road and Rail Traffic act' assessment undertaken in 1937



Cross Section

Taken from general arrangement within 'Road and Rail Traffic act' assessment undertaken in 1938