LIMITSTATE ASSESSMENT REPORT

LS-EX/26
Revision A
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Finchingfield (No. 26)

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Summary

Essex bridge no. 26 (Finchingfield) has been assessed **not** to have the capacity to carry 40/44 tonne vehicles in accordance with BD21/01 (2001). It has been found that the bridge is capable of carrying a maximum gross vehicle weight of 10 tonnes.

Contents

Appendix

1 Introduction

Essex bridge no. 26 (Finchingfield) comprises a 330mm thick brickwork arch overlain by a 110mm thick layer of fill and surfacing at the crown. The clear square span is 4300mm with crown rise of 1226mm.

A 40mm thick steel plate lies beneath the carriageway surfacing at the crown.

A concrete bridge widening has been constructed on the downstream side of the bridge; this is not assessed here.

2 Assessment

2.1 Scope of work

The bridge has has been assessed using LimitState:RING 2.0, a software application designed to predict the ultimate load carrying capacity of masonry arch bridges. However, certain features of the bridge mean that LimitState:RING 2.0 is likely to underestimate the load carrying capacity. A preliminary analysis has also been undertaken using LimitState:GEO 2.0. Unlike conventional limit analysis models which have been applied to masonry arch bridges, LimitState:GEO 2.0 is capable of explicitly modelling both the masonry, surrounding backfill material and features such as steel plates and reinforced concrete slabs.

The adequacy of the parapets has not been considered as part of this assessment.

The detailed principles of assessment are set out in the document 'Principles of Assessment for Essex Masonry Arch Bridges' (LimitState Ltd 2009).

2.1.1 Application of limit analysis to the assessment of arch bridges

As stresses in short span bridges tend generally to be comparatively low, such bridges will typically fail in a mechanism involving predominantly rigid body rotations and/or translations; other modes of failure (e.g. 'elastic snap-through') are less likely to occur. Additionally, in the case of short span bridges, foreseeable live loadings will normally be relatively large in comparison to structural self-weight. For these two reasons the limit analysis method is likely to be suitable for analysing such bridges.

2.2 Materials, geometry and loading

2.2.1 Parameters used in the analysis

Unless otherwise stated, the (generally conservative) values listed in Table 1 have been used throughout the assessment.

Note that in the case of bridges with soil backfill it has been found to be inappropriate to use

Parameter	Value	Units	Reference
Road surface			
Internal angle of friction	45	°	LimitState Ltd (2009)
Unit weight	20	kN/m^3	LimitState Ltd (2009)
Thickness: lesser of 250mm and crown fill depth			LimitState Ltd (2009)
Loaded length	0.3	m	BD21/01 (2001) Cl.6.11
Masonry			
Compressive strength	2.3	N/mm^2	BD21/01 (2001), assuming London stocks bricks and lime mortar
Coefficient of friction	0.6		BS5628:2001 (2001)
Brick unit weight	20	kN/m^3	LimitState Ltd (2009)
Masonry backing			
As masonry			
Clay backfill			
Peak cohesion	30	kPa	LimitState Ltd (2009)
Peak angle of friction	0	°	LimitState Ltd (2009)
Fill unit weight	18	kN/m^3	LimitState Ltd (2009)
Steel plate			
Yield stress	250	N/mm^2	Assumed (see LimitState Ltd 2009)
Plastic moment of resistance	100	kNm/m	Calculated
Mobilized soil strength multiplier			
Active	1.0		
Passive (LimitState:RING 2.0)	Software defaults		Passive side properties calculated by software using built-in default values, see LimitState Ltd (2008a).
Passive (LimitState:GEO 2.0)	0.45 × peak soil strength		LimitState Ltd (2009)
Soil-masonry interfaces*			
1/3 of peak soil strength			LimitState Ltd (2009)
Soil-plate interfaces			
1/3 of peak soil strength			Assumed

* In LimitState:RING 2.0 the default properties are used, which are: friction multiplier on ϕ = 0.66, adhesion multiplier on c = 0.5

Table 1: Material properties used in the assessment of Finchingfield bridge (26)

peak soil strengths directly in the analysis as this would lead to significantly over-estimated bridge load carrying capacities. Therefore, for the assessment of this bridge, a passive side mobilization factor has been applied (see LimitState Ltd (2009) and LimitState Ltd (2008b))

2.2.2 Arch and road profiles

A concrete bridge widening has been added to the downstream (southern) side of the bridge; this has not been assessed. The nature of the joint between the two sections cannot be verified, therefore the bridge was analysed in two cases. The first case assumed the two sections act independently of each other whilst the second assumed full load distribution of live load through the joint.

Drawing BR0026/P03 shows an elevation detailing the brickwork arch geometry. Notes discuss the north east corner of the bridge and associate this with penetrometer tests F and C. Using this information, and drawing BR0026/P02, it was determined that BR0026/P03 represents the upstream (north) face.

Four arch section profiles were provided (drawing BR0026/P03). When entered into LimitState:RING 2.0 these suggest that the bridge may possess a slightly asymmetric profile. Photographs of the site are inconclusive but it is possible that this may be the case. For the purposes of this assessment, a single arch profile was generated by taking the average rise at each point and the resulting asymmetric geometry was used without modification.

Drawing BR0026/P03 indicates that the bridge either possesses an arch barrel of variable thick-

ness, or alternatively contains an arch barrel of uniform thickness with backing in the haunch regions. For the purposes of assessment the latter scenario was assumed, with the barrel thickness assumed to be constant at 330mm and with the backing thickness scaled from the drawings.

Notes indicate that the arch barrel includes headers interconnecting the constituent brickwork rings; this is confirmed by photographs. Notes also state that there is no evidence of ring separation; therefore none was taken into consideration during the assessment.

It was not possible to tie in the road levels given on drawing BR0026/P02 with the arch geometry; therefore they were scaled from the drawing. Road levels were determined by averaging the level readings provided both on the bridge and immediately to either side. Beyond these points the slope of the road was extrapolated.

The vertical road profile is slightly humped over the bridge (as indicated by the level readings and photographs of the carriageway). However axle lift-off was not considered during the assessment.

Photographs and the plan of the site (drawing BR0026/P02) suggest that the road may exhibit some horizontal curvature in the vicinity of the bridge. However, there are no notes explicitly stating this in the site investigation data and, therefore, centrifugal effects were not taken into consideration during the assessment.

Figure 1 shows the arch and road profiles; all dimensions are in mm and were taken or derived from survey drawings BR026/P02 and BR026/P03. These dimensions were used in all analyses.

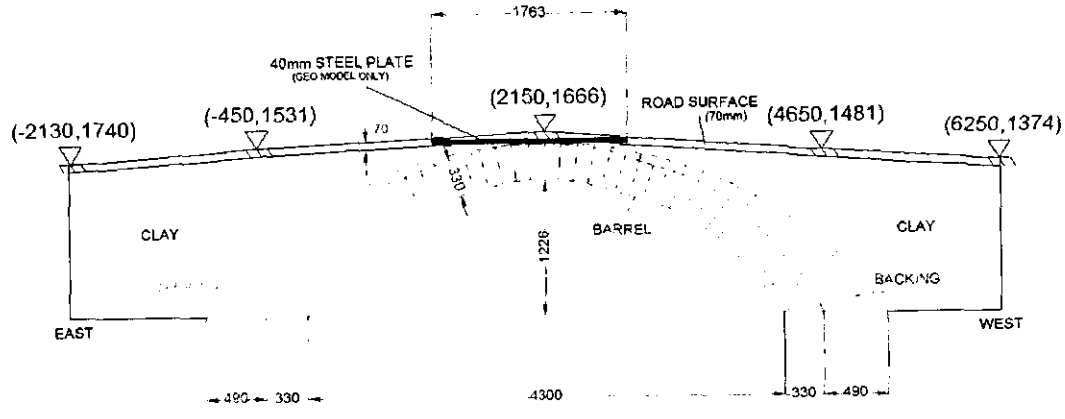


Figure 1: Geometry of Finchingfield bridge (26)

2.2.3 *Condition of the arch*

Brick core samples indicate that the arch consists of soft red bricks with lime mortar in good condition. Hammer tests show some areas of poor compaction on the north-east corner, however this was neglected for the purposes of assessment.

2.2.4 Steel plate

Drawing BR0026/P03 and notes taken during the site investigation indicate the presence of a steel plate over the crown of the arch. The thickness of the plate was measured at 40mm; however the extents of the plate were not determined.

2.2.5 Backfill and water conditions

Except in the case of relatively shallow arches, the restraint offered by fill material behind an arch can lead to very significant increases in carrying capacity. The problem lies in determining, for the purposes of analysis, what level of restraint is likely to be available.

This assessment is based on the bridge as investigated and in particular:

- is dependent on extrapolating the soil profile from trial pits, penetrometer tests and samples taken where applicable.
- assumes water levels at or below springing level. Specifically it excludes the potentially deleterious effect of high water levels.

Data was available from 12 penetrometer tests and 4 samples extracted through holes cored through the arch. The samples indicated a gravelly sandy clay. In the absence of any other data, it was assumed that the backfill material comprises mainly of clay. The penetrometer data indicated a weak material consistent with clay on the east side of the arch, with somewhat stronger material on the west side. A 'default' low-strength clay material (cohesion = 30kPa) was therefore used for the purposes of assessment (see Table 1).

2.2.6 Ring separation

Although a small area of 'poor compaction' was noted during the site investigation, no evidence of ring separation was found during the inspection. Hence this was not taken into account in the analyses.

2.2.7 Horizontal backfill pressures and 'backing'

Site investigation data indicates that there is a significant amount of backing behind the arch barrel. Backing was therefore taken into account in the assessment using dimensions taken from drawing BR0026/P03. The backing was assumed to possess the same masonry / joint material properties as the arch (see Table 1). It was not possible to determine whether the arch barrel and backing are capable of acting in a composite manner.

2.3 LimitState:RING 2.0 Analysis

2.3.1 Assumptions made for the purposes of assessment

1. All analyses were carried out in accordance with the guidelines set out in LimitState Ltd (2009) and the points identified by Mouchel (Appendix A).
2. In a statement issued by Mouchel, no ring separation was evident within the arch barrel, therefore none was taken into account (Appendix A).
3. Details given on drawings BR0026/P02 and P03 and photographs of the site were used to construct the geometry of this bridge for modelling (Figure 1). The arch profile was determined using an average of the four section profiles detailed in BR0026/P03.
4. Photographs and notes indicate that the arch barrel comprises header and stretcher bonded brickwork. This was considered as a single ring of masonry with a total thickness of 330mm. For numerical efficiency reasons the total number of masonry units in the arch barrel was taken as 40. This is likely to have a negligible effect on the accuracy of the solution obtained.
5. The two sections of the bridge (original and concrete extension) were considered to act independently of each other. Only the masonry arch is considered here.
6. Brickwork backing was included in the model using dimensions taken from drawing BR0026/P03 and material properties described in Table 1. This was either ignored or assumed to act compositely with the arch barrel in the assessment.
7. Road levels were determined by averaging the north, centerline and south readings provided in drawing BR0026/P02. The positions of the readings were scaled from the same drawing.
8. The road profile over the bridge is humped; however axle lift-off was not considered during this assessment.
9. The upstream bridge span (4300mm) was used in all calculations.
10. The carriageway width is reported (drawing BR0026/P02) as being 3820mm. This was assumed to provide a single lane (photographs suggest this to be the case).
11. In line with guidance set out in LimitState Ltd (2009) it was assumed that, where appropriate, the top 250mm of fill comprises of road surfacing in place of any other backfill material (i.e. the total depth of fill was not altered).
12. The backfill material below the road surface was assumed to be clay with a cohesion of 30kPa (see Table 1).
13. Following advice from Mouchel, the bridge was not assessed under flood conditions. Under such conditions the load carrying capacity of the bridge is likely to be significantly reduced.
14. Due to insufficient modelling capabilities, the steel plate was not considered during the LimitState:RING 2.0 analysis.

2.3.2 Loading Case Considered and Conversion to an Allowable Axle Loading

It has been found that the single axle loading given in BD21/01 (2001) represents the most critical loading case for short span bridges. Thus for this analysis only the single axle loading case has been considered.

LimitState:RING 2.0 has been used to determine a 'failure load factor' for the bridge. An 11.5 tonne single axle load, together with an appropriate bridge width and BD21/01 (2001) impact and axle load factors were applied. A failure load factor above 1.0 therefore indicates that the bridge is able to withstand the loading from a 40 / 44 tonne vehicle in accordance with BD21/01 (2001).

2.3.3 Analysis R1 - no backing, no load distribution between bridge sections

As it was not possible to determine whether the arch barrel and backing are capable of acting in a composite manner, an initial analysis was conducted neglecting backing material altogether.

A series of 40 load cases was considered, moving from the east to the west side of the bridge. Results from the analyses are plotted as a graph of failure load factor against load position in Figure 2.

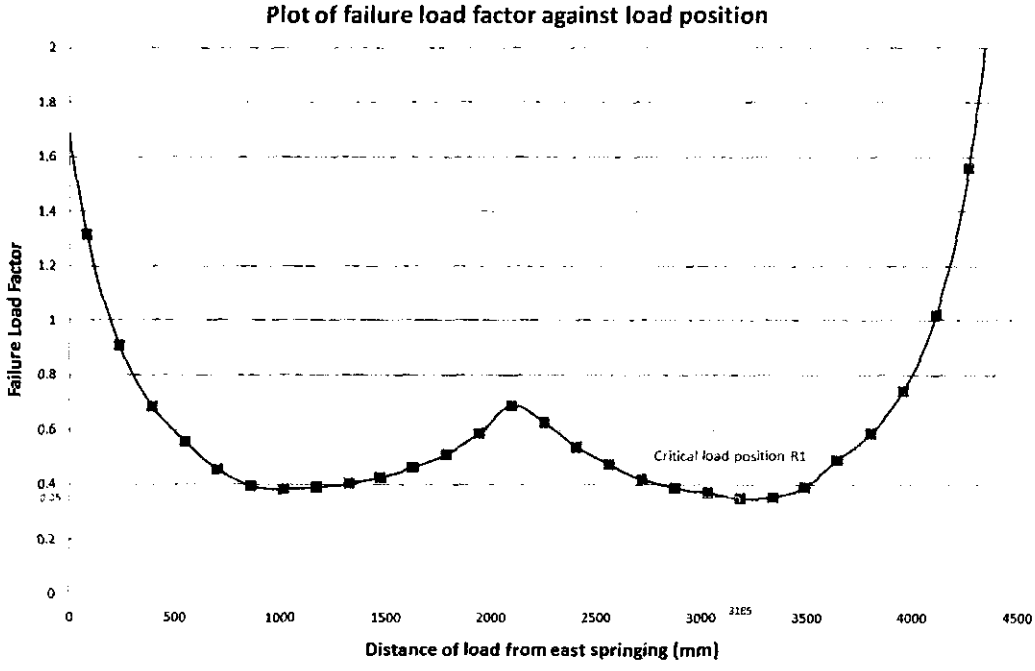


Figure 2: Plot of failure load factor against load position for Finchingfield bridge (26) as identified by LimitState:RING 2.0 (Analysis R1 - no backing).

The critical load position was found to be at 3.19m from the east springing, with the effective bridge width (2.06m) being governed by the case of a wheel over the joint between the two bridge sections. The computed failure load factor was found to be 0.35, which corresponds to a failure load of 39.5kN/m and a maximum gross vehicle carrying capacity of 3 tonnes according to BD21/01 (2001).

For details of the calculations see Appendix B. A full report output from the LimitState:RING 2.0 analysis is given in Appendix C.

2.3.4 Analysis R1 - Critical failure mechanism

Figure 3 shows the critical loading position and corresponding failure mechanism for Analysis R1:

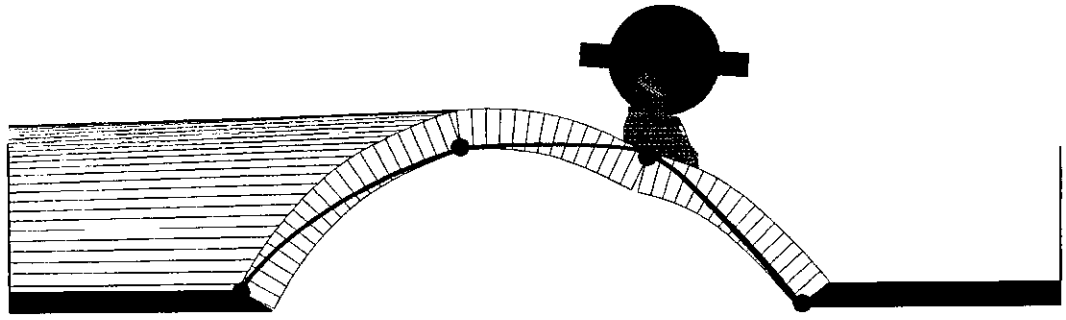


Figure 3: Failure mechanism for Finchingfield bridge (26) as identified by LimitState:RING 2.0 (no backing, maximum gross vehicle carrying capacity = 3 tonnes).

2.3.5 Analysis R1 - Comments

The bridge was found to have insufficient capacity to carry 40 / 44 tonne vehicles when conservatively assuming that no backing was present. A second analysis was performed to investigate whether the presence of composite (bonded) backing significantly increased the load carrying capacity and this is reported in the next section.

2.3.6 Analysis R2 - composite backing, no load distribution between bridge sections

A series of 40 load cases was again considered, moving from the east to the west side of the bridge. Results from these analyses are plotted as a graph of failure load factor against load position in Figure 4 (Analysis R1 results are also plotted for comparison).

The critical load position was found to be at 3.38m from the east springing, with the effective bridge width (2.04m) again being governed by the case of a wheel over the join between the two bridge sections. The computed failure load factor was found to be 0.68, which corresponds to a failure load of 76.7kN/m and a maximum gross vehicle carrying capacity of 10 tonnes in accordance with BD21/01 (2001).

For details of the calculations see Appendix B. A full report output from the LimitState:RING 2.0 analysis is given in Appendix C.

2.3.7 Analysis R2 - Critical failure mechanism

Figure 5 shows the critical loading position and corresponding failure mechanism for Analysis R2. This involves four hinges and is very similar to the mechanism identified in R1.

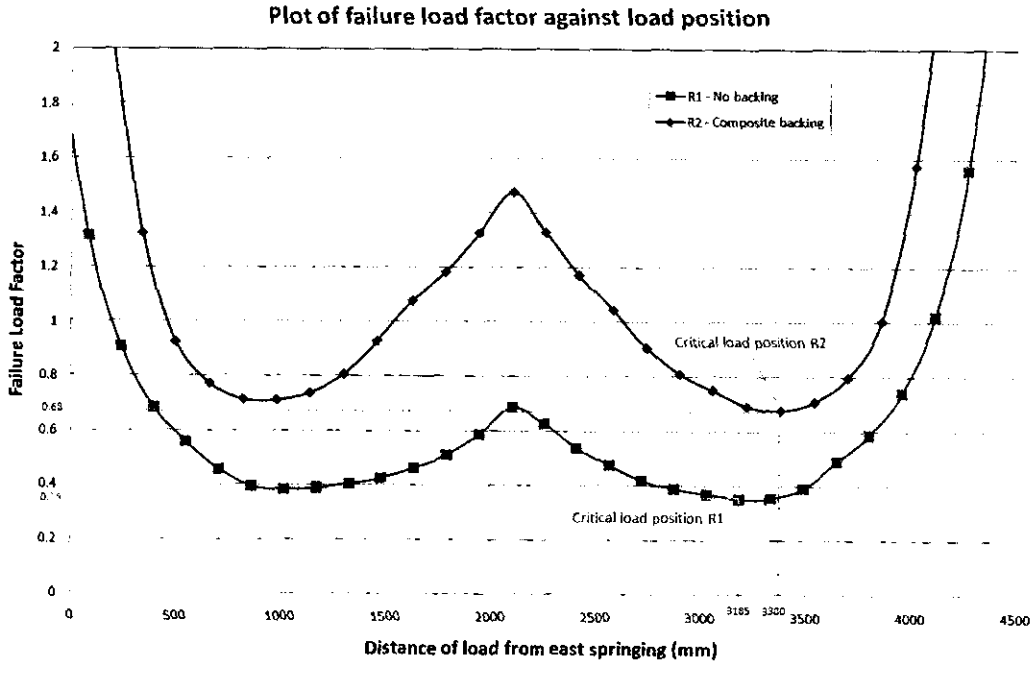


Figure 4: Plot of failure load factor against load position for Finchingfield bridge (26) as identified by LimitState:RING 2.0 (Analyses R1 & R2).

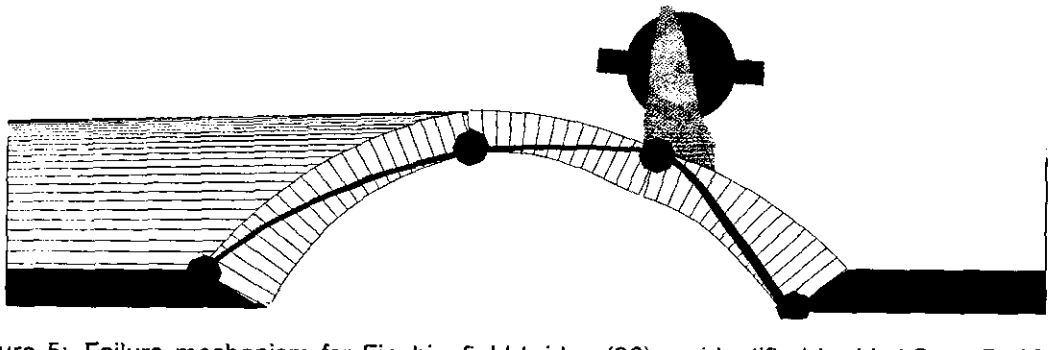


Figure 5: Failure mechanism for Finchingfield bridge (26) as identified by LimitState:RING 2.0 (composite backing, maximum gross vehicle carrying capacity = 10 tonnes).

2.3.8 Analysis R2 - Comments

The bridge was found to be able to carry 10 tonne vehicles in accordance with BD21/01 (2001). However, the amount of load distribution that can in reality occur across the joint between the original arch barrel and extension is unclear. A third analysis was therefore performed to investigate whether assuming full distribution of live load across the joint could significantly increase the computed load carrying capacity. This is reported in the next section.

2.3.9 Analysis R3 - composite backing, full load distribution across joint between bridge sections

A series of 40 load cases was again considered, moving from the east to the west side of the bridge. Results from these analyses are plotted as a graph of failure load factor against load position in Figure 6 (Analysis R1 & R2 results are also plotted for comparison).

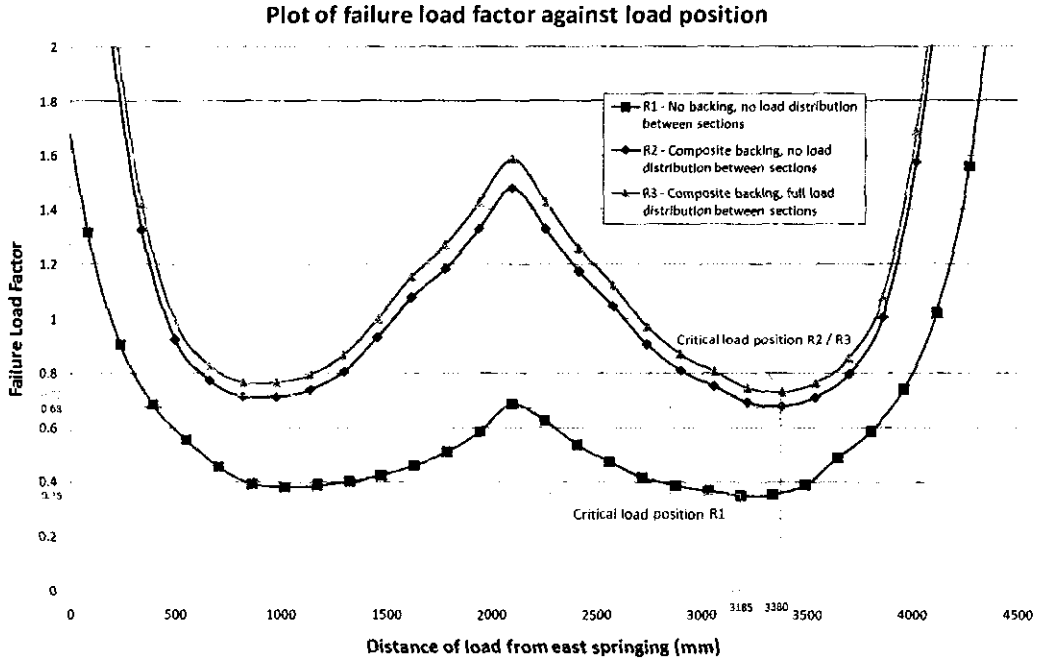


Figure 6: Plot of failure load factor against load position for Finchingfield bridge (26) as identified by LimitState:RING 2.0 (Analyses R1, R2 and R3).

The critical load position was found to be at 3.38m from the east springing, with the effective bridge width (2.19m) being governed by the case of a wheel near to the west parapet. The computed failure load factor was found to be 0.73, which corresponds to a failure load of 82.3kN/m and a maximum gross vehicle carrying capacity of 10 tonnes according to BD21/01 (2001).

For details of the calculations see Appendix B. A full report output from the LimitState:RING 2.0 analysis is given in Appendix C.

2.3.10 Analysis R3 - Critical failure mechanism

Figure 7 shows the critical loading position and corresponding failure mechanism for Analysis R2. This involves four hinges and is very similar to the mechanism identified in R1.

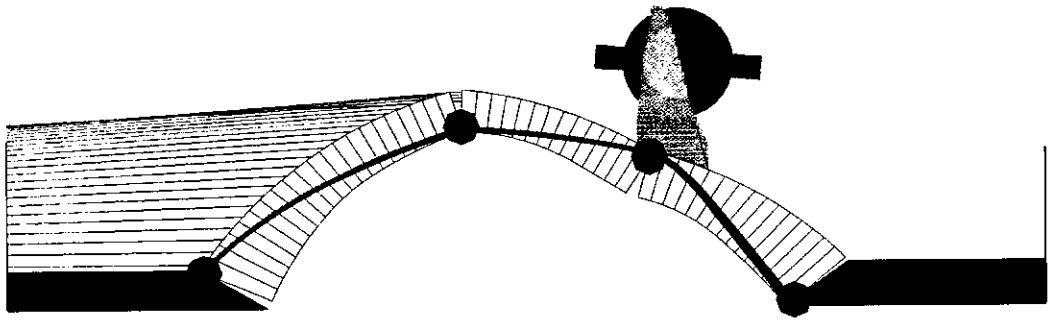


Figure 7: Failure mechanism for Finchingfield bridge (26) as identified by LimitState:RING 2.0 (composite backing, full distribution of live load across joint between arch and extension, maximum gross vehicle carrying capacity = 10 tonnes).

2.3.11 Analysis R3 - Comments

The effective width corresponding to the case of a wheel next to the west parapet (2.19m) was found to be governing in this analysis. This value is only marginally higher than that corresponding to a wheel over the joint between the two bridge sections (2.04m) which is critical in analysis R2. For this reason, there is minimal increase in the calculated load carrying capacity when assuming full distribution of live load across the joint.

3 Comments

The bridge was found to have a capacity of 10 tonnes when analysed using LimitState:RING 2.0, assuming composite action between the arch barrel and backing material (as implied in the drawings supplied, which show an arch barrel of varying thickness).

A preliminary LimitState:GEO 2.0 analysis was also conducted to more accurately determine the effects of the near-traffic surface steel plate. It was found that, although the capacity of the bridge increased when loading was applied directly above the plate, it was still low in other areas. i.e. the analyses confirmed that this bridge is not capable of carrying 40 / 44 tonne vehicles at this time.

4 Conclusions

Bridge No. 26 (Finchingfield) has been assessed to **not** be capable of carrying 40/44 tonne vehicles at this time. It was found that a maximum load of 10 tonnes can be carried assuming

that the arch barrel and backing act compositely (or equivalently, that the arch barrel has variable thickness and has no 'ring separation').

5 Recommendations

The bridge has been found to be capable of carrying 10 tonne vehicles at this time.

Confirmation that the arch barrel and backing act compositely should be sought, and, if so, imposition of a weight restriction of 10 tonnes should be considered (if composite action is absent then imposition of a weight restriction of 3 tonnes should be considered).

Consideration should also be given to strengthening or renewal of the bridge. If strengthening options are pursued, the following points should be clarified:

- The extents of the steel plate, both longitudinally and transversely across the bridge.
- Whether there is any horizontal radius of curvature of the road over the bridge.

It should be borne in mind that the humped profile of the road surface over the bridge is likely to rule out placement of a near-surface load relieving concrete slab. There may, however, be scope to dig out and replace the backfill material.

6 References

BD21/01 2001 *DMRB Volume 3 Section 4 Part 3 - BD 21/01 - The Assessment of Highway Bridges and Structures*. Highways Agency.

BS5628:2001 2001 *BS5628:2001 Code of practice for use of masonry. Materials and components, design and workmanship*. British Standards Institute.

LimitState Ltd 2008a *LimitState:RING Program Reference Guide, Version 2.0j Edition*, LimitState Ltd, Sheffield, UK.

LimitState Ltd 2008b *LimitState:RING Theory And Modelling Guide, Version 2.0j Edition*, Sheffield, UK.

LimitState Ltd 2009 *Principles of Assessment for Essex Masonry Arch Bridges*, Sheffield, UK.

Appendix A Notes on the Assessment of ECC masonry arch bridges

In a letter from Mouchel dated 10/09/03, the following points regarding the assessments of Essex County Council bridges were made:

1. There are no as built drawings for most of the Essex County Council Bridges to be assessed. Therefore, the drawings provided by Mouchel are based on observational evidence obtained during the bridge inspection only.
2. There are no conclusive details of the bridge abutments, (though coring through some bridge abutments did take place).
3. Ring separation should be ignored during the analyses unless specifically mentioned by Mouchel on the drawings provided.
4. The bridges are regularly maintained, therefore, it is not necessary to make allowances for weakness in the bridges due to lack of maintenance.

Disclaimer

All dimensions and material data used in this assessment have been supplied by Mouchel. Limit-State Ltd has not been involved in any intrusive investigations and therefore takes no responsibility for the accuracy of these values.

Appendix B Calculations

Bridge Geometry

Span	4300	mm	Sq. Span	4300	mm	Skew	0.0 degrees
Width	4385	mm					
Ring thickness	330	mm					
Carriageway width	3.82	m					
Radius of curvature	0.00	m	(Centrifugal effects not present)				

Arch Barrel Intrados Profile

Section	X	A	B	C	D	E	F	G	Y
1	0	660	980	1160	1230	1140	970	630	0
2	0	630	970	1150	1240	1140	960	630	0
3	0	660	990	1180	1240	1160	980	620	0
4	0	630	980	1140	1195	1140	960	630	0
Average	0	645	980	1158	1226	1145	968	628	0
x	0	538	1075	1613	2150	2688	3225	3763	4300

Use average profile for purposes of assessment.

Depth of Fill Above Crown

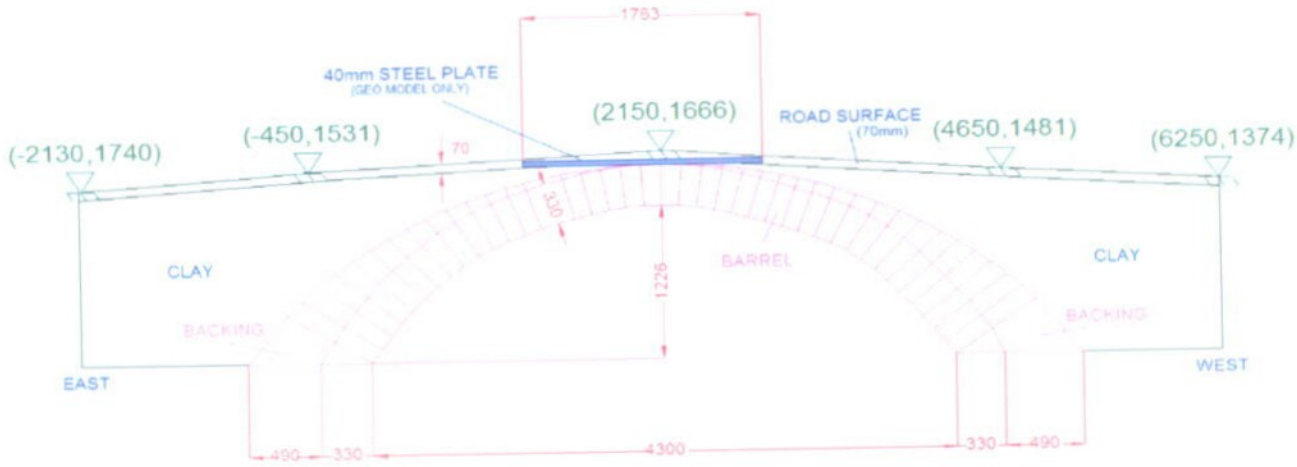
Asphalt	70	mm
Concrete (Slab)	0	mm
Fill	40	mm
Asphalt + Concrete + Fill	110	mm
Rise at crown	1226	mm
Ring thickness at crown	330	mm
Depth of fill at crown above springing level	1666	mm

Road Levels

Position	North	Midspan	South	Avg.	Posn.	x	y	y-70
East (near)	770		800	785	LHS	-2130	1406	1336
East springing	650		670	660		-450	1531	1461
Midspan	520		530	525		2150	1666	1596
West springing	710		710	710		4650	1481	1411
West (near)	830		805	818	Midspan	6250	1374	1304

Level readings relative to instument datum (i.e. high readings = low road level)

Diagram of Structure



LimitState:RING Analysis

The LimitState:RING analyses were conducted as follows:
1. Obtain a solution using a fixed effective bridge width of 2500mm
2. Using the fill depth at the critical load position in 1, work out the correct effective bridge width
3. Re-run the analysis with the new effective width from 2 and obtain a corrected solution

Analysis R1 - No backing, no load distribution between bridge sections

Note that the barrel is assumed to be uniform thickness (330mm) and that backing is omitted from the model

Effective Bridge Width

(BD 21/01 Cl 6.20-6.23)

Critical Position	3.19	m	(From RING analysis)
Critical fill depth, h	0.26	m	(Obtained in Step 2 above)

The effective width is the least of the following expressions:

One Lane

Single Wheel (1)	w =	(1.5+h) x 2	=	3.52	m	(BD21 Para 6/23)
Single Wheel (2)	w =	(0.9+h/2) x 2	=	2.06	m	Wheel next to joint
Single Wheel (3)	w =	(0.225+0.75+h/2) x 2	=	2.21	m	Wheel next to W parapet
Single Axle (1)	w =	(1.5+h) +1.8	=	3.56	m	(BD21 Para 6/23)
Single Axle (2)	w =	Bridge width	=	4.39	m	(BD21 Para 6/23)
Single Axle (3)	w =	(0.225+0.75+h/2) + 1.8	=	2.91	m	Wheel next to W parapet

Two Lanes

Two Axles Side by Side (1)	w =	$\frac{0.7+(2x1.8)+(1.5+h)}{2}$	=	3.03	m	
Two Axles Side by Side (2)	w =	$\frac{\text{Bridge width}}{2}$	=	2.19	m	(BD21 Para 6/23)

Number of Lanes 1 (Typically a 5m carriageway width is required for two lanes.)

Capacity

Effective width, w			=	2.06	m	Lowest value
Failure Load Factor, FLF				0.35	(from RING analysis)	
Failure Load, FL	=	112.8 x FLF	=	39.48	kN/m	
Gravity Constant, g				9.81	m/s^2	
Equivalent Axle Load, EAL	=	$\frac{FL}{g}$	=	4.02	tonnes	

Maximum Gross Vehicle Weight 3 tonnes

This bridge has the capacity to carry 3 tonne vehicles in accordance with BD21/01

Analysis R2 - Composite backing, no load distribution between bridge sections

Effective Bridge Width

(BD 21/01 Cl 6.20-6.23)

Critical Position	3.38	m	(From RING analysis)
Critical fill depth, h	0.24	m	(Obtained in Step 2 above)

The effective width is the least of the following expressions:

One Lane

Single Wheel (1)	w =	(1.5+h) x 2	=	3.47	m	(BD21 Para 6/23)
Single Wheel (2)	w =	(0.9+h/2) x 2	=	2.04	m	Wheel next to joint
Single Wheel (3)	w =	(0.225+0.75+h/2) x 2	=	2.19	m	Wheel next to W parapet
Single Axle (1)	w =	(1.5+h) +1.8	=	3.54	m	(BD21 Para 6/23)
Single Axle (2)	w =	Bridge width	=	4.39	m	(BD21 Para 6/23)
Single Axle (3)	w =	(0.225+0.75+h/2) + 1.8	=	2.89	m	Wheel next to W parapet

Two Lanes

Two Axles Side by Side (1)	w =	$\frac{0.7+(2x1.8)+(1.5+h)}{2}$	=	3.02	m	
Two Axles Side by Side (2)	w =	$\frac{\text{Bridge width}}{2}$	=	2.19	m	(BD21 Para 6/23)

Number of Lanes: 1 (Typically a 5m carriageway width is required for two lanes.)

Capacity

Effective width, w			=	2.04	m	Lowest value
Failure Load Factor, FLF				0.68	(from RING analysis)	
Failure Load, FL	=	112.8 x FLF	=	76.65	kN/m	
Gravity Constant, g				9.81	m/s^2	
Equivalent Axle Load, EAL	=	$\frac{FL}{g}$	=	7.81	tonnes	

Maximum Gross Vehicle Weight: 10 tonnes

This bridge has the capacity to carry 10 tonne vehicles in accordance with BD21/01

Analysis R3 - Composite backing, full load distribution between bridge sections

Effective Bridge Width

(BD 21/01 Cl 6.20-6.23)

Critical Position	3.38	m	(From RING analysis)
Critical fill depth, h	0.24	m	(Obtained in Step 2 above)

The effective width is the least of the following expressions:

One Lane

Single Wheel (1)	w =	(1.5+h) x 2	=	3.47	m	(BD21 Para 6/23)
Single Wheel (3)	w =	(0.225+0.75+h/2) x 2	=	2.19	m	Wheel next to W parapet
Single Axle (1)	w =	(1.5+h) +1.8	=	3.54	m	(BD21 Para 6/23)
Single Axle (2)	w =	Bridge width	=	4.39	m	(BD21 Para 6/23)
Single Axle (3)	w =	(0.225+0.75+h/2) + 1.8	=	2.89	m	Wheel next to W parapet

Two Lanes

Two Axles Side by Side (1)	w =	$\frac{0.7+(2x1.8)+(1.5+h)}{2}$	=	3.02	m	
Two Axles Side by Side (2)	w =	$\frac{\text{Bridge width}}{2}$	=	2.19	m	(BD21 Para 6/23)

Number of Lanes: 1 (Typically a 5m carriageway width is required for two lanes.)

Capacity

Effective width, w			=	2.19	m	Lowest value
Failure Load Factor, FLF				0.73	(from RING analysis)	
Failure Load, FL	=	112.8 x FLF	=	82.27	kN/m	
Gravity Constant, g				9.81	m/s^2	

Equivalent Axle Load, EAL	=	$\frac{FL}{g}$	=	8.39	tonnes
Maximum Gross Vehicle Weight				10	tonnes

This bridge has the capacity to carry 10 tonne vehicles in accordance with BD21/01

Key

	User input data
	Calculated data
	Output data

Appendix C LimitState:RING 2.0 Report Output

limitstate ring

www.limitstate.com

a rapid analysis tool for masonry arch bridges

This report was generated by ring2.0.k[rlm].10866

Summary

Bridge name	Location	Reference No.	Map reference
Finchingfield		26	

Bridge type	Name of assessor	Assessing organization	Date of assessment
Highway	Tom Pritchard	LimitState	Wed Mar 31 2010

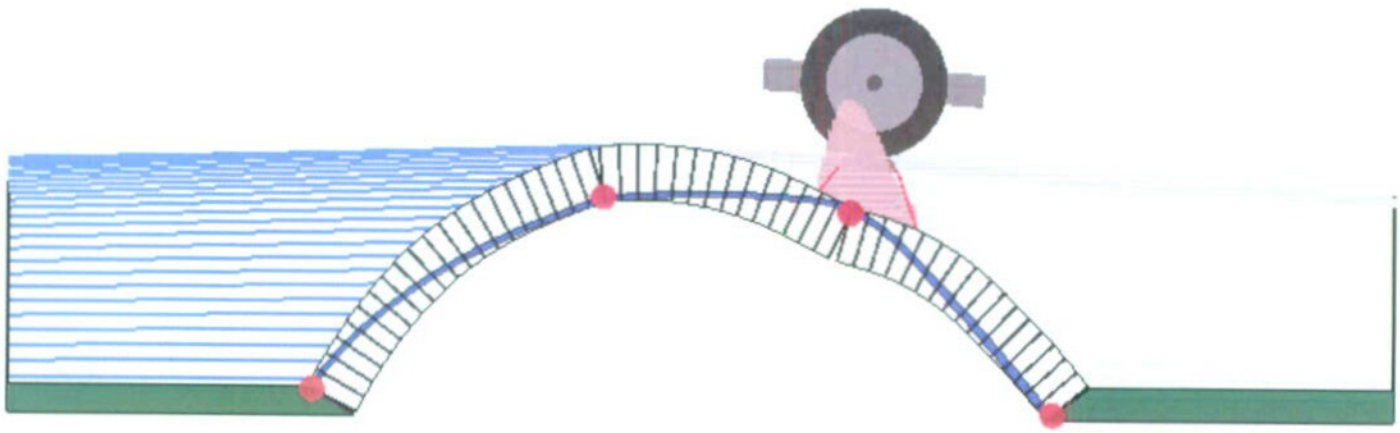
Comments

NO BACKING, NO LOAD DISTRICBUTION
* Effective width calculated based wheel over joint
* Critical load position = LC28 = 3185mm
* h = 1590 - 1330 = 260mm
* Effective width = 2*(0.9 + h/2) = 2.06m

Analysis result

Failure load factor = 0.350286, load case 28 (this is the critical load case)

Mode of response at current load case



Units

Unless specified otherwise, the following units are used throughout this report:

Distance	Force*	Moment*	Angle	Unit weight	Material strength
mm	kN	kNmm	Degrees	kN/m3	N/mm2

* = per metre width

Geometry

Global:	No. Spans	Bridge width
	1	2060

Span 1:	Type	Shape	No. Rings	Bed joints normal to intrados
	Bonded brick	User defined	1	Yes

Intrados points:

x	y
0	0
538	645
1075	980
1613	1158
2150	1226
2688	1145
3225	968
3763	628
4300	0

Ring 1:	No. Blocks	Ring thickness
	50	330

Fill Profile Properties

x	y	Surface fill depth
-2130	1336	70
-450	1461	70
2150	1596	70
4650	1411	70
6520	1304	70

Partial Factors

Factors applied to LOADS

Masonry unit weight	Fill unit weight	Surface unit weight	Axle load	Dynamic
1	1	1	1.9	1.8

Factors applied to MATERIALS

Masonry strength	Masonry friction
1	1

Backfill Properties

Unit weight	Angle of friction	Cohesion
18	0	30

Model dispersion of live load?	Model horizontal 'passive' pressures?
Yes	Yes
Dispersion type	**Cutoff angle**
Boussinesq	30
Soil arch interface, friction multiplier	**Soil arch interface, cohesion multiplier**
0.66	0.5
Mobilisation multiplier on Kp (mp)	***Mobilisation multiplier on cohesion (mpc)***
0.33	0.01
Keep mp.Kp > 1?	**Auto identify passive zones?**
Yes	Yes

Position	Passive pressures?
Abutment 0	Yes
Abutment 1	Yes

Surface Fill Properties

Basic properties

Unit weight	Load dispersion limiting angle
20	26.6

Load Cases

Load case	Vehicle	Position	Mirror?
Load Case1	112.8kN single Axle	-1000	No
Load Case2	112.8kN single Axle	-845	No
Load Case3	112.8kN single Axle	-690	No
Load Case4	112.8kN single Axle	-535	No
Load Case5	112.8kN single Axle	-380	No
Load Case6	112.8kN single Axle	-225	No
Load Case7	112.8kN single Axle	-70	No
Load Case8	112.8kN single Axle	85	No
Load Case9	112.8kN single Axle	240	No

Load Case10	112.8kN single Axle	395	No
Load Case11	112.8kN single Axle	550	No
Load Case12	112.8kN single Axle	705	No
Load Case13	112.8kN single Axle	860	No
Load Case14	112.8kN single Axle	1015	No
Load Case15	112.8kN single Axle	1170	No
Load Case16	112.8kN single Axle	1325	No
Load Case17	112.8kN single Axle	1480	No
Load Case18	112.8kN single Axle	1635	No
Load Case19	112.8kN single Axle	1790	No
Load Case20	112.8kN single Axle	1945	No
Load Case21	112.8kN single Axle	2100	No
Load Case22	112.8kN single Axle	2255	No
Load Case23	112.8kN single Axle	2410	No
Load Case24	112.8kN single Axle	2565	No
Load Case25	112.8kN single Axle	2720	No
Load Case26	112.8kN single Axle	2875	No
Load Case27	112.8kN single Axle	3030	No
Load Case28	112.8kN single Axle	3185	No
Load Case29	112.8kN single Axle	3340	No
Load Case30	112.8kN single Axle	3495	No
Load Case31	112.8kN single Axle	3650	No
Load Case32	112.8kN single Axle	3805	No
Load Case33	112.8kN single Axle	3960	No
Load Case34	112.8kN single Axle	4115	No
Load Case35	112.8kN single Axle	4270	No
Load Case36	112.8kN single Axle	4425	No
Load Case37	112.8kN single Axle	4580	No
Load Case38	112.8kN single Axle	4735	No
Load Case39	112.8kN single Axle	4890	No
Load Case40	112.8kN single Axle	5045	No

Vehicles

Name	Axle No.	Load magnitude	Axle position	Dynamic factor
Default 1kN Single Axle	1	1	0	No
112.8kN single Axle	1	112.8	0	Yes

Blocks

Label	Position	Point 1	Point 2	Point 3	Point 4	Area	Unit weight	Support	Support movement X/Y/Rot.	Fill force (V)	Fill force (H)
Block 0	Skewback 0	-2150/0	0/0	-281/172	-2150/172	345422.56	20	X/Y/Rot	0/0/0	43.99	0
Block 1	Span 1, Ring 1	12/21	61/113	-228/272	-282/170	36075.25	20	None	0/0/0	1.48	2.39
Block 2	Span 1, Ring 1	61/113	112/202	-170/372	-228/272	36075.25	20	None	0/0/0	1.45	2.17
Block 3	Span 1, Ring 1	112/203	167/290	-109/470	-170/372	36075.25	20	None	0/0/0	1.42	1.96
Block 4	Span 1, Ring 1	167/291	225/376	-44/566	-109/471	36075.25	20	None	0/0/0	1.37	1.77
Block 5	Span 1, Ring 1	225/377	286/460	23/659	-44/566	36075.25	20	None	0/0/0	1.32	1.58
Block 6	Span 1, Ring 1	287/460	351/542	95/750	24/660	36075.25	20	None	0/0/0	1.26	1.41
Block 7	Span 1, Ring 1	351/542	418/621	170/839	95/751	36075.25	20	None	0/0/0	1.19	1.24
Block 8	Span 1, Ring 1	418/621	487/698	247/924	170/839	36075.25	20	None	0/0/0	1.12	1.09
Block 9	Span 1, Ring 1	488/698	560/771	333/1010	248/924	36958.58	20	None	0/0/0	1.09	0.98
Block 10	Span 1, Ring 1	561/771	637/841	423/1092	333/1010	37118.83	20	None	0/0/0	1.03	0.83
Block 11	Span 1, Ring 1	638/841	718/906	518/1168	424/1092	37118.83	20	None	0/0/0	0.95	0.69
Block 12	Span 1, Ring 1	719/906	803/966	617/1240	519/1169	37118.83	20	None	0/0/0	0.87	0.56
Block 13	Span 1, Ring 1	803/967	890/1022	720/1305	618/1240	37118.83	20	None	0/0/0	0.79	0.45
Block 14	Span 1, Ring 1	890/1022	980/1073	827/1365	721/1305	37118.83	20	None	0/0/0	0.72	0.36
Block 15	Span 1, Ring 1	981/1073	1073/1119	930/1416	827/1365	35964.94	20	None	0/0/0	0.61	0.27
Block 16	Span 1, Ring 1	1074/1119	1167/1163	1031/1464	930/1417	35455.59	20	None	0/0/0	0.53	0.22
Block 17	Span 1, Ring 1	1167/1163	1262/1205	1133/1509	1031/1464	35455.59	20	None	0/0/0	0.48	0.19
Block 18	Span 1, Ring 1	1262/1205	1358/1244	1237/1551	1134/1509	35455.59	20	None	0/0/0	0.43	0.16
Block 19	Span 1, Ring 1	1358/1244	1455/1281	1341/1591	1237/1551	35455.59	20	None	0/0/0	0.38	0.13
Block 20	Span 1, Ring 1	1455/1281	1553/1316	1448/1629	1342/1591	35719.90	20	None	0/0/0	0.34	0.11
Block 21	Span 1, Ring 1	1548/1315	1651/1324	1633/1653	1514/1644	36716.04	20	None	0/0/0	0.31	0.08
Block 22	Span 1, Ring 1	1652/1324	1755/1327	1753/1657	1634/1653	36716.04	20	None	0/0/0	0.28	0.06
Block 23	Span 1, Ring 1	1756/1327	1859/1325	1873/1655	1754/1657	36716.04	20	None	0/0/0	0.26	0.04
Block 24	Span 1, Ring 1	1861/1325	1964/1318	1993/1647	1874/1655	36716.04	20	None	0/0/0	0.25	0.02
Block 25	Span 1, Ring 1	1965/1318	2067/1307	2113/1633	1994/1647	36716.04	20	None	0/0/0	0.25	0.01
Block 26	Span 1, Ring 1	2069/1306	2171/1289	2234/1613	2114/1633	37159.47	20	None	0/0/0	0.25	0
Block 27	Span 1, Ring 1	2172/1289	2272/1267	2354/1586	2235/1613	37178.16	20	None	0/0/0	0.25	0
Block 28	Span 1, Ring 1	2274/1266	2373/1238	2473/1552	2355/1586	37178.16	20	None	0/0/0	0.26	0
Block 29	Span 1, Ring 1	2374/1238	2472/1204	2589/1512	2474/1552	37178.16	20	None	0/0/0	0.28	0
Block 30	Span 1, Ring 1	2473/1203	2568/1164	2703/1465	2590/1512	37178.16	20	None	0/0/0	0.31	0
Block 31	Span 1, Ring 1	2569/1163	2663/1120	2804/1418	2704/1465	35370.52	20	None	0/0/0	0.33	0
Block 32	Span 1, Ring 1	2664/1119	2757/1075	2901/1372	2805/1417	34505.59	20	None	0/0/0	0.35	0

Block 33	Span 1, Ring 1	2758/1074	2851/1029	2997/1325	2902/1371	34505.59	20	None	0/0/0	0.40	0
Block 34	Span 1, Ring 1	2852/1029	2944/982	3092/1277	2998/1325	34505.59	20	None	0/0/0	0.44	0
Block 35	Span 1, Ring 1	2999/963	3098/934	3190/1251	3088/1280	34505.59	20	None	0/0/0	0.49	0
Block 36	Span 1, Ring 1	3098/934	3198/905	3296/1220	3190/1251	35245.98	20	None	0/0/0	0.56	0
Block 37	Span 1, Ring 1	3198/905	3295/871	3416/1178	3296/1220	38042.10	20	None	0/0/0	0.71	0
Block 38	Span 1, Ring 1	3295/871	3390/829	3533/1127	3416/1178	38042.10	20	None	0/0/0	0.78	0
Block 39	Span 1, Ring 1	3390/829	3482/781	3646/1068	3533/1127	38042.10	20	None	0/0/0	0.85	0
Block 40	Span 1, Ring 1	3482/781	3570/727	3754/1000	3646/1068	38042.10	20	None	0/0/0	0.92	0
Block 41	Span 1, Ring 1	3570/726	3653/666	3857/925	3754/1000	38042.10	20	None	0/0/0	1.00	0
Block 42	Span 1, Ring 1	3654/666	3732/599	3955/843	3857/925	38042.10	20	None	0/0/0	1.06	0
Block 43	Span 1, Ring 1	3733/599	3808/528	4035/768	3955/843	35124.63	20	None	0/0/0	0.98	0
Block 44	Span 1, Ring 1	3808/528	3883/457	4114/692	4035/768	35123.57	20	None	0/0/0	1.06	0
Block 45	Span 1, Ring 1	3883/457	3956/384	4192/615	4114/692	35123.57	20	None	0/0/0	1.14	0
Block 46	Span 1, Ring 1	3956/383	4028/309	4268/536	4192/615	35123.57	20	None	0/0/0	1.21	0
Block 47	Span 1, Ring 1	4028/309	4099/233	4342/456	4268/536	35123.57	20	None	0/0/0	1.29	0
Block 48	Span 1, Ring 1	4099/233	4168/156	4416/374	4342/456	35123.57	20	None	0/0/0	1.36	0
Block 49	Span 1, Ring 1	4168/156	4235/78	4487/291	4416/374	35123.57	20	None	0/0/0	1.42	0
Block 50	Span 1, Ring 1	4235/78	4302/-1	4557/207	4487/291	35123.57	20	None	0/0/0	1.49	0
Block 0	Skewback 1	4300/0	6450/0	6450/195	4566/195	393949.46	20	X/Y/Rot	0/0/0	42.22	0

Key:
X = X direction, Y = Y direction, Rot = Rotational direction

Contacts

Label	Position	Point 1	Point 2	Length	Loss A	Loss B	CS	FC	Status	Inter-ring?	Normal	Shear	Moment
Contact 0	Span 1, Ring 1	-281/172	0/0	330.00	0	0	2.30	0.60	S/H/C	No	63.09	11.13	-9544.56
Contact 1	Span 1, Ring 1	-219/269	55/87	330.00	0	0	2.30	0.60	S/H/C	No	62.93	12.04	-8281.59
Contact 2	Span 1, Ring 1	-154/364	114/172	330.00	0	0	2.30	0.60	S/H/C	No	62.82	12.79	-6927.57
Contact 3	Span 1, Ring 1	-85/457	176/255	330.00	0	0	2.30	0.60	S/H/C	No	62.74	13.38	-5500.71
Contact 4	Span 1, Ring 1	-13/547	240/336	330.00	0	0	2.30	0.60	S/H/C	No	62.70	13.80	-4018.85
Contact 5	Span 1, Ring 1	61/634	308/415	330.00	0	0	2.30	0.60	S/H/C	No	62.69	14.07	-2499.45
Contact 6	Span 1, Ring 1	140/719	378/490	330.00	0	0	2.30	0.60	S/H/C	No	62.71	14.18	-959.48
Contact 7	Span 1, Ring 1	221/801	451/564	330.00	0	0	2.30	0.60	S/H/C	No	62.74	14.14	584.58
Contact 8	Span 1, Ring 1	305/879	526/634	330.00	0	0	2.30	0.60	S/H/C	No	62.79	13.96	2116.76
Contact 9	Span 1, Ring 1	397/958	605/702	330	0	0	2.30	0.60	S/H/C	No	63.05	12.69	3613.77
Contact 10	Span 1, Ring 1	493/1032	687/765	330.00	0	0	2.30	0.60	S/H/C	No	63.29	11.09	4948.02
Contact 11	Span 1, Ring 1	594/1101	772/823	330.00	0	0	2.30	0.60	S/H/C	No	63.48	9.36	6095.09
Contact 12	Span 1, Ring 1	698/1163	861/876	330.00	0	0	2.30	0.60	S/H/C	No	63.59	7.51	7040.49
Contact 13	Span 1, Ring 1	806/1220	952/925	330.00	0	0	2.30	0.60	S/H/C	No	63.64	5.55	7771.41
Contact 14	Span 1, Ring 1	916/1271	1046/968	330.00	0	0	2.30	0.60	S/H/C	No	63.60	3.50	8276.75
Contact 15	Span 1, Ring 1	1022/1314	1142/1007	330.00	0	0	2.30	0.60	S/H/C	No	63.46	2.67	8588.08
Contact 16	Span 1, Ring 1	1127/1353	1239/1043	330.00	0	0	2.30	0.60	S/H/C	No	63.30	2.35	8854.25
Contact 17	Span 1, Ring 1	1232/1390	1336/1077	330.00	0	0	2.30	0.60	S/H/C	No	63.14	1.97	9083.30
Contact 18	Span 1, Ring 1	1338/1424	1435/1108	330.00	0	0	2.30	0.60	S/H/C	No	62.98	1.55	9269.48
Contact 19	Span 1, Ring 1	1446/1455	1534/1137	330.00	0	0	2.30	0.60	S/H/C	No	62.84	1.07	9407.57
Contact 20	Span 1, Ring 1	1555/1484	1634/1163	330.00	0	0	2.30	0.60	S/H/C	No	62.69	0.26	9489.92
Contact 21	Span 1, Ring 1	1671/1509	1735/1186	330.00	0	0	2.30	0.60	S/H/C	No	62.51	-1.70	9407.87
Contact 22	Span 1, Ring 1	1789/1530	1837/1203	330.00	0	0	2.30	0.60	S/H/C	No	62.27	-3.68	9106.49
Contact 23	Span 1, Ring 1	1907/1544	1939/1216	330.00	0	0	2.30	0.60	S/H/C	No	61.97	-5.68	8584.25
Contact 24	Span 1, Ring 1	2026/1553	2042/1223	330.00	0	0	2.30	0.60	S/H/C	No	61.60	-7.66	7841.20
Contact 25	Span 1, Ring 1	2145/1556	2146/1226	330.00	0	0	2.30	0.60	S/H/C	No	61.17	-9.62	6878.91
Contact 26	Span 1, Ring 1	2267/1553	2249/1223	330.00	0	0	2.30	0.60	S/H/C	No	60.58	-12.05	5657.50
Contact 27	Span 1, Ring 1	2389/1543	2352/1215	330.00	0	0	2.30	0.60	S/H/C	No	59.91	-14.47	4158.56
Contact 28	Span 1, Ring 1	2510/1526	2455/1200	330.00	0	0	2.30	0.60	S/H/C	No	59.17	-16.85	2386.30
Contact 29	Span 1, Ring 1	2629/1502	2556/1180	330.00	0	0	2.30	0.60	S/H/C	No	58.35	-19.18	345.72
Contact 30	Span 1, Ring 1	2747/1472	2656/1155	330.00	0	0	2.30	0.60	S/H/C	No	57.46	-21.43	-1956.96
Contact 31	Span 1, Ring 1	2854/1439	2755/1124	330.00	0	0	2.30	0.60	S/H/C	No	57.26	-21.77	-4320.03
Contact 32	Span 1, Ring 1	2954/1407	2853/1093	330.00	0	0	2.30	0.60	S/H/C	No	57.67	-20.40	-6616.02
Contact 33	Span 1, Ring 1	3055/1374	2952/1061	330.00	0	0	2.30	0.60	S/H/C	No	60.93	-10.47	-8829.06
Contact 34	Span 1, Ring 1	3155/1341	3050/1028	330.00	0	0	2.30	0.60	S/H/C	No	66.20	4.97	-9970.94
Contact 35	Span 1, Ring 1	3255/1307	3148/995	330.00	0	0	2.30	0.60	S/H/C	No	71.73	20.40	-9487.85
Contact 36	Span 1, Ring 1	3359/1270	3245/961	330.00	0	0	2.30	0.60	S/H/C	No	76.90	31.84	-7335.38
Contact 37	Span 1, Ring 1	3477/1222	3341/921	330.00	0	0	2.30	0.60	S/H/C	No	82.95	34.87	-3978.03
Contact 38	Span 1, Ring 1	3591/1165	3433/875	330.00	0	0	2.30	0.60	S/H/C	No	87.49	32.84	-292.56
Contact 39	Span 1, Ring 1	3701/1100	3522/823	330.00	0	0	2.30	0.60	S/H/C	No	90.51	27.75	3132.22
Contact 41	Span 1, Ring 1	3805/1028	3607/764	330.00	0	0	2.30	0.60	S/H/C	No	93.30	22.45	5941.82
Contact 42	Span 1, Ring 1	3904/948	3688/699	330.00	0	0	2.30	0.60	S/H/C	No	95.84	16.94	8111.06
Contact 43	Span 1, Ring 1	3997/860	3763/628	330.00	0	0	2.30	0.60	S/H/C	No	98.11	11.22	9615.66
Contact 44	Span 1, Ring 1	4074/782	3835/554	330.00	0	0	2.30	0.60	S/H/C	No	99.52	10.56	10658.51
Contact 45	Span 1, Ring 1	4149/702	3906/479	330.00	0	0	2.30	0.60	S/H/C	No	101.00	9.91	11620.13
Contact 46	Span 1, Ring 1	4222/621	3975/402	330.00	0	0	2.30	0.60	S/H/C	No	102.54	9.26	12500.84
Contact 47	Span 1, Ring 1	4294/538	4043/324	330.00	0	0	2.30	0.60	S/H/C	No	104.15	8.61	13300.45
Contact 48	Span 1, Ring 1	4364/455	4110/245	330.00	0	0	2.30	0.60	S/H/C	No	105.83	7.94	14018.23
Contact 49	Span 1, Ring 1	4433/369	4175/164	330.00	0	0	2.30	0.60	S/H/C	No	107.57	7.26	14652.89
Contact 50	Span 1, Ring 1	4500/283	4238/83	330.00	0	0	2.30	0.60	S/H/C	No	109.38	6.55	15202.61
Contact 40	Span 1, Ring 1	4566/195	4300/0	330	0	0	2.30	0.60	S/H/C	No	111.24	5.82	15665.04

Key:
CS = Crushing Strength, FC = Friction Coefficient, S = Sliding enabled, H = Hinging enabled, C = Crushing enabled

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a rapid analysis tool for masonry arch bridges

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Summary

Bridge name	Location	Reference No.	Map reference
Finchingfield		26	

Bridge type	Name of assessor	Assessing organization	Date of assessment
Highway	Tom Pritchard	LimitState	Wed Mar 31 2010

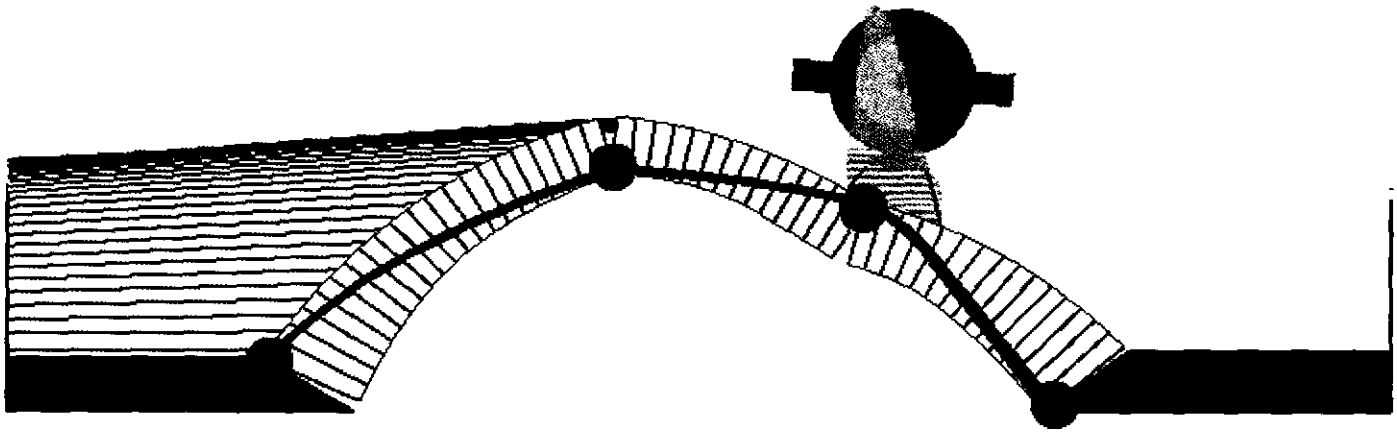
Comments

BONDED BACKING, NO LOAD DISTRIBUTION BETWEEN SECTIONS
* Effective width calculated based wheel over joint
* Critical load position = LC29 = 3380mm
* h = 1575 - 1338 = 237mm
* Effective width = 2*(0.9 + h/2) = 2.037m

Analysis result

Failure load factor = 0.679354, load case 29 (this is the critical load case)

Mode of response at current load case



Units

Unless specified otherwise, the following units are used throughout this report:

Distance	Force*	Moment*	Angle	Unit weight	Material strength
mm	kN	kNmm	Degrees	kN/m3	N/mm2

* = per metre width

Geometry

Global:	No. Spans	Bridge width
	1	2037

Span 1:	Type	Shape	No. Rings	Bed joints normal to intrados
	Bonded brick	User defined	1	Yes

Intrados points:

x	y
0	0
538	645
1075	980
1613	1158
2150	1226
2688	1145
3225	968
3763	628
4300	0

Extrados points of Ring 1:

x	y
-560	320
2150	1556
4815	370

Ring 1:	No. Blocks
	50

Fill Profile Properties

x	y	Surface fill depth
-2130	1336	70
-450	1461	70
2150	1596	70
4650	1411	70
6520	1304	70

Partial Factors

Factors applied to LOADS

Masonry unit weight	Fill unit weight	Surface unit weight	Axle load	Dynamic
1	1	1	1.9	1.8

Factors applied to MATERIALS

Masonry strength	Masonry friction
1	1

Backfill Properties

Unit weight	Angle of friction	Cohesion
18	0	30

Model dispersion of live load?	Model horizontal 'passive' pressures?
Yes	Yes
Dispersion type	**Cutoff angle**
Boussinesq	30
Soil arch interface, friction multiplier	**Soil arch interface, cohesion multiplier**
0.66	0.5
Mobilisation multiplier on Kp (mp)	**Mobilisation multiplier on cohesion (mpc)**
0.33	0.01
Keep mp.Kp > 1?	**Auto identify passive zones?**
Yes	Yes

Position	Passive pressures?
Abutment 0	Yes
Abutment 1	Yes

Surface Fill Properties

Basic properties

Unit weight	Load dispersion limiting angle
20	26.6

Load Cases

Load case	Vehicle	Position	Mirror?
Load Case1	112.8kN single Axle	-1100	No
Load Case2	112.8kN single Axle	-940	No
Load Case3	112.8kN single Axle	-780	No
Load Case4	112.8kN single Axle	-620	No
Load Case5	112.8kN single Axle	-460	No

Load Case6	112.8kN single Axle	-300	No
Load Case7	112.8kN single Axle	-140	No
Load Case8	112.8kN single Axle	20	No
Load Case9	112.8kN single Axle	180	No
Load Case10	112.8kN single Axle	340	No
Load Case11	112.8kN single Axle	500	No
Load Case12	112.8kN single Axle	660	No
Load Case13	112.8kN single Axle	820	No
Load Case14	112.8kN single Axle	980	No
Load Case15	112.8kN single Axle	1140	No
Load Case16	112.8kN single Axle	1300	No
Load Case17	112.8kN single Axle	1460	No
Load Case18	112.8kN single Axle	1620	No
Load Case19	112.8kN single Axle	1780	No
Load Case20	112.8kN single Axle	1940	No
Load Case21	112.8kN single Axle	2100	No
Load Case22	112.8kN single Axle	2260	No
Load Case23	112.8kN single Axle	2420	No
Load Case24	112.8kN single Axle	2580	No
Load Case25	112.8kN single Axle	2740	No
Load Case26	112.8kN single Axle	2900	No
Load Case27	112.8kN single Axle	3060	No
Load Case28	112.8kN single Axle	3220	No
Load Case29	112.8kN single Axle	3380	No
Load Case30	112.8kN single Axle	3540	No
Load Case31	112.8kN single Axle	3700	No
Load Case32	112.8kN single Axle	3860	No
Load Case33	112.8kN single Axle	4020	No
Load Case34	112.8kN single Axle	4180	No
Load Case35	112.8kN single Axle	4340	No
Load Case36	112.8kN single Axle	4500	No
Load Case37	112.8kN single Axle	4660	No
Load Case38	112.8kN single Axle	4820	No
Load Case39	112.8kN single Axle	4980	No
Load Case40	112.8kN single Axle	5140	No

Vehicles

Name	Axle No.	Load magnitude	Axle position	Dynamic factor
Default 1kN Single Axle	1	1	0	No
112.8kN single Axle	1	112.8	0	Yes

Blocks

Label	Position	Point 1	Point 2	Point 3	Point 4	Area	Unit weight	Support	Support movement X/Y/Rot.	Fill force (V)	Fill force (H)
Block 0	Skewback 0	-2150/0	0/0	-560/320	-2150/320	598400.00	20	X/Y/Rot	0/0/0	32.95	0
Block 1	Span 1, Ring 1	36/68	80/162	-475/436	-559/315	78295.13	20	None	0/0/0	2.06	2.34
Block 2	Span 1, Ring 1	81/163	128/255	-398/538	-475/436	69608.12	20	None	0/0/0	1.71	1.80
Block 3	Span 1, Ring 1	128/255	179/345	-318/637	-398/539	66909.61	20	None	0/0/0	1.62	1.59
Block 4	Span 1, Ring 1	180/346	234/434	-235/732	-317/637	64258.45	20	None	0/0/0	1.52	1.40
Block 5	Span 1, Ring 1	234/435	291/521	-149/824	-234/733	61657.19	20	None	0/0/0	1.43	1.23
Block 6	Span 1, Ring 1	292/522	352/606	-60/912	-148/824	59108.21	20	None	0/0/0	1.33	1.07
Block 7	Span 1, Ring 1	352/607	416/689	30/997	-60/913	56613.72	20	None	0/0/0	1.23	0.93
Block 8	Span 1, Ring 1	416/689	482/769	123/1078	31/997	54175.75	20	None	0/0/0	1.13	0.80
Block 9	Span 1, Ring 1	483/770	552/846	224/1159	124/1078	53515.87	20	None	0/0/0	1.10	0.72
Block 10	Span 1, Ring 1	553/847	626/920	328/1238	225/1160	51419.08	20	None	0/0/0	1.00	0.61
Block 11	Span 1, Ring 1	627/920	705/989	434/1311	329/1238	49348.47	20	None	0/0/0	0.90	0.51
Block 12	Span 1, Ring 1	705/989	786/1053	542/1381	435/1312	47627.07	20	None	0/0/0	0.80	0.42
Block 13	Span 1, Ring 1	787/1054	872/1113	651/1446	543/1381	46246.36	20	None	0/0/0	0.71	0.34
Block 14	Span 1, Ring 1	873/1114	960/1168	762/1506	652/1446	45199.43	20	None	0/0/0	0.63	0.28
Block 15	Span 1, Ring 1	961/1169	1051/1219	867/1560	763/1507	42841.39	20	None	0/0/0	0.52	0.21
Block 16	Span 1, Ring 1	1052/1220	1143/1268	970/1608	868/1560	41548.60	20	None	0/0/0	0.45	0.16
Block 17	Span 1, Ring 1	1144/1268	1237/1314	1074/1652	971/1608	40897.20	20	None	0/0/0	0.40	0.13
Block 18	Span 1, Ring 1	1238/1314	1332/1358	1180/1694	1075/1653	40160.96	20	None	0/0/0	0.36	0.11
Block 19	Span 1, Ring 1	1332/1358	1427/1399	1287/1732	1181/1694	39340.95	20	None	0/0/0	0.32	0.08
Block 20	Span 1, Ring 1	1428/1400	1524/1438	1397/1767	1288/1732	38742.79	20	None	0/0/0	0.29	0.07
Block 21	Span 1, Ring 1	1525/1439	1622/1474	1513/1800	1398/1767	38914.86	20	None	0/0/0	0.28	0.05
Block 22	Span 1, Ring 1	1609/1474	1712/1468	1743/1804	1624/1819	38060.95	20	None	0/0/0	0.26	0.04
Block 23	Span 1, Ring 1	1715/1468	1818/1456	1864/1786	1746/1804	37420.32	20	None	0/0/0	0.25	0.03
Block 24	Span 1, Ring 1	1821/1456	1923/1439	1985/1764	1867/1786	36991.35	20	None	0/0/0	0.24	0.02
Block 25	Span 1, Ring 1	1926/1439	2027/1417	2104/1738	1988/1764	36772.91	20	None	0/0/0	0.25	0.01
Block 26	Span 1, Ring 1	2031/1417	2130/1390	2225/1708	2107/1738	37236.82	20	None	0/0/0	0.25	0
Block 27	Span 1, Ring 1	2134/1390	2232/1358	2346/1673	2229/1707	37578.34	20	None	0/0/0	0.24	0

Block 28	Span 1, Ring 1	2235/1357	2331/1319	2465/1634	2349/1672	38239.24	20	None	0/0/0	0.24	0
Block 29	Span 1, Ring 1	2334/1318	2428/1275	2584/1590	2469/1633	39242.28	20	None	0/0/0	0.25	0
Block 30	Span 1, Ring 1	2431/1274	2522/1226	2702/1542	2587/1589	40593.41	20	None	0/0/0	0.26	0
Block 31	Span 1, Ring 1	2525/1225	2614/1172	2808/1495	2705/1541	39858.36	20	None	0/0/0	0.26	0
Block 32	Span 1, Ring 1	2617/1171	2705/1118	2906/1447	2811/1494	39947.30	20	None	0/0/0	0.27	0
Block 33	Span 1, Ring 1	2708/1117	2796/1063	3003/1397	2909/1446	40848.06	20	None	0/0/0	0.30	0
Block 34	Span 1, Ring 1	2799/1061	2887/1007	3099/1344	3006/1396	41494.40	20	None	0/0/0	0.33	0
Block 35	Span 1, Ring 1	2889/1006	2977/950	3193/1288	3102/1343	41886.65	20	None	0/0/0	0.37	0
Block 36	Span 1, Ring 1	3081/909	3180/882	3292/1267	3184/1296	43125.52	20	None	0/0/0	0.44	0
Block 37	Span 1, Ring 1	3181/882	3279/849	3419/1228	3292/1267	47450.41	20	None	0/0/0	0.59	0
Block 38	Span 1, Ring 1	3279/849	3375/810	3545/1184	3419/1228	48113.58	20	None	0/0/0	0.67	0
Block 39	Span 1, Ring 1	3375/810	3467/763	3670/1135	3545/1184	49416.03	20	None	0/0/0	0.77	0
Block 40	Span 1, Ring 1	3468/763	3556/710	3795/1081	3671/1135	51376.17	20	None	0/0/0	0.87	0
Block 41	Span 1, Ring 1	3557/710	3641/651	3920/1021	3795/1080	54021.67	20	None	0/0/0	0.99	0
Block 42	Span 1, Ring 1	3642/651	3722/586	4044/954	3920/1020	57389.80	20	None	0/0/0	1.12	0
Block 43	Span 1, Ring 1	3722/586	3799/517	4144/897	4044/954	54146.84	20	None	0/0/0	1.00	0
Block 44	Span 1, Ring 1	3800/517	3876/447	4242/836	4144/897	56694.10	20	None	0/0/0	1.08	0
Block 45	Span 1, Ring 1	3876/446	3950/375	4338/772	4242/836	59081.12	20	None	0/0/0	1.16	0
Block 46	Span 1, Ring 1	3951/375	4024/302	4432/705	4338/772	61302.48	20	None	0/0/0	1.23	0
Block 47	Span 1, Ring 1	4024/302	4096/227	4524/634	4433/704	63355.29	20	None	0/0/0	1.31	0
Block 48	Span 1, Ring 1	4096/227	4167/151	4614/561	4525/634	65236.88	20	None	0/0/0	1.38	0
Block 49	Span 1, Ring 1	4167/151	4236/74	4702/485	4614/561	66944.82	20	None	0/0/0	1.45	0
Block 50	Span 1, Ring 1	4236/74	4304/-3	4791/402	4702/485	70552.40	20	None	0/0/0	1.60	0
Block 0	Skewback 1	4300/0	6450/0	6450/370	4815/370	700225.00	20	X/Y/Rot	0/0/0	31.27	0

Key:
X = X direction, Y = Y direction, Rot = Rotational direction

Contacts

Label	Position	Point 1	Point 2	Length	Loss A	Loss B	CS	FC	Status	Inter-ring?	Normal	Shear	Moment
Contact 0	Span 1, Ring 1	-560/320	0/0	644.98	0	0	2.30	0.60	S/H/C	No	89.25	38.11	-27050.82
Contact 1	Span 1, Ring 1	-461/429	55/87	619.60	0	0	2.30	0.60	S/H/C	No	89.80	36.19	-23527.00
Contact 2	Span 1, Ring 1	-372/520	114/172	597.89	0	0	2.30	0.60	S/H/C	No	89.58	36.19	-20233.30
Contact 3	Span 1, Ring 1	-281/607	176/255	576.41	0	0	2.30	0.60	S/H/C	No	89.46	36.00	-16968.70
Contact 4	Span 1, Ring 1	-187/691	240/336	555.19	0	0	2.30	0.60	S/H/C	No	89.43	35.62	-13753.03
Contact 5	Span 1, Ring 1	-91/770	308/415	534.25	0	0	2.30	0.60	S/H/C	No	89.50	35.06	-10605.32
Contact 6	Span 1, Ring 1	7/846	378/490	513.62	0	0	2.30	0.60	S/H/C	No	89.63	34.31	-7543.85
Contact 7	Span 1, Ring 1	107/918	451/564	493.32	0	0	2.30	0.60	S/H/C	No	89.83	33.40	-4586.03
Contact 8	Span 1, Ring 1	209/986	526/634	473.38	0	0	2.30	0.60	S/H/C	No	90.09	32.31	-1748.48
Contact 9	Span 1, Ring 1	319/1054	605/702	453.38	0	0	2.30	0.60	S/H/C	No	90.85	29.68	985.08
Contact 10	Span 1, Ring 1	431/1118	687/765	435.81	0	0	2.30	0.60	S/H/C	No	91.66	26.60	3473.04
Contact 11	Span 1, Ring 1	545/1177	772/823	420.90	0	0	2.30	0.60	S/H/C	No	92.40	23.34	5688.38
Contact 12	Span 1, Ring 1	659/1232	861/876	408.63	0	0	2.30	0.60	S/H/C	No	93.05	19.91	7619.40
Contact 13	Span 1, Ring 1	775/1282	952/925	398.98	0	0	2.30	0.60	S/H/C	No	93.59	16.34	9255.56
Contact 14	Span 1, Ring 1	892/1328	1046/968	391.94	0	0	2.30	0.60	S/H/C	No	94.00	12.64	10587.42
Contact 15	Span 1, Ring 1	1002/1367	1142/1007	387.01	0	0	2.30	0.60	S/H/C	No	94.08	10.80	11615.21
Contact 16	Span 1, Ring 1	1109/1402	1239/1043	381.62	0	0	2.30	0.60	S/H/C	No	94.03	9.74	12472.91
Contact 17	Span 1, Ring 1	1218/1433	1336/1077	375.46	0	0	2.30	0.60	S/H/C	No	93.99	8.61	13176.48
Contact 18	Span 1, Ring 1	1327/1460	1435/1108	368.55	0	0	2.30	0.60	S/H/C	No	93.93	7.44	13719.96
Contact 19	Span 1, Ring 1	1437/1485	1534/1137	360.88	0	0	2.30	0.60	S/H/C	No	93.87	6.21	14098.04
Contact 20	Span 1, Ring 1	1550/1505	1634/1163	352.39	0	0	2.30	0.60	S/H/C	No	93.83	4.49	14301.63
Contact 21	Span 1, Ring 1	1669/1524	1735/1186	344.38	0	0	2.30	0.60	S/H/C	No	93.78	1.03	14236.40
Contact 22	Span 1, Ring 1	1788/1538	1837/1203	338.14	0	0	2.30	0.60	S/H/C	No	93.61	-2.45	13865.94
Contact 23	Span 1, Ring 1	1907/1548	1939/1216	333.67	0	0	2.30	0.60	S/H/C	No	93.32	-5.95	13189.35
Contact 24	Span 1, Ring 1	2026/1554	2042/1223	330.95	0	0	2.30	0.60	S/H/C	No	92.89	-9.44	12206.81
Contact 25	Span 1, Ring 1	2145/1556	2146/1226	330.00	0	0	2.30	0.60	S/H/C	No	92.34	-12.90	10919.69
Contact 26	Span 1, Ring 1	2267/1554	2249/1223	331.27	0	0	2.30	0.60	S/H/C	No	91.52	-17.07	9289.32
Contact 27	Span 1, Ring 1	2389/1548	2352/1215	335.29	0	0	2.30	0.60	S/H/C	No	90.52	-21.23	7307.39
Contact 28	Span 1, Ring 1	2512/1538	2455/1200	342.08	0	0	2.30	0.60	S/H/C	No	89.34	-25.33	4975.64
Contact 29	Span 1, Ring 1	2634/1523	2556/1180	351.64	0	0	2.30	0.60	S/H/C	No	87.99	-29.34	2295.88
Contact 30	Span 1, Ring 1	2757/1504	2656/1155	364.01	0	0	2.30	0.60	S/H/C	No	86.49	-33.23	-729.35
Contact 31	Span 1, Ring 1	2867/1484	2755/1124	376.53	0	0	2.30	0.60	S/H/C	No	86.02	-34.21	-3882.27
Contact 32	Span 1, Ring 1	2972/1461	2853/1093	386.22	0	0	2.30	0.60	S/H/C	No	86.10	-33.80	-7043.33
Contact 33	Span 1, Ring 1	3075/1435	2952/1061	393.50	0	0	2.30	0.60	S/H/C	No	86.20	-33.36	-10266.25
Contact 34	Span 1, Ring 1	3177/1406	3050/1028	398.39	0	0	2.30	0.60	S/H/C	No	87.48	-29.47	-13713.66
Contact 35	Span 1, Ring 1	3278/1374	3148/995	400.89	0	0	2.30	0.60	S/H/C	No	95.72	-5.59	-17195.43
Contact 36	Span 1, Ring 1	3384/1337	3245/961	401.12	0	0	2.30	0.60	S/H/C	No	107.82	25.63	-18379.44
Contact 37	Span 1, Ring 1	3508/1289	3341/921	403.74	0	0	2.30	0.60	S/H/C	No	124.73	51.55	-16299.36
Contact 38	Span 1, Ring 1	3630/1236	3433/875	411.12	0	0	2.30	0.60	S/H/C	No	138.96	62.21	-10892.72
Contact 39	Span 1, Ring 1	3751/1179	3522/823	423.30	0	0	2.30	0.60	S/H/C	No	149.31	61.59	-3687.17
Contact 41	Span 1, Ring 1	3872/1116	3607/764	440.37	0	0	2.30	0.60	S/H/C	No	154.53	52.11	4270.40
Contact 42	Span 1, Ring 1	3991/1047	3688/699	462.42	0	0	2.30	0.60	S/H/C	No	159.27	42.31	11512.06
Contact 43	Span 1, Ring 1	4110/973	3763/628	489.58	0	0	2.30	0.60	S/H/C	No	163.53	32.23	18014.91
Contact 44	Span 1, Ring 1	4206/908	3835/554	512.92	0	0	2.30	0.60	S/H/C	No	165.61	30.63	23148.58
Contact 45	Span 1, Ring 1	4299/841	3906/479	534.76	0	0	2.30	0.60	S/H/C	No	167.77	29.06	27989.53
Contact 46	Span 1, Ring 1	4390/770	3975/402	555.07	0	0	2.30	0.60	S/H/C	No	170.03	27.50	32534.24
Contact 47	Span 1, Ring 1	4479/697	4043/324	573.84	0	0	2.30	0.60	S/H/C	No	172.38	25.95	36778.16
Contact 48	Span 1, Ring 1	4566/621	4110/245	591.08	0	0	2.30	0.60	S/H/C	No	174.82	24.39	40716.05
Contact 49	Span 1, Ring 1	4650/541	4175/164	606.76	0	0	2.30	0.60	S/H/C	No	177.35	22.81	44341.94
Contact 50	Span 1, Ring 1	4732/459	4238/83	620.88	0	0	2.30	0.60	S/H/C	No	179.96	21.22	47648.95
Contact 40	Span 1, Ring 1	4815/370	4300/0	634.13	0	0	2.30	0.60	S/H/C	No	182.94	17.77	50728.83

Key:
CS = Crushing Strength, FC = Friction Coefficient, S = Sliding enabled, H = Hinging enabled, C = Crushing enabled

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limitstate ring

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a rapid analysis tool for masonry arch bridges

This report was generated by ring2.0.k[rlm].10866

Summary

Bridge name	Location	Reference No.	Map reference
Finchingfield		26	
Bridge type	**Name of assessor**	**Assessing organization**	**Date of assessment**
Highway	*Tom Pritchard*	LimitState	Wed Mar31 2010

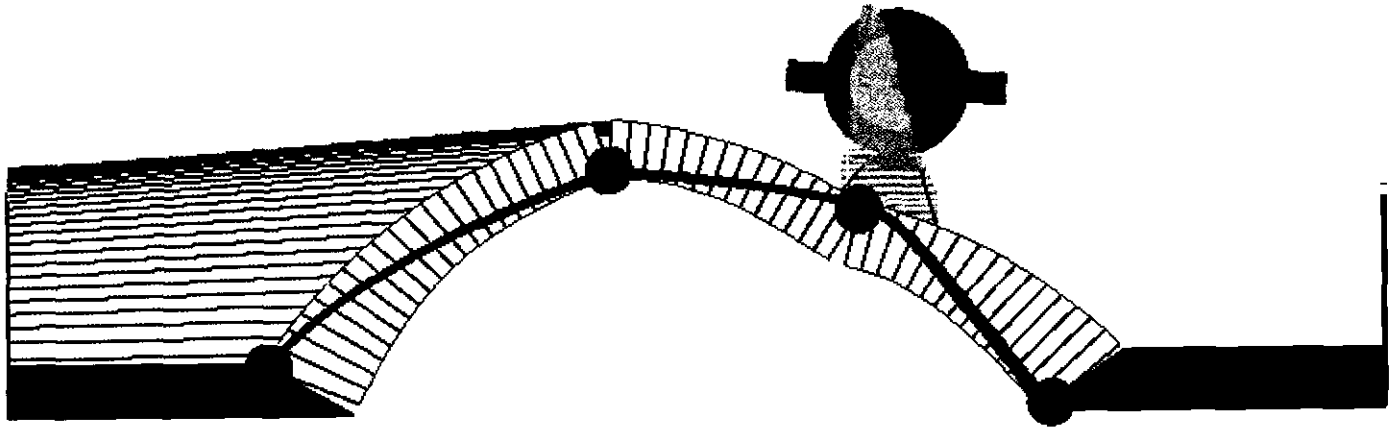
Comments

BONDED BACKING, FULL LOAD DISTRIBUTION BETWEEN SECTIONS
* Effective width calculated based wheel near west parapet
* Critical load position = LC29 = 3380mm
* h = 1575 - 1338 = 237mm
* Effective width = 2*(0.225 + 0.75 + h/2) = 2.187m

Analysis result

Failure load factor = 0.72938, load case 29 (this is the critical load case)

Mode of response at current load case



Units

Unless specified otherwise, the following units are used throughout this report:

Distance	Force*	Moment*	Angle	Unit weight	Material strength
mm	kN	kNmm	Degrees	kN/m3	N/mm2

* = per metre width

Geometry

Global:	No. Spans	Bridge width		
	1	2187		
Span 1:	**Type**	**Shape**	**No. Rings**	**Bed joints *normal* to intrados**
	Bonded brick	User defined	1	Yes

Intrados points:

x	y
0	0
538	645
1075	980
1613	1158
2150	1226
2688	1145
3225	968
3763	628
4300	0

Extrados points of Ring 1:

x	y
-560	320
2150	1556
4815	370

Ring 1:	No. Blocks
	50

Fill Profile Properties

x	y	Surface fill depth
-2130	1336	70
-450	1461	70
2150	1596	70
4650	1411	70
6520	1304	70

Partial Factors

Factors applied to LOADS

Masonry unit weight	Fill unit weight	Surface unit weight	Axle load	Dynamic
1	1	1	1.9	1.8

Factors applied to MATERIALS

Masonry strength	Masonry friction
1	1

Backfill Properties

Unit weight	Angle of friction	Cohesion
18	0	30

Model dispersion of live load? Yes
Model horizontal 'passive' pressures? Yes
Dispersion type Boussinesq
Cutoff angle 30
Soil arch interface, friction multiplier 0.66
Soil arch interface, cohesion multiplier 0.5
Mobilisation multiplier on Kp (mp) 0.33
Mobilisation multiplier on cohesion (mpc) 0.01
Keep mp.Kp > 1? Yes
Auto identify passive zones? Yes

Position	Passive pressures?
Abutment 0	Yes
Abutment 1	Yes

Surface Fill Properties

Basic properties

Unit weight	Load dispersion limiting angle
20	26.6

Load Cases

Load case	Vehicle	Position	Mirror?
Load Case1	112.8kN single Axle	-1100	No
Load Case2	112.8kN single Axle	-940	No
Load Case3	112.8kN single Axle	-780	No
Load Case4	112.8kN single Axle	-620	No
Load Case5	112.8kN single Axle	-460	No

Load Case6	112.8kN single Axle	-300	No
Load Case7	112.8kN single Axle	-140	No
Load Case8	112.8kN single Axle	20	No
Load Case9	112.8kN single Axle	180	No
Load Case10	112.8kN single Axle	340	No
Load Case11	112.8kN single Axle	500	No
Load Case12	112.8kN single Axle	660	No
Load Case13	112.8kN single Axle	820	No
Load Case14	112.8kN single Axle	980	No
Load Case15	112.8kN single Axle	1140	No
Load Case16	112.8kN single Axle	1300	No
Load Case17	112.8kN single Axle	1460	No
Load Case18	112.8kN single Axle	1620	No
Load Case19	112.8kN single Axle	1780	No
Load Case20	112.8kN single Axle	1940	No
Load Case21	112.8kN single Axle	2100	No
Load Case22	112.8kN single Axle	2260	No
Load Case23	112.8kN single Axle	2420	No
Load Case24	112.8kN single Axle	2580	No
Load Case25	112.8kN single Axle	2740	No
Load Case26	112.8kN single Axle	2900	No
Load Case27	112.8kN single Axle	3060	No
Load Case28	112.8kN single Axle	3220	No
Load Case29	112.8kN single Axle	3380	No
Load Case30	112.8kN single Axle	3540	No
Load Case31	112.8kN single Axle	3700	No
Load Case32	112.8kN single Axle	3860	No
Load Case33	112.8kN single Axle	4020	No
Load Case34	112.8kN single Axle	4180	No
Load Case35	112.8kN single Axle	4340	No
Load Case36	112.8kN single Axle	4500	No
Load Case37	112.8kN single Axle	4660	No
Load Case38	112.8kN single Axle	4820	No
Load Case39	112.8kN single Axle	4980	No
Load Case40	112.8kN single Axle	5140	No

Vehicles

Name	Axle No.	Load magnitude	Axle position	Dynamic factor
Default 1kN Single Axle	1	1	0	No
112.8kN single Axle	1	112.8	0	Yes

Blocks

Label	Position	Point 1	Point 2	Point 3	Point 4	Area	Unit weight	Support	Support movement X/Y/Rot.	Fill force (V)	Fill force (H)
Block 0	Skewback 0	-2150/0	0/0	-560/320	-2150/320	598400.00	20	X/Y/Rot	0/0/0	32.95	0
Block 1	Span 1, Ring 1	36/68	80/162	-475/436	-559/315	78295.13	20	None	0/0/0	2.06	2.34
Block 2	Span 1, Ring 1	81/163	128/255	-398/538	-475/436	69608.12	20	None	0/0/0	1.71	1.80
Block 3	Span 1, Ring 1	128/255	179/345	-318/637	-398/539	66909.61	20	None	0/0/0	1.62	1.59
Block 4	Span 1, Ring 1	180/346	234/434	-235/732	-317/637	64258.45	20	None	0/0/0	1.52	1.40
Block 5	Span 1, Ring 1	234/435	291/521	-149/824	-234/733	61657.19	20	None	0/0/0	1.43	1.23
Block 6	Span 1, Ring 1	292/522	352/606	-60/912	-148/824	59108.21	20	None	0/0/0	1.33	1.07
Block 7	Span 1, Ring 1	352/607	416/689	30/997	-60/913	56613.72	20	None	0/0/0	1.23	0.93
Block 8	Span 1, Ring 1	416/689	482/769	123/1078	31/997	54175.75	20	None	0/0/0	1.13	0.80
Block 9	Span 1, Ring 1	483/770	552/846	224/1159	124/1078	53515.87	20	None	0/0/0	1.10	0.72
Block 10	Span 1, Ring 1	553/847	626/920	328/1238	225/1160	51419.08	20	None	0/0/0	1.00	0.61
Block 11	Span 1, Ring 1	627/920	705/989	434/1311	329/1238	49348.47	20	None	0/0/0	0.90	0.51
Block 12	Span 1, Ring 1	705/989	786/1053	542/1381	435/1312	47627.07	20	None	0/0/0	0.80	0.42
Block 13	Span 1, Ring 1	787/1054	872/1113	651/1446	543/1381	46246.36	20	None	0/0/0	0.71	0.34
Block 14	Span 1, Ring 1	873/1114	960/1168	762/1506	652/1446	45199.43	20	None	0/0/0	0.63	0.28
Block 15	Span 1, Ring 1	961/1169	1051/1219	867/1560	763/1507	42841.39	20	None	0/0/0	0.52	0.21
Block 16	Span 1, Ring 1	1052/1220	1143/1268	970/1608	868/1560	41548.60	20	None	0/0/0	0.45	0.16
Block 17	Span 1, Ring 1	1144/1268	1237/1314	1074/1652	971/1608	40897.20	20	None	0/0/0	0.40	0.13
Block 18	Span 1, Ring 1	1238/1314	1332/1358	1180/1694	1075/1653	40160.96	20	None	0/0/0	0.36	0.11
Block 19	Span 1, Ring 1	1332/1358	1427/1399	1287/1732	1181/1694	39340.95	20	None	0/0/0	0.32	0.08
Block 20	Span 1, Ring 1	1428/1400	1524/1438	1397/1767	1288/1732	38742.79	20	None	0/0/0	0.29	0.07
Block 21	Span 1, Ring 1	1525/1439	1622/1474	1513/1800	1398/1767	38914.86	20	None	0/0/0	0.28	0.05
Block 22	Span 1, Ring 1	1609/1474	1712/1468	1743/1804	1624/1819	38060.95	20	None	0/0/0	0.26	0.04
Block 23	Span 1, Ring 1	1715/1468	1818/1456	1864/1786	1746/1804	37420.32	20	None	0/0/0	0.25	0.03
Block 24	Span 1, Ring 1	1821/1456	1923/1439	1985/1764	1867/1786	36991.35	20	None	0/0/0	0.24	0.02
Block 25	Span 1, Ring 1	1926/1439	2027/1417	2104/1738	1988/1764	36772.91	20	None	0/0/0	0.25	0.01
Block 26	Span 1, Ring 1	2031/1417	2130/1390	2225/1708	2107/1738	37236.82	20	None	0/0/0	0.25	0
Block 27	Span 1, Ring 1	2134/1390	2232/1358	2346/1673	2229/1707	37578.34	20	None	0/0/0	0.24	0

Block 28	Span 1, Ring 1	2235/1357	2331/1319	2465/1634	2349/1672	38239.24	20	None	0/0/0	0.24	0
Block 29	Span 1, Ring 1	2334/1318	2428/1275	2584/1590	2469/1633	39242.28	20	None	0/0/0	0.25	0
Block 30	Span 1, Ring 1	2431/1274	2522/1226	2702/1542	2587/1589	40593.41	20	None	0/0/0	0.26	0
Block 31	Span 1, Ring 1	2525/1225	2614/1172	2808/1495	2705/1541	39858.36	20	None	0/0/0	0.26	0
Block 32	Span 1, Ring 1	2617/1171	2705/1118	2906/1447	2811/1494	39947.30	20	None	0/0/0	0.27	0
Block 33	Span 1, Ring 1	2708/1117	2796/1063	3003/1397	2909/1446	40848.06	20	None	0/0/0	0.30	0
Block 34	Span 1, Ring 1	2799/1061	2887/1007	3099/1344	3006/1396	41494.40	20	None	0/0/0	0.33	0
Block 35	Span 1, Ring 1	2889/1006	2977/950	3193/1288	3102/1343	41886.65	20	None	0/0/0	0.37	0
Block 36	Span 1, Ring 1	3081/909	3180/882	3292/1267	3184/1296	43125.52	20	None	0/0/0	0.44	0
Block 37	Span 1, Ring 1	3181/882	3279/849	3419/1228	3292/1267	47450.41	20	None	0/0/0	0.59	0
Block 38	Span 1, Ring 1	3279/849	3375/810	3545/1184	3419/1228	48113.58	20	None	0/0/0	0.67	0
Block 39	Span 1, Ring 1	3375/810	3467/763	3670/1135	3545/1184	49416.03	20	None	0/0/0	0.77	0
Block 40	Span 1, Ring 1	3468/763	3556/710	3795/1081	3671/1135	51376.17	20	None	0/0/0	0.87	0
Block 41	Span 1, Ring 1	3557/710	3641/651	3920/1021	3795/1080	54021.67	20	None	0/0/0	0.99	0
Block 42	Span 1, Ring 1	3642/651	3722/586	4044/954	3920/1020	57389.80	20	None	0/0/0	1.12	0
Block 43	Span 1, Ring 1	3722/586	3799/517	4144/897	4044/954	54146.84	20	None	0/0/0	1.00	0
Block 44	Span 1, Ring 1	3800/517	3876/447	4242/836	4144/897	56694.10	20	None	0/0/0	1.08	0
Block 45	Span 1, Ring 1	3876/446	3950/375	4338/772	4242/836	59081.12	20	None	0/0/0	1.16	0
Block 46	Span 1, Ring 1	3951/375	4024/302	4432/705	4338/772	61302.48	20	None	0/0/0	1.23	0
Block 47	Span 1, Ring 1	4024/302	4096/227	4524/634	4433/704	63355.29	20	None	0/0/0	1.31	0
Block 48	Span 1, Ring 1	4096/227	4167/151	4614/561	4525/634	65236.88	20	None	0/0/0	1.38	0
Block 49	Span 1, Ring 1	4167/151	4236/74	4702/485	4614/561	66944.82	20	None	0/0/0	1.45	0
Block 50	Span 1, Ring 1	4236/74	4304/-3	4791/402	4702/485	70552.40	20	None	0/0/0	1.60	0
Block 0	Skewback 1	4300/0	6450/0	6450/370	4815/370	700225.00	20	X/Y/Rot	0/0/0	31.27	0

Key:
X = X direction, Y = Y direction, Rot = Rotational direction

Contacts

Label	Position	Point 1	Point 2	Length	Loss A	Loss B	CS	FC	Status	Inter-ring?	Normal	Shear	Moment
Contact 0	Span 1, Ring 1	-560/320	0/0	644.98	0	0	2.30	0.60	S/H/C	No	89.25	38.11	-27050.82
Contact 1	Span 1, Ring 1	-461/429	55/87	619.60	0	0	2.30	0.60	S/H/C	No	89.80	36.19	-23527.00
Contact 2	Span 1, Ring 1	-372/520	114/172	597.89	0	0	2.30	0.60	S/H/C	No	89.58	36.19	-20233.30
Contact 3	Span 1, Ring 1	-281/607	176/255	576.41	0	0	2.30	0.60	S/H/C	No	89.46	36.00	-16968.70
Contact 4	Span 1, Ring 1	-187/691	240/336	555.19	0	0	2.30	0.60	S/H/C	No	89.43	35.62	-13753.03
Contact 5	Span 1, Ring 1	-91/770	308/415	534.25	0	0	2.30	0.60	S/H/C	No	89.50	35.06	-10605.32
Contact 6	Span 1, Ring 1	7/846	378/490	513.62	0	0	2.30	0.60	S/H/C	No	89.63	34.31	-7543.85
Contact 7	Span 1, Ring 1	107/918	451/564	493.32	0	0	2.30	0.60	S/H/C	No	89.83	33.40	-4586.03
Contact 8	Span 1, Ring 1	209/986	526/634	473.38	0	0	2.30	0.60	S/H/C	No	90.09	32.31	-1748.48
Contact 9	Span 1, Ring 1	319/1054	605/702	453.38	0	0	2.30	0.60	S/H/C	No	90.85	29.68	985.08
Contact 10	Span 1, Ring 1	431/1118	687/765	435.81	0	0	2.30	0.60	S/H/C	No	91.66	26.60	3473.04
Contact 11	Span 1, Ring 1	545/1177	772/823	420.90	0	0	2.30	0.60	S/H/C	No	92.40	23.34	5688.38
Contact 12	Span 1, Ring 1	659/1232	861/876	408.63	0	0	2.30	0.60	S/H/C	No	93.05	19.91	7619.40
Contact 13	Span 1, Ring 1	775/1282	952/925	398.98	0	0	2.30	0.60	S/H/C	No	93.59	16.34	9255.56
Contact 14	Span 1, Ring 1	892/1328	1046/968	391.94	0	0	2.30	0.60	S/H/C	No	94.00	12.64	10587.42
Contact 15	Span 1, Ring 1	1002/1367	1142/1007	387.01	0	0	2.30	0.60	S/H/C	No	94.08	10.80	11615.21
Contact 16	Span 1, Ring 1	1109/1402	1239/1043	381.62	0	0	2.30	0.60	S/H/C	No	94.03	9.74	12472.91
Contact 17	Span 1, Ring 1	1218/1433	1336/1077	375.46	0	0	2.30	0.60	S/H/C	No	93.99	8.61	13176.48
Contact 18	Span 1, Ring 1	1327/1460	1435/1108	368.55	0	0	2.30	0.60	S/H/C	No	93.93	7.44	13719.96
Contact 19	Span 1, Ring 1	1437/1485	1534/1137	360.88	0	0	2.30	0.60	S/H/C	No	93.87	6.21	14098.04
Contact 20	Span 1, Ring 1	1550/1505	1634/1163	352.39	0	0	2.30	0.60	S/H/C	No	93.83	4.49	14301.63
Contact 21	Span 1, Ring 1	1669/1524	1735/1186	344.38	0	0	2.30	0.60	S/H/C	No	93.78	1.03	14236.40
Contact 22	Span 1, Ring 1	1788/1538	1837/1203	338.14	0	0	2.30	0.60	S/H/C	No	93.61	-2.45	13865.94
Contact 23	Span 1, Ring 1	1907/1548	1939/1216	333.67	0	0	2.30	0.60	S/H/C	No	93.32	-5.95	13189.35
Contact 24	Span 1, Ring 1	2026/1554	2042/1223	330.95	0	0	2.30	0.60	S/H/C	No	92.89	-9.44	12206.81
Contact 25	Span 1, Ring 1	2145/1556	2146/1226	330.00	0	0	2.30	0.60	S/H/C	No	92.34	-12.90	10919.69
Contact 26	Span 1, Ring 1	2267/1554	2249/1223	331.27	0	0	2.30	0.60	S/H/C	No	91.52	-17.07	9289.32
Contact 27	Span 1, Ring 1	2389/1548	2352/1215	335.29	0	0	2.30	0.60	S/H/C	No	90.52	-21.23	7307.39
Contact 28	Span 1, Ring 1	2512/1538	2455/1200	342.08	0	0	2.30	0.60	S/H/C	No	89.34	-25.33	4975.64
Contact 29	Span 1, Ring 1	2634/1523	2556/1180	351.64	0	0	2.30	0.60	S/H/C	No	87.99	-29.34	2295.88
Contact 30	Span 1, Ring 1	2757/1504	2656/1155	364.01	0	0	2.30	0.60	S/H/C	No	86.49	-33.23	-729.35
Contact 31	Span 1, Ring 1	2867/1484	2755/1124	376.53	0	0	2.30	0.60	S/H/C	No	86.02	-34.21	-3882.27
Contact 32	Span 1, Ring 1	2972/1461	2853/1093	386.22	0	0	2.30	0.60	S/H/C	No	86.10	-33.80	-7043.33
Contact 33	Span 1, Ring 1	3075/1435	2952/1061	393.50	0	0	2.30	0.60	S/H/C	No	86.20	-33.36	-10266.25
Contact 34	Span 1, Ring 1	3177/1406	3050/1028	398.39	0	0	2.30	0.60	S/H/C	No	87.48	-29.47	-13713.66
Contact 35	Span 1, Ring 1	3278/1374	3148/995	400.89	0	0	2.30	0.60	S/H/C	No	95.72	-5.59	-17195.43
Contact 36	Span 1, Ring 1	3384/1337	3245/961	401.12	0	0	2.30	0.60	S/H/C	No	107.82	25.63	-18379.44
Contact 37	Span 1, Ring 1	3508/1289	3341/921	403.74	0	0	2.30	0.60	S/H/C	No	124.73	51.55	-16299.36
Contact 38	Span 1, Ring 1	3630/1236	3433/875	411.12	0	0	2.30	0.60	S/H/C	No	138.96	62.21	-10892.72
Contact 39	Span 1, Ring 1	3751/1179	3522/823	423.30	0	0	2.30	0.60	S/H/C	No	149.31	61.59	-3687.17
Contact 41	Span 1, Ring 1	3872/1116	3607/764	440.37	0	0	2.30	0.60	S/H/C	No	154.53	52.11	4270.40
Contact 42	Span 1, Ring 1	3991/1047	3688/699	462.42	0	0	2.30	0.60	S/H/C	No	159.27	42.31	11512.06
Contact 43	Span 1, Ring 1	4110/973	3763/628	489.58	0	0	2.30	0.60	S/H/C	No	163.53	32.23	18014.91
Contact 44	Span 1, Ring 1	4206/908	3835/554	512.92	0	0	2.30	0.60	S/H/C	No	165.61	30.63	23148.58
Contact 45	Span 1, Ring 1	4299/841	3906/479	534.76	0	0	2.30	0.60	S/H/C	No	167.77	29.06	27989.53
Contact 46	Span 1, Ring 1	4390/770	3975/402	555.07	0	0	2.30	0.60	S/H/C	No	170.03	27.50	32534.24
Contact 47	Span 1, Ring 1	4479/697	4043/324	573.84	0	0	2.30	0.60	S/H/C	No	172.38	25.95	36778.16
Contact 48	Span 1, Ring 1	4566/621	4110/245	591.08	0	0	2.30	0.60	S/H/C	No	174.82	24.39	40716.05
Contact 49	Span 1, Ring 1	4650/541	4175/164	606.76	0	0	2.30	0.60	S/H/C	No	177.35	22.81	44341.94
Contact 50	Span 1, Ring 1	4732/459	4238/83	620.88	0	0	2.30	0.60	S/H/C	No	179.96	21.22	47648.95
Contact 40	Span 1, Ring 1	4815/370	4300/0	634.13	0	0	2.30	0.60	S/H/C	No	182.94	17.77	50728.83

Key:
CS = Crushing Strength, FC = Friction Coefficient, S = Sliding enabled, H = Hinging enabled, C = Crushing enabled

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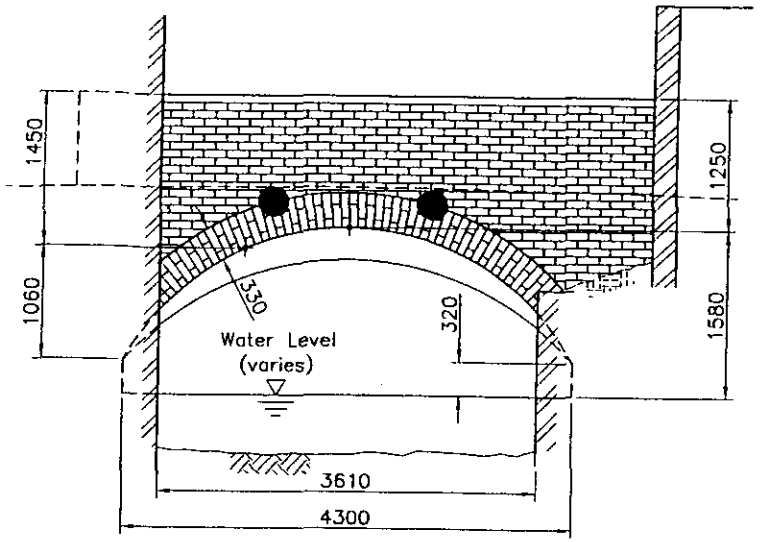
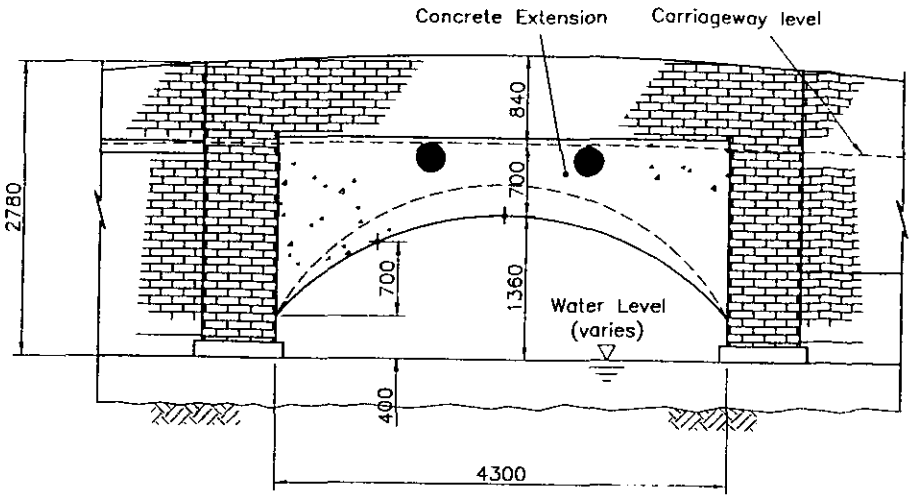
Appendix D Drawings



UPSTREAM ELEVATION

Scale 1:50

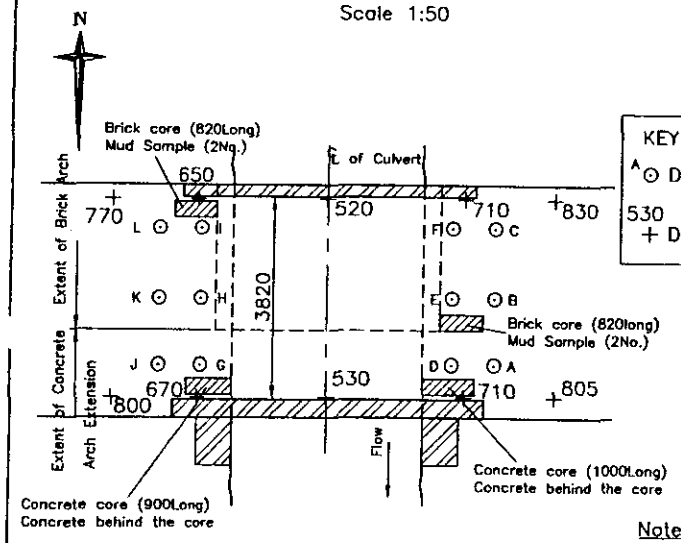


DOWNSTREAM ELEVATION

Scale 1:50

NOTES:

1. All dimensions are in millimetres unless noted.
2. All levels are in metres above Ordnance Suvey Datum.



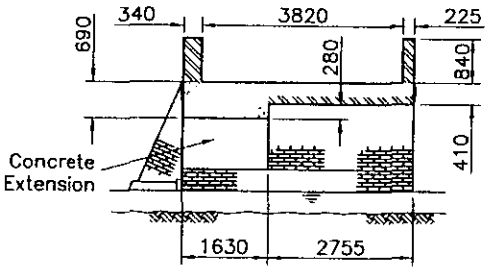
PLAN

Scale 1:100

KEY:

A ⊙ Denotes Penetrometer Test

530 + Denotes Relative Road Level

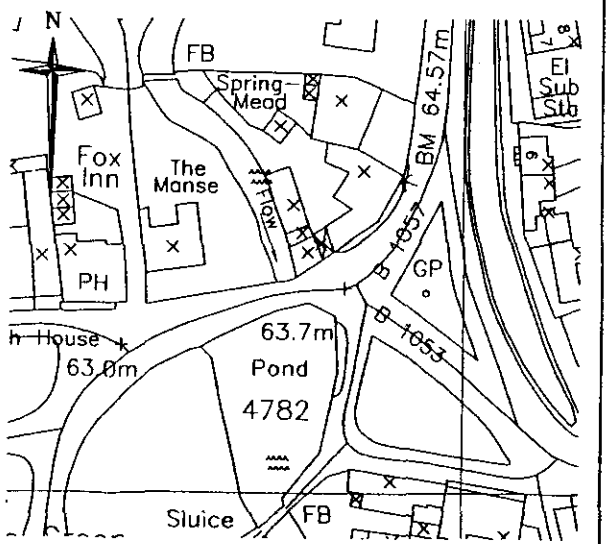


SECTION ALONG CENTRELINE OF CULVERT

Scale 1:100

Notes

All Levels stated are staff readings relative to instrument datum.



LOCATION PLAN

Scale 1:1000

A3

Essex County Council

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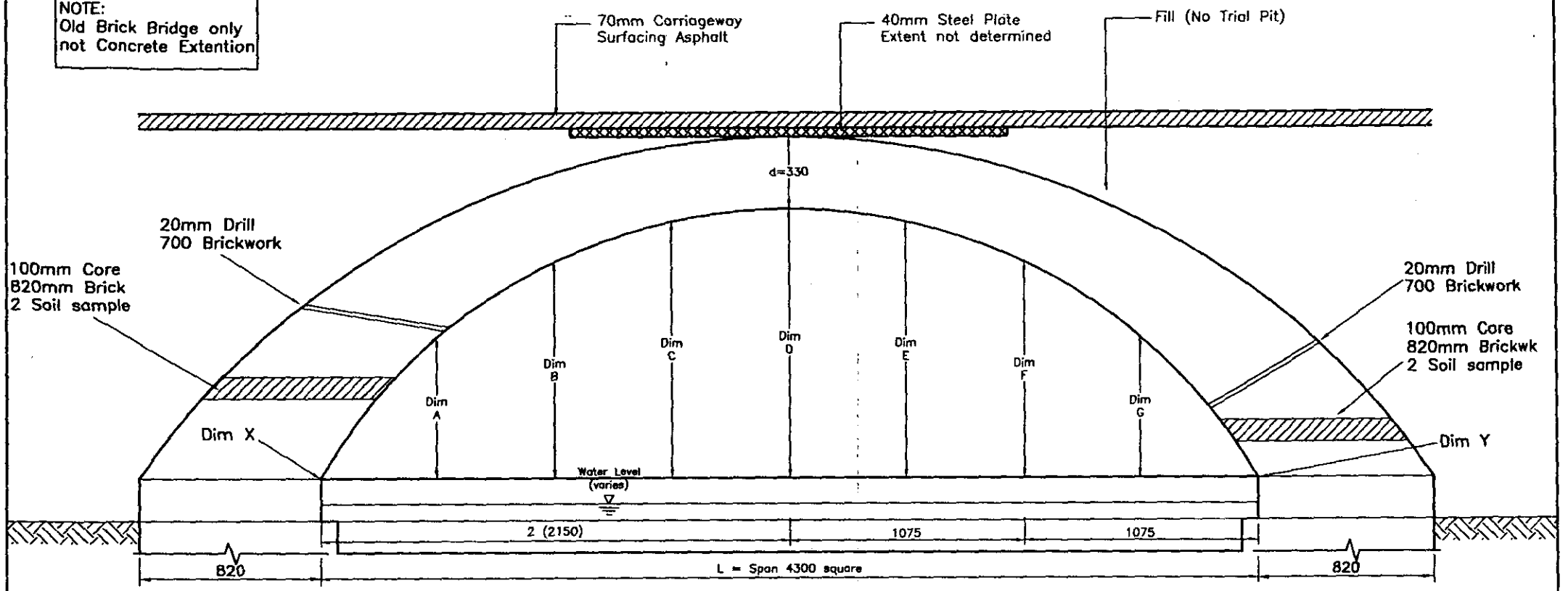
SCALES	AS SHOWN		SURVEYED	LEVELLED	DESIGNED	DRAWN	CHECKED	AUTHORISED
		INITIALS				JEB		
CAD FILE	BR026-P02-	DATE				14/05/03		
CONSTRUCTION AUDIT		REVISION			REVISION SUFFIX	BY	CHECKED DATE	BY

DESCRIPTION OF DRAWING: INTRUSIVE INVESTIGATION

SCHEME TITLE: FINCHINGFIELD BRIDGE E.C.C BRIDGE No. 026

DRAWING NO. BR026/P02-

NOTE:
Old Brick Bridge only
not Concrete Extention



Condition of Arch

1. Brick Arch in generally good condition.
2. Hammer Test has shown poor area in N.E corner below spring confirmed by 'Pen' Test F&C
3. Some pointing/minor repairs required.

	Dimension A	Dimension B	Dimension C	Dimension D	Dimension E	Dimension F	Dimension G	Dimension X & Y
Section 1–1	660	980	1160	1230	1140	970	630	0
Section 2–2	630	970	1150	1240	1140	960	630	0
Section 3–3	660	990	1180	1240	1160	980	620	0
Section 4–4	630	980	1140	1195	1140	960	630	0

NOTES

1. All dimensions are in millimetres unless otherwise stated.
2. No trial holes were dug due to road geometry.
3. 100mm cores and 20mm drillings were obtained.

A4

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CAD NO. BR0026–P03–

DESCRIPTION OF DRAWING
TYPICAL SECTION
STRUCTURAL DIMENSIONS
FINCHINGFIELD BRIDGE E.C.C No.026

DRWG.NO.	BR0026/P03–
SCALES	1:25
DATE 15/05/03	DRAWN JEB
DATE	CHECKED
DATE	AUTHORISED

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