GENERAL ASSESSMENT REPORT

Bushy Ruff Bridge

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General Assessment Report

Bushy Ruff Bridge

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Executive Summary

This report covers the assessment and the survey findings of Bushy Ruff Bridge in Temple Ewell, Dover CT16 3EE. The separate report for the findings from the site survey can be found in Annex.

The assessment is in accordance with BA 16/97 (DMRB 3.4.4), assessment of masonry arch bridges by the modified MEXE method. Also, Swantest has conducted a site survey to obtain the structural dimensions needed for the assessment of the bridge.

The report finds that the allowable axle load for a single axle bogie per axle is 11.5 tonnes and 9.5 tonnes for double axle bogie. As a result, the vehicle type restriction for Bushy Ruff masonry arch bridge is HGV-3 axles.

Introduction

The aim of this report is to assess the capacity of a masonry arch bridge. The modified MEXE method is conducted to assess the arch of Bushy Ruff bridge located in Temple Ewell, Dover, CT16 3EE.

The arch of the bridge is 1.522m and its width is 4.8m according to the survey findings. The height of the fill varies throughout the bridge and at down stream is 250mm going up to 510mm towards the upstream.

The materials used in construction of the arch barrel is brick and mortar and the general condition of them is good.

Also, Mortar joints and the brickwork is also found to be in good condition and the joint thickness are 10mm.

All the structural data used are conducted from the site survey report in annex which explains the findings from the general visual inspection of the current condition of the bridge. The assessment method is the modified MEXE method of arch assessment conducted from Ba16/97 volume 3 section 4 part 4.

The bridge location and its accessibility are marked up in Figure.1.

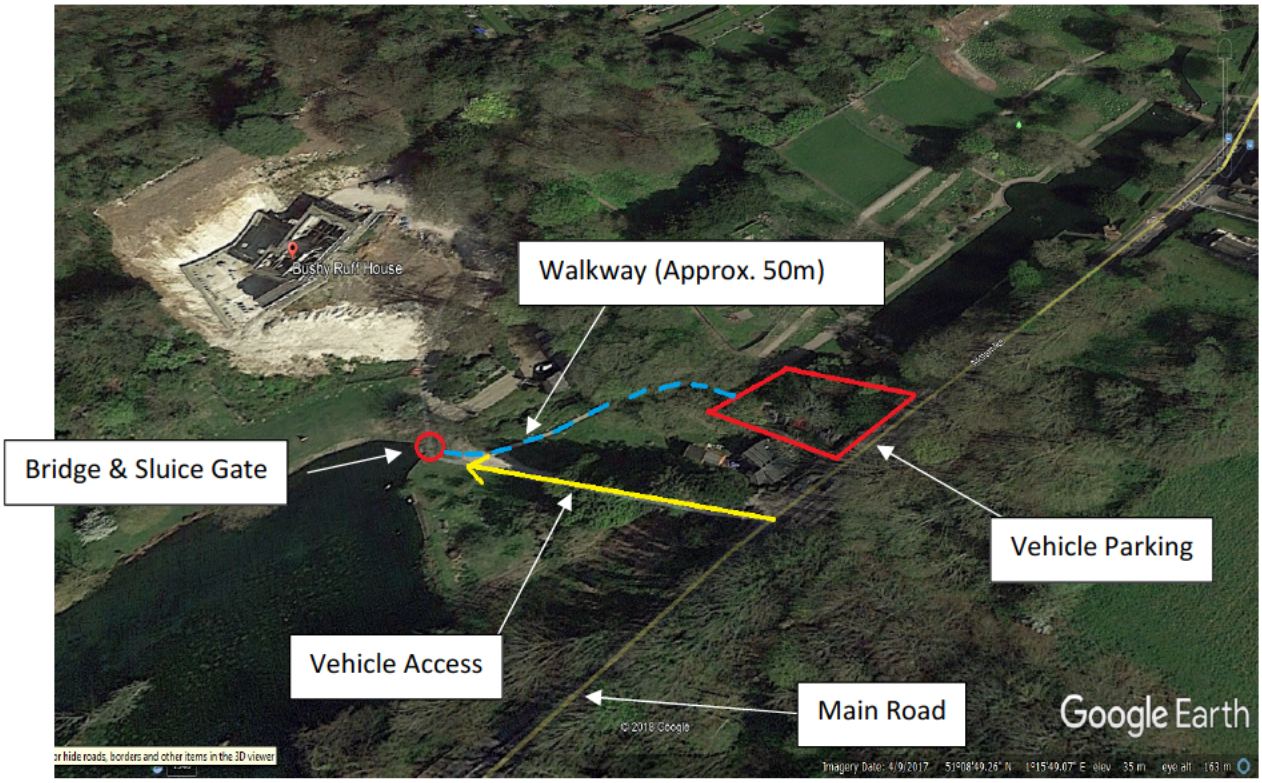


Figure 1. Bushy Ruff bridge location

The following data from the structural survey is required in order to examine the current capacity of the bridge and its allowance for different type of vehicles.

The span of the arch (L)	L = 1522mm
The rise of the arch barrel at the crown (Rc)	Rc = 440mm
The rise of the arch barrel at the quarter points (Rq)	Rq= 360mm
The thickness of the arch barrel adjacent to the keystone (d)	d= 230mm

The depth of fill at the downstream where 10mm drilled holes were executed and depth of fill measured is 250mm.

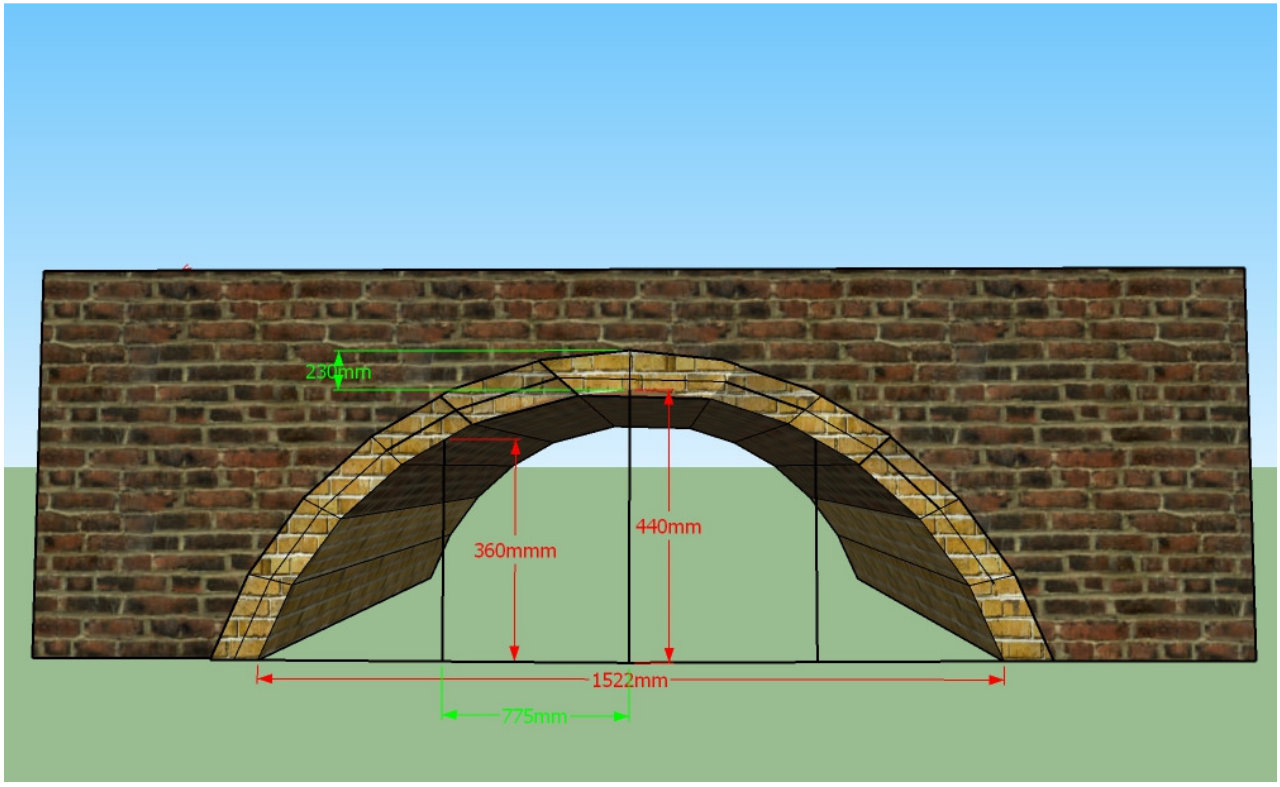


Figure 2. Structural dimensions sketch

Defects of the bridge

All defects found during inspection are not extreme and thus, they have not affected the condition of the bridge massively. In overall, 12 spots where found with cracks at the soffit of the arch bridge.

At the top centre of the arch barrel, 3 cracks are found where the mortar was missing and, there are signs of moisture infiltration in the cracks.

At the downstream of the bridge the brick has experienced spalling and therefore, the surface of the brickwork is flacking, and some cracks are developed.

There is a vertical crack spanning on 8 brick layers close to the upstream and moreover, cracks are produced in calcium build up of bottom of the side wall. Of the arch barrel.

Finally, there are 2 diagonal cracks at the down stream of the bridge and one from bottom of side wall to 1/3 of barrel height where there is evidence of water infiltration and the other crack is spanning from bottom to top of side wall on calcium build up.

Assessment

The modified MEXE method is a comprehensive method for determining the carrying capacity of single span masonry arches in terms of allowable axle weight. It depends only on the strength of the arch barrel by considering the materials, various defects and geometric proportions of the arch. In order to implement the effects of multiple axle bogies, factors are used.

All calculations are in accordance to BA16/97- The assessment of highway bridges and structures. In order to use this method, it is assumed that the arch is parabolic in shape and built in good quality brick work with well pointed joints.

As the depth of fill varies in different locations the lowest value (at downstream) will be used to calculate the capacity of the bridge.

Provisional Assessment

According to work carried out by Department of Transport and British Rail, the provisional axle loads are based on Pippard's allowable axle loads which were calculated to be those producing the permissible masonry compressive stress in the arch barrel.

The provisional axle loading (PAL) is:

$PAL: \frac{740(d+h)^2}{L^{1.3}}$ or 70, whichever is less.

$$PAL: \frac{740(0.23+0.25)^2}{1.522^{1.3}} = 98.76 > 70$$

Hence, PAL = 70

Modifying Factors

Span/Rise Factor

As the flat arches are not as strong in comparison to steeper profile arches, the provisional assessment must be adjusted to consider the arch profile.

$$\frac{Span}{rise} = \frac{1.522}{0.44} = 3.46$$

As span/rise ratio < 4, it gives optimum strength and a factor (F_{sr}) of 1.0 will be applied to PAL.

Profile Factor

Parabolic arches are stronger compared to the elliptical arches with the same barrel thickness and span/rise ration. Thus, the ideal profile has been taken to be at the quarter points.

$$\frac{r_q}{r_c} = \frac{0.36}{0.44} = 0.818$$

As the ratio is grater that 0.75, the profile factor should be calculated from below expression:

$$F_p = 2.3\left[\frac{r_c - r_q}{r_c}\right]^{0.6} = 2.3\left[\frac{0.44-0.36}{0.44}\right]^{0.6} = 0.827$$

Material Factor

To comprise the material type in the provisional axle load, the two factors of arch barrel and the fill are required. Tables below are used in order to conduct the factors for the brick and mortar.

Arch Barrel	Barrel Factor (F_b)
Granite and Whinstone whether random or coursed and all built-in-course masonry except limestone, all with large shapes voussoirs	1.5
Ashlar quality siliceous sandstone	1.4
Concrete# or engineering bricks and similar sized masonry (not limestone).	1.2
Limestone, whether random or coursed, ashlar quality calcareous sandstone, good random masonry and building bricks, all in good condition.	1.0
Masonry of any kind in poor condition (many voussoirs flaking or badly spalling, shearing etc). Some discretion is permitted if the dilapidation is only moderate.	0.7

Table 1. Barrel Factor

Filling	Fill Factor (F_f)
Concrete #	1.0
Grouted materials (other than those with a clay content)	0.9
Well compacted materials*	0.7
Weak materials evidenced by tracking of the carriageway surface	0.5

Table 2.Fill Factor

Thus, barrel factor is 1.2 and fill factor is 1.0 and the material factor is calculated.

$$F_m = \frac{(F_b.d) + (F_f.h)}{d + h} = \frac{(1.2 \times 0.23) + (1.0 \times 0.25)}{0.23 + 0.25} = 0.94$$

Joint Factor

The stability and strength of the arch barrel depends on the size and the condition of the joints. The joint factor is subject to the width, depth and mortar factors. According to site survey, the width of the joints is 10mm and the mortar and pointed joints are in a good condition.

Width of Joint	Width Factor (F_w)
Joints with widths up to 6mm	1.0
Joints with widths between 6mm and 12.5mm	0.9
Joints with widths over 12.5mm	0.8

Table 3.Width Factor

Condition of Joint	Mortar Factor (F_{mo})
Mortar in good condition	1.0
Loose or friable mortar	0.9

Table 4.Mortar Factor

Similarly, the depth factor is 1.0 as the joints are filled sufficiently and they are in good condition.

Hence, the joint factor is:

$$F_j = F_w . F_d . F_{mo} = 0.9 \times 1.0 \times 1.0 = 0.9$$

Condition Factor

Condition factor depends on an objective assessment of the importance of the various cracks and deformations presented on the bridge. According to the survey done, the overall bridge condition is good. Although there are some minor cracks and defects on the arch barrel, the condition factor is estimated to be 0.9.

Load Capacity

In order to obtain the load capacity, Firstly the modified axle load needs to be calculated by multiplying the PAL by the modification and condition factors to make it pertinent to the Bushy Ruff bridge.

Modified axle load = $F_{sr}.F_p.F_m.F_j.F_{cM}.PAL$ = 1.0 x 0.83 x 0.94 x 0.9 x 0.9 x 70 =44.237

Axle factor (A_f) = 0.66

Load capacity = 0.66 x 44.237= 29.196 tonnes = 29 tonnes.

Therefore, allowable axle load for a single axle bogie per axle is 11.5 tonnes and 9.5 tonnes for double axle bogie.

The vehicle type restriction for Bushy Ruff masonry arch bridge is HGV-3 axles.

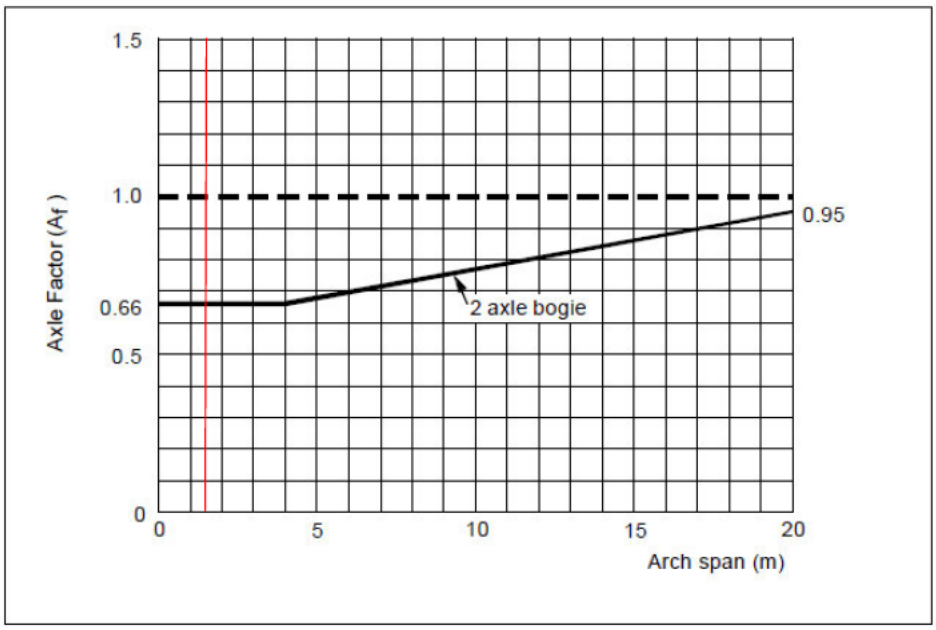


Figure 5. Conversions of modified axle loads

Allowable Axle Load (tonnes) per axle			Max Gross Vehicle Weight (gvw) (tonnes)	Weight Restriction (tonnes)	Type of Vehicle
Single	Double	Triple			
11.5	10	8*	40/44	N/A	HGV-5 or 6 axles
11.5	9.5	-	32	33	HGV-4 axles
11.5	9.5	-	26	26	HGV-3 axles
11.5	-	-	18	18	HGV-2 axles
9	-	-	12.5	13	
7	-	-	10	10	
5.5	-	-	7.5	7.5	LGV
2	-	-	3	3	Car/Van

Table 5.Load capacity and Gross vehicle weight restrictions for Masonry Arches

Conclusion

Regarding to the findings from the Bushy Ruff bridge survey and the results obtained by the MEXE method from the assessment, the bridge has a maximum gross vehicle weight capacity of 29 tonnes. Thus, it is safe for the vehicles up to HGV-3 axles to travel across the bridge. Moreover, the bridge condition is acceptable and there is no need for any maintenance.

Annex

Project:	Bushy Ruff Bridge
Title:	General Condition Survey
Client:	C.H.P.
Project Ref:	SC-1802
Report Number:	SC-1802-GS-01
Date:	13-11-18

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GENERAL INFORMATION	
Client:	C.H.P.
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Client Contact:	[redacted]@swantonconsulting.co.uk>
Inspection Date:	08-11-18

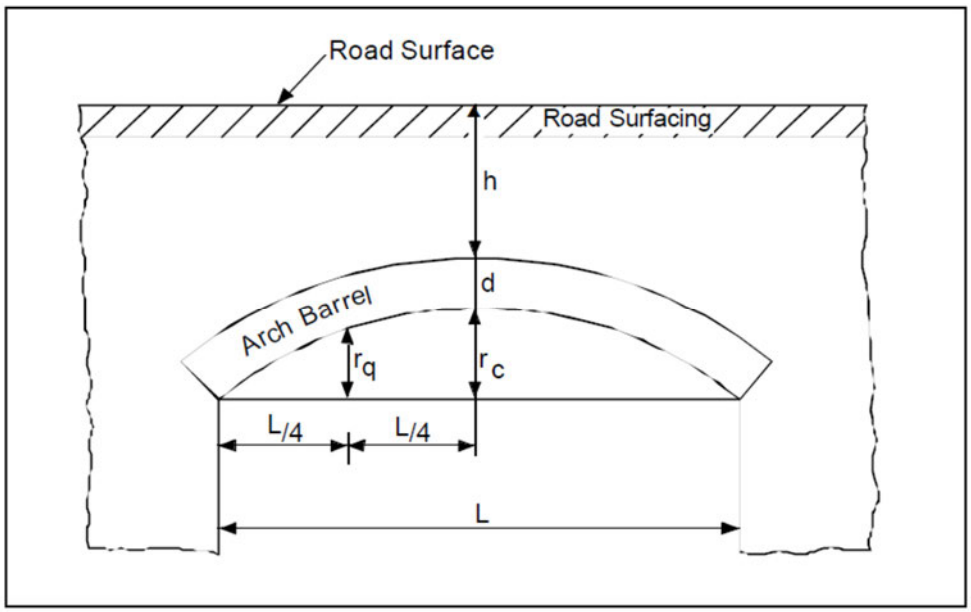
Inspection Carried Out By:	[redacted] & [redacted]	
Report By:	**Name:** [redacted]	**Signature:** [redacted]

1. Executive Summary:

This report covers the findings of a condition survey carried out at Bushy Ruff Bridge in Temple Ewell, Dover CT16 3EE on Thursday the 08th November 2018.

This report is based on a full structural survey in accordance with Chapter 2 of BD 21 (DMRB 3.4.3) in which the following sections were surveyed as per BA 16/97 section 3.5 as detailed below:

- The span of the arch (L)
- The rise of the arch barrel at the crown (Rc)
- The rise of the arch barrel at the quarter points (Rq)
- The thickness of the arch barrel adjacent to the keystone (d)
- The average depth of fill at various locations (h)
- Type of materials used for the arch barrel i.e. brick and mortar
- Dimensions of cracks and/damage
- Dimensions of joints
- General condition of all materials



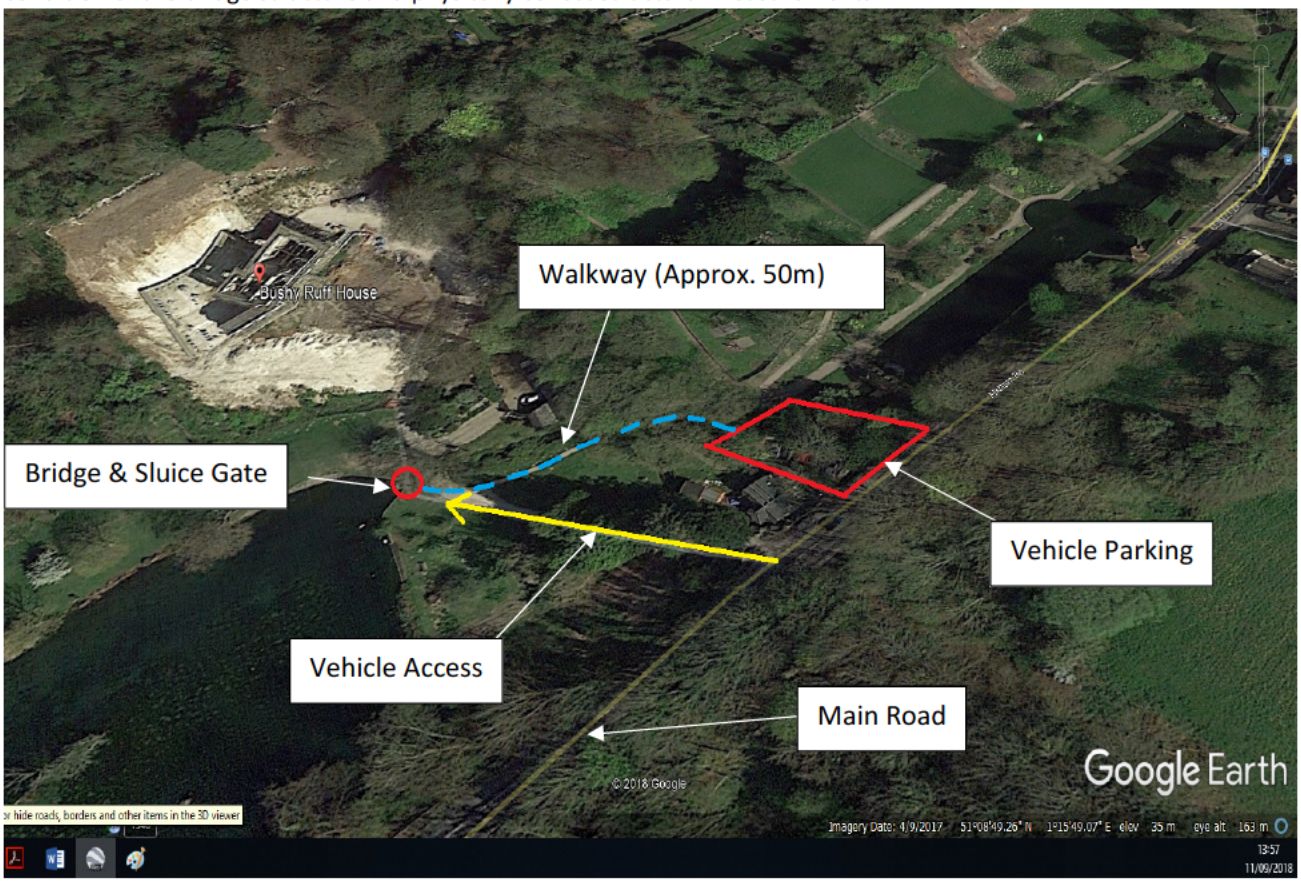
In order to establish the material thicknesses and ascertain material composition and condition an intrusive survey was undertaken from the top of the bridge. A 10mm drill bit was used to drill sections of the road to ascertain the thickness of the road covering and the road build up between the arch barrel and the road covering (location 'h' on the above illustration) Three areas were drilled along the arch midpoint. The arch barrel thickness (d) was ascertained by continuing the drill through the existing drilled hole until the drill bit penetrated the underside of the arch barrel.

Once drilling was completed, to prevent water ingress the resulting holes were filled with quick drying cement.

BA 16/97 section 3.5 particulars and survey instructions are detailed overleaf.

1. Introduction:

Swantest have been appointed by C.H.P.to carry out a condition survey and structural assessment on an access bridge in Bushy Ruff, Temple Ewell, Dover CT16 3EE. This was a general visual inspection to establish the current condition of the bridge structure and physically collect structural measurements.



Bushy Ruff Bridge

This report is based on a full structural survey in accordance with Chapter 2 of BD 21 (DMRB 3.4.3) in which the following sections were surveyed as per BA 16/97 section 3.5.

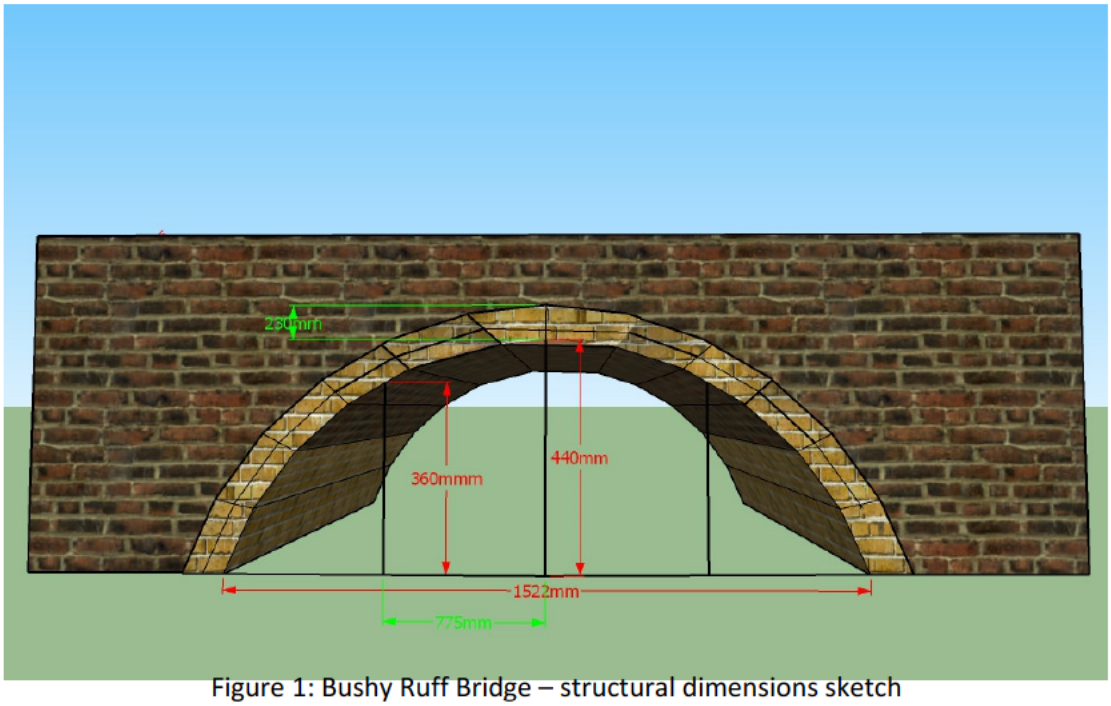


Figure 1: Bushy Ruff Bridge – structural dimensions sketch

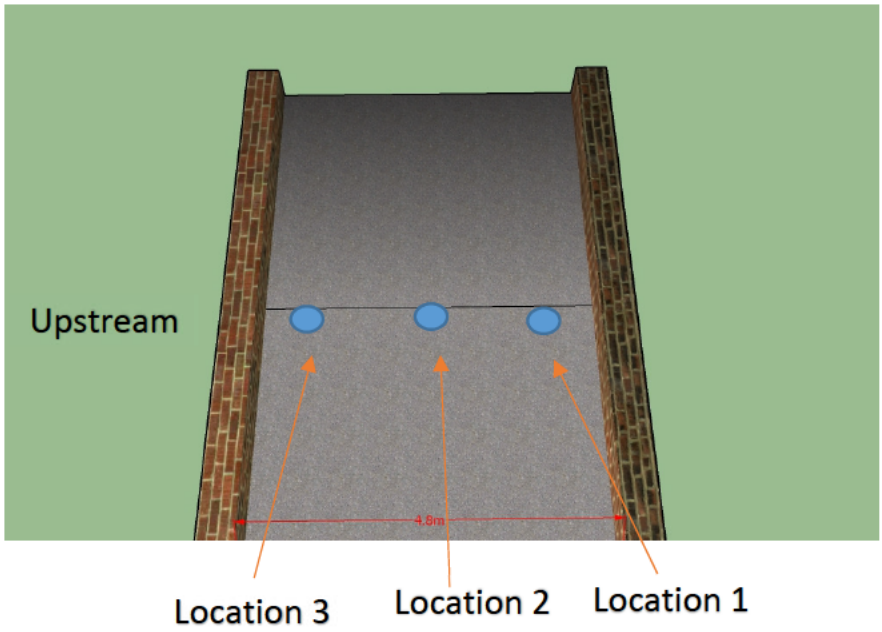
The span of the arch (L)
L = 1522mm

The rise of the arch barrel at the crown (Rc)
Rc = 440mm

The rise of the arch barrel at the quarter points (Rq)
Rq= 360mm

The thickness of the arch barrel adjacent to the keystone (d)
d= 230mm

The average depth of fill at various locations (h); Below blue dots represent where 10mm drilled holes were executed and depth of fill measured



Location 1 downstream – 250mm
Location 2 midpoint – 370mm
Location 3 upstream – 510mm

Type of materials used for the arch barrel
Brick and mortar

Dimensions of joints
10mm mortar joints

General condition of all materials
Good condition of brickwork and mortar joints

All defects found during inspection are represented bellow with red dots and detailed with exact location pictures attached.

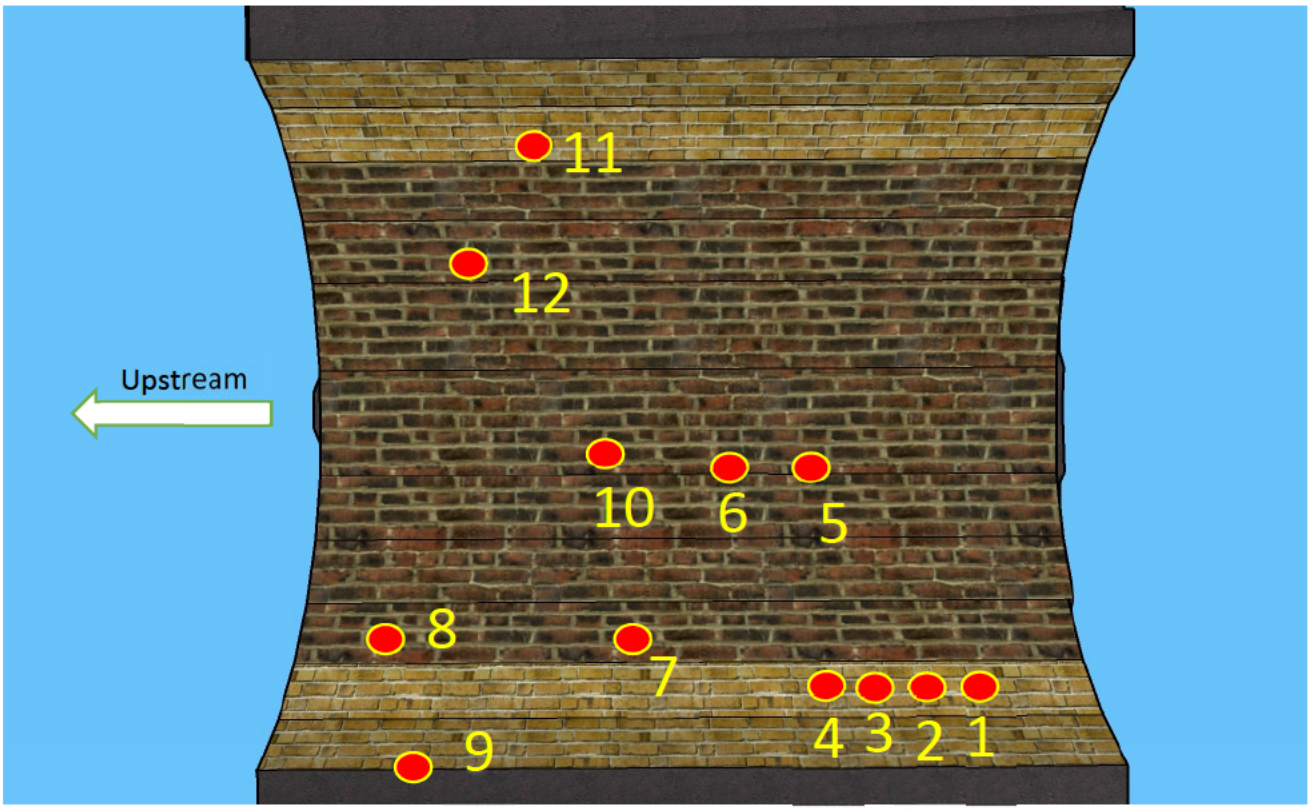


Figure 1: Bushy Ruff Bridge – soffit layout sketch

1.- 1st brickwork layer on barrel -585mm from downstream entrance

Figure 2: Brick cracked and spilling section

2.- 1st brickwork layer on barrel -1100mm from downstream entrance

Figure 3: Brick cracked and spilling section

3.- 1st brickwork layer on barrel -1400mm from downstream entrance

Figure 4: Brick cracked and spilling section

4.- 1st brickwork layer on barrel -1800mm from downstream entrance

Figure 5: mortar missing and moistness infiltration

5.- top centre of the barrel -1700mm from downstream entrance

Figure 6: mortar missing and moistness infiltration

6.- top centre of the barrel -2600mm from downstream entrance

Figure 7: mortar missing and moistness infiltration

7.- 4th layer of the barrel -3800mm from downstream entrance

Figure 8: mortar missing

8.- crack from top to ¼ of the barrel -4400mm from downstream entrance

Figure 9: vertical crack on 8 brick layers

9. -crack in calcium build-up of the barrel -3300mm from downstream entrance

Figure 10: cracking surface in calcium build up

10. – 3300mm from downstream entrance

Figure 11: mortar missing from top centre joint – barrel midpoint

11.- 4500mm from downstream entrance

Figure 12: diagonal crack from bottom to top of side wall on calcium build up

12.- 4500mm from downstream entrance

Figure 13: diagonal crack from bottom of side wall to 1/3 of barrel height and water infiltration



Figure 2: Brick cracked and spilling section



Figure 3: Brick cracked and spilling section



Figure 4: Brick cracked and spilling section



Figure 5: mortar missing and moistness infiltration



Figure 6: mortar missing and moistness infiltration



Figure 7: mortar missing and moistness infiltration



Figure 8: mortar missing



Figure 9: vertical crack on 8 brick layers



Figure 10: cracking surface in calcium build up



Figure 11: mortar missing from top centre joint – barrel midpoint



Figure 12: diagonal crack from bottom to top of side wall on calcium build up



Figure 13: diagonal crack from bottom of side wall to 1/3 of barrel height and water infiltration



Figure 14: general condition us stream side of barrel

