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STAGE 1 STRUCTURAL ASSESSMENT REPORT
BRIDGE REF. LM-LP3400-001.00
HARTLEY BRIDGE

JANUARY 2016

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Civil Engineering
Structural Engineering
Traffic & Transportation
CDM Co-ordination
Project Management

STAGE 1 STRUCTURAL ASSESSMENT REPORT
BRIDGE REF. LM-LP3400-001.00, HARTLEY BRIDGE

JANUARY 2016

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EXECUTIVE SUMMARY

Hartley Bridge (LM-LP3400-001.00) is located in the town land of Hartley on the LP3400 in County Leitrim, approximately 2km north of Carrick-on-Shannon. Hartley Bridge, which is located on the Co. Leitrim/Roscommon border on the River Shannon, was constructed in 1915 making it one of the first reinforced concrete bridges in Ireland. The bridge consists of eight spans, six (Spans 1 to 6) of which form one structure, with the remaining two spans (Spans 7 and 8) forming a separate abutting structure. Span lengths vary from 7.2m to a maximum of 12.3m.

This report presents the findings of the condition inspection and structural assessment of Spans 1 to 6 of Hartley Bridge. Spans 7 and 8 were not assessed, as no information is currently available for this separate structure. The condition inspection was carried out using boat access. The structural assessment was undertaken using structural details provided in the Electricity Supply Board (ESB) Hartley Bridge Structural Report, dated May 1984. No additional structural opening up or material testing was completed as part of this assessment, as per the requirements of our brief. No structural information was available for the separate two-span section and a structural assessment of this section was not therefore completed. A summary of the results of the structural assessment are presented in the table below.

Structure ID	Name	No of Spans	Span (m)	Structure Type	Assessed Capacity
LM-LP3400-001.00	Hartley Bridge	6-span section	62.2m (6-span section) 72.05m (overall length)	Reinforced concrete	< 3 tonnes

This Structural Assessment of the six-span structure indicates that of the six major components of the structure (deck slab, transverse deck beam, parapet beam, columns, diagonal brace and the horizontal tie), five of these fail the Stage 1 Assessment, with only the horizontal tie section being of sufficient capacity to carry the imposed loading. Of these five components, three elements; the deck slab, transverse deck beam and parapet beam, received a rating of < 3 tonnes live load carrying capacity. One section of the structure, the parapet beam, was assessed as being unable to support its own self weight under shear. It should be noted that further opening up works would be required to determine the reinforcement in this element to more accurately assess the shear capacity. Generally, the results from this assessment are in line with those found in the ESB Structural Report of 1984.

The following works are recommended for this structure:

- More comprehensive opening up works to determine reinforcement in the structural elements of both the main six-span structure and the separate two-span structure.
- More comprehensive materials testing in each structural element.
- A Stage 2 Assessment, based on the findings of the above. This should include the separate two-span structure (Spans 7 and 8).

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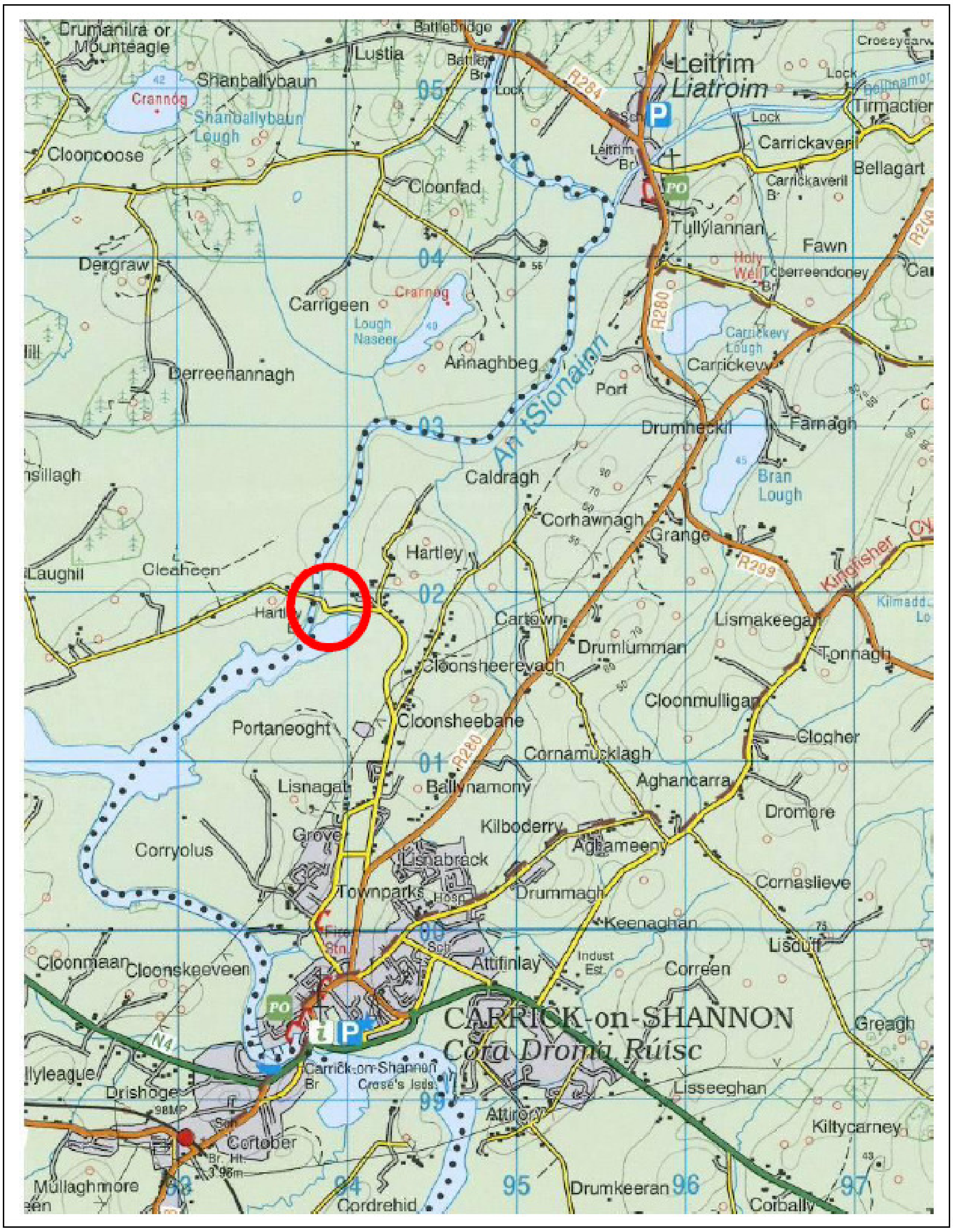
LOCATION MAP



Coordinates:

Northing - 301954.406

Easting - 193834.067

1.0 INTRODUCTION

1.1. Doran Consulting Ltd was commissioned by Leitrim County Council to undertake a Stage 1 Structural Assessment of Hartley Bridge.

1.2. In December 2012, Doran Consulting Ltd completed a Principal Inspection of Hartley Bridge. The bridge achieved an overall Condition Rating of 4.

1.3. Hartley Bridge was constructed in 1915 and comprises of two sections; a six-span reinforced concrete integral structure and an adjoining two-span cast in/situ reinforced concrete structure butting the six-span structure to the west. All components of the structure are composed of reinforced concrete.

1.4. Both the six-span section and two-span section of the structure consists of:

- Reinforced concrete deck slab,
- Reinforced concrete transverse deck beams,
- Reinforced concrete parapet beams,
- Reinforced concrete columns with reinforced concrete diagonal bracing and reinforced concrete horizontal ties.

1.5. The Structural Assessment has been undertaken using Tedds Software by Tekla to assess the parapet beam sections of the structure. In addition, the software Masterseries Masterframe by Civil and Structural Computer Services Ltd has also been used to assess the columns, braces and ties. Elastic Analysis of the reinforced concrete sections has been undertaken to determine their Elastic Bending Capacities and Shear Capacities.

1.6. The brief for this report is to assess the load carrying capacity of the main six-span structure in accordance with NRA BD 21/14 and NRA BD 44/14. The live loading applied to the bridge is the 40-tonne assessment live loading. The adjoining two-span structure has not been assessed, as there is currently no information available for this separate structure.

1.7. The following documents were used in the assessment of Bridge Ref. LM-LP3400-001.00. Hartley Bridge:

National Roads Authority Publications

NRA BD 21/14	The Assessment of Road Bridges and Structures (including Erratum No. 1, dated December 2014)
NRA BD 44/14	The Assessment of Concrete Road Bridges and Structures

Electricity Supply Board Reports

Hartley Bridge, Structural Report, May 1984

Leitrim County Council Drawings

Drawing No. 214/24 Hartley Bridge, Carrick-on-Shannon

Doran Consulting Reports

Principal Inspection and Inventory Gathering of Leitrim County Council Bridge Network Hartley Bridge, LM-LP3400-001.00, October 2013

2.0 DESCRIPTION OF STRUCTURE

2.1 Structure: Ref, LM-LP3400-001.00, Hartley Bridge

2.1.1 Basic Details and Dimensions

Route Number	:	LP3400
OS Reference	:	301954.406 N 193834.067 E
Bridge Ref:	:	LM-LP3400-001.00
Bridge Name	:	Hartley Bridge
Number of spans	:	8
Number of sections	:	2
Total length	:	72.05m
Span Lengths	:	Span 1 - 7.00m Span 2 - 10.37m Span 3 - 11.82m Span 4 - 10.41m Span 5 - 10.39m Span 6 - 10.39m Span 7 - 3.64m* Span 8 - 3.68m* *Note: Spans 7 and 8 were not assessed
Angle of skew	:	0 degrees
Overall bridge width	:	5.84m
Carriageway width	:	3.97m
Verge widths (Grass)	:	North – 0.31m South – 0.31m

2.2 Bridge Components

2.2.1 Deck Slab : Reinforced concrete deck slab, 6" (152mm) deep with top reinforcement of ½"Ø (12.7mm) bars at 9½" (241mm) centres and bottom reinforcement of ½"Ø (12.7mm) bars at 4¾" (121mm) spacing.

2.2.2	*Transverse Deck Beam*	:	Transverse deck beams of reinforced concrete measuring 8" x 5" (203mmx127mm), reinforcement of 2x'Moss bars' and 1x 1"Ø (25mm) bar.
2.2.3	*Parapet Beam*	:	Parapet Beams of reinforced concrete are 70" x 12" (1778mm x 305mm). Beams are reinforced as follows; Bottom at mid-span outer 3xMoss bars, 3xØ25mm bars and 1x22mm bar. Bottom at mid-span inner 3xMoss bars, 3x1"Ø (25mm) bars and 2x22mm bars. Top at mid span 2xMoss bars and 2x7/8"Ø (22mm) bars. Top at supports 2xMoss bars.
2.2.4	*Column*	:	Reinforced concrete columns measuring 15"x18" (381mmx457mm), reinforcement consists of 6x3/4"Ø (19.1mm) bars with 3/16" (4.76mm) links at 6" (150mm) centres.
2.2.5	*Diagonal Brace*	:	Diagonal braces connect the columns and measure 12"x10" (305mmx254mm), reinforcement consists of 4x ½"Ø (12mm) bars with 3/16" (4.7mm) links at 10" (225mm) centres.
2.2.6	*Horizontal Tie*	:	Horizontal Ties also connect the columns and measure 10"x10" (254mmx254mm), reinforcement consists of 4x ½"Ø (12mm) bars with 3/16" (4.7mm) links at 10" (225mm) centres.
2.4	Abutments/Wing Walls	:	Concrete abutment - East side, earthwork revetment abutment on the west side.

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2.5	Construction Materials	:	Reinforced concrete. Concrete strengths used in assessment: Concrete compressive strength = 25 N/mm^2 Reinforcement yield strength = 250 N/mm^2 Material properties are taken from ESB Structural Report 1984.
2.6	Depth of fill over structure	:	No fill over structure.

3.0 CONDITION OF STRUCTURE

A condition survey was carried out as part of the 2012 Principal Inspection works completed by Doran Consulting. Photographs from this assessment are provided in Appendix A.

3.1 General

The structure is in poor condition with significant areas of spalled concrete to the deck, the parapet beams and the transverse deck beams. Reinforcement is exposed and corroded.

3.2 Surfacing

The carriageway surfacing is in good condition.

3.3 Footways/verges

There are grass verges on both sides of this bridge; no footways are provided.

3.4 Parapets

Parapets consist of the main structural parapet beams which are reinforced concrete. Spalled concrete and exposed reinforcement is a regular occurrence along the length of the parapet beams.

3.5 Deck Slab

There is severe spalling of concrete with corroded reinforcement throughout the entire soffit.

3.6 Transverse Deck Beams

There is widespread spalling of the concrete and exposed reinforcement.

3.7 Piers (Columns, Diagonal Braces and Horizontal Ties)

Piers are generally in a fair condition with some minor areas of spalled concrete and cracking to the concrete cover.

3.8 Abutments

East abutment - spalling of concrete and exposure of reinforcement.
West abutment - transverse member is spalled and reinforcement is exposed and corroded.

3.9 Other Elements - Separate 2 span structure

There are minor areas of spalling throughout.

3.10 The 2012 Principal Inspection assigned the bridge a Condition Rating of 4; poor condition.

4.0 STRUCTURAL INVESTIGATION RESULTS

4.1 No Structural Investigation works were completed for this Assessment, as per the requirements of our brief.

4.2 Yield strength of reinforcement and compressive strength of concrete have been taken from ESB Structural Report 1984. Copies of these Assessment results are included in Appendix B.

4.3 Material Properties are as follows:

- Worst Credible Concrete Compressive Strength = 25 N/mm^2
- Yield Strength of Reinforcement = 250 N/mm^2

5.0 ASSESSMENT METHODOLOGY

5.1 Loading

40-tonne Assessment Loading has been applied to each element of the structure in accordance with NRA BD 21/14, *The Assessment of Road Bridges and Structures* and NRA BD 37/01, *Loads for Highway Bridges*.

The abutments have not been subject to a quantitative assessment; these elements have been assessed qualitatively, based on their condition.

5.2 Loading Parameters

Number of Nominal Lanes	:	1
Road Class	:	Local
Traffic Volume Category	:	Low
Road Condition	:	Good

Partial Factors for Loads

Permanent Dead Load – Concrete	:	1.15
Superimposed DL – Fill	:	1.20
Superimposed DL – Surfacing	:	1.75
Live Load Factor	:	1.50
Load Effects Factor	:	1.10

5.3 Load Cases

The following basic load cases have been considered:

A Dead load and Superimposed Dead Load

B 40 tonne Assessment Live Load (UDL and KEL)

C 40 tonne Assessment Live Load (Single Axle)

5.4 The following typical load case combinations were considered:

1) A+B: 40 tonne Assessment Load (UDL&KEL)
2) A+C: 40 tonne Assessment Load (Single Axle)

Each load case combination was positioned at a number of locations to achieve the highest Bending Moment and Shear force.

5.5 Nominal Loads

5.5.1 Dead Load (un-factored)

Deck slab Assessment Calculation
Self weight reinforced concrete slab : 3.648 kN/m/m

Parapet Beam Assessment Calculation
Self weight reinforced concrete sections : 24.67 kN/m (per beam)

Column, Diagonal Brace & Horizontal Tie Calculations
Self weight reinforced concrete slab : *self weight included in model*

5.5.2 Superimposed dead load (un-factored)

Deck slab Assessment Calculation
Self weight of surfacing : 1.92 kN/m/m

Parapet Beam Assessment Calculation
Self weight of surfacing : 5.02 kN/m

Column, Diagonal Brace & Horizontal Tie Calculations
Self weight of surfacing : 1.87 kN/m^2

5.5.3 Live Load

Assessment Live load (un-factored)

Deck slab Assessment Calculation	
Single Wheel	Lg = 82 kN
Deck Beam Assessment Calculations	
HA UDL & KEL	UDL = 28.8 kN/m
	KEL = 27.7 kN/m
Single Axle	Lg = 82 kN
Parapet Beam Assessment Calculations	
HA UDL & KEL	UDL = 10.1 kN/m
	KEL = 50.6 kN/m
Single Axle	Lg = 82 kN
Column, Diagonal Brace & Horizontal Tie Calculations	
HA UDL & KEL	UDL = 6.53 kN/m^2
	KEL = 32.9 kN/m

6.0 ASSESSMENT RESULTS

6.1 Deck Superstructure

6.1.1 General

The results of the Structural Assessment of the main six-span structure of Hartley Bridge, LM-LP3400-001.00, are presented below. Each component of the bridge was assessed individually for bending, shear and axial forces, where applicable. Bending effects are given in kNm, shear in kN and axial forces in kN.

Due to its poor condition of the structure, a Condition Factor of **0.80** has been used in the assessment of the bridge, in the determination of member capacities in bending, shear and axial load.

Assessment calculations can be found in Appendix C.

6.1.2 Assessment Rating - six-span section

An Assessment Rating (AR) is presented for each structural element under each of the Loadcase Combinations considered. An AR of less the unity (1.00) indicates that the capacity of the structure exceeds the applied loading effect. Values of AR greater than 1.00 are highlighted in **red bold text**.

6.1.2.1 Deck Slab

Table 1: Single Wheel (40 tonne) Assessment Loading Results for Deck Slab component, shows the results of the Single Wheel Assessment Loading for the deck slab in bending and shear. The calculated maximum Assessment Rating for the deck slab component was **3.97**, in hogging Bending Moment.

Loadcase Combination	Applied Loading (kNm)/(kN)	Capacity (kNm)/(kN)	AR
Single Wheel (40t) - Moment Sagging	37.1	18.34	**2.02**
Single Wheel (40t) - Moment Hogging	37.6	9.47	**3.97**
Single Wheel (40t) - Shear	106.1	79.14	**1.34**

Table 1: Single Wheel (40 tonne) Assessment Loading Results for Deck Slab component

The Deck Slab elements of Hartley Bridge have therefore been assessed as being incapable of sustaining the effects of the 40 tonne assessment loading; the element is overstressed by 297%, in hogging moment.

Based on these results the deck slab component of the structure has a reduced Live Load capacity of < 3 tonnes.

6.1.2.2 Transverse Deck Beams

Table 2: 40 tonne (HA) Assessment Loading Results for Transverse Beam component, shows the results of the 40 tonne Assessment Loading for the transverse deck beam in bending and shear. The calculated maximum Assessment Rating for the transverse deck beam component was **2.90**, in Shear.

Loadcase Combination	Applied Loading (kNm)/(kN)	Capacity (kNm)/(kN)	AR
HA UDL+KEL (40t)- Moment	332.35	127.85	**2.60**
HA UDL+KEL (40t)- Shear	187.61	65.11	**2.90**

Table 2: 40 tonne (HA) Assessment Loading Results for Transverse Beam component

The Transverse Deck Beam element of Hartley Bridge has therefore been assessed as being incapable of sustaining the effects of the 40 tonne assessment loading; the element is overstressed by 190%, in shear.

Based on these results the transverse deck beam component of the structure has been assessed as having a reduced Live Load capacity of < 3 tonnes.

Table 3: Single Axle Assessment Loading Results for Transverse Beam component, shows the results of the Single Axle Assessment Loading for the deck beam in bending and shear. The calculated maximum Assessment Rating for the transverse deck beam component was in **3.90**, in Shear.

Loadcase Combination	Applied Loading (kNm)/(kN)	Capacity (kNm)/(kN)	AR
Single Axle (40t)- Moment	399.1	127.85	**3.12**
Single Axle (40t)- Shear	253.99	65.11	**3.90**

Table 3: Single Axle Assessment Loading Results for Transverse Beam component

The Transverse Deck Beam element of Hartley Bridge has therefore been assessed as being incapable of sustaining the moment and shear effects of the Single Axle 40 tonne assessment loading; the element is overstressed by 290%, in shear.

Based on these results the transverse deck beam component of the structure has a reduced Live Load capacity of < 3 tonnes.

6.1.2.3 Parapet Beam

Table 4: Assessment Loading Results for Parapet Beam, shows the results of the Assessment Loadings for the parapet beam in bending and shear. The calculated maximum Assessment Rating for the parapet beam component was **2.77**, in Shear under the Single Axle loading.

Loadcase Combination	Applied Loading (kNm)/(kN)	Capacity (kNm)/(kN)	AR
HA UDL+KEL (40t) - Moment sagging	425.0	1306.48	0.36
HA UDL+KEL (40t) - Moment hogging	664.5	557.37	1.19
HA UDL+KEL (40t) - Shear	339.0	138.84	2.44
Single Axle (40t) - Moment sagging	507	1306.48	0.39
Single Axle (40t) - Moment hogging	684	557.37	1.23
Single Axle (40t) - Shear	372	138.84	2.77

Table 4: Assessment Loading Results for Parapet Beam

The Parapet Beam element of Hartley Bridge has therefore been assessed as being incapable of sustaining the hogging moment and shear effects of the 40 tonne assessment loading, the element is overstressed by 177% in shear.

Based on these results the parapet beam component of the structure has a reduced Live Load capacity of <u>< 3 tonnes.</u>

6.1.2.4 Columns

Table 5: 40 tonne Assessment Loading Results for Column (Pier) component, shows the results of the 40 tonne Assessment Loading for the column component. The calculated maximum Assessment Rating for the column component was **1.41**.

Loadcase Combination	Applied Loading (kNm)/(kN)	Capacity (kNm)/(kN)	AR
HA (40t) UDL + KEL - Moment & Axial combined	58.05 kNm 822.31 kN	105.82 kNm 949.87 kN	1.41

Table 5: 40 tonne Assessment Loading Results for Column (Pier) component

The Column element of Hartley Bridge has therefore been assessed as being incapable of sustaining the effects of the 40 tonne assessment loading; the element is overstressed by 41% in combined bending and axial load.

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6.1.2.5 Diagonal Brace

Table 6: 40 tonne Assessment Loading Results for Diagonal Brace, shows the results of the 40 tonne Assessment Loading for the diagonal brace component. The calculated maximum Assessment Rating for the diagonal brace component was **1.19**.

Loadcase Combination	Applied Loading (kNm)/(kN)	Capacity (kNm)/(kN)	AR
HA (40t) UDL + KEL - Moment & Axial combined	21.22 kNm 140.83 kN	26.13 kNm 376.83 kN	**1.19**

Table 6: 40 tonne Assessment Loading Results for Diagonal Brace

The Diagonal Brace element of Hartley Bridge has therefore been assessed as being incapable of sustaining the combined axial and moment effects of the 40 tonne assessment loading, the element is overstressed by 19%.

6.1.2.6 Horizontal Tie

Table 7: 40 tonne Assessment Loading Results for Horizontal Tie component, shows the results of the 40 tonne Assessment Loading for the tie component. The calculated maximum Assessment Rating for the horizontal tie component was 0.81.

Loadcase Combination	Applied Loading (kNm)/(kN)	Capacity (kNm)/(kN)	AR
HA (40t) UDL + KEL - Axial Force	63.72	78.68	0.81

Table 7: 40 tonne Assessment Loading Results for Horizontal Tie component

Based on these results, the horizontal ties sustain the full effects of the 40 tonne Assessment Loading, with a reserve capacity of 19% available.

6.2 Parapets

The existing parapet beams do not comply with the current guidelines for vehicle containment.

6.3 Abutments

The concrete and earth retaining abutments supporting the structure were not assessed quantitatively, but were assessed qualitatively based on their condition. The east side abutment has some concrete spalling and reinforcement exposure, some concrete repair work is required. The west side abutment is of unusual construction consisting of concrete piers and an earth revetment. There is concrete spalling to the transverse member and reinforcement exposure concrete repairs are required. The abutments are considered to be adequate.

7.0 CONCLUSIONS

7.1. The six-span section (Spans 1 to 6) of Bridge Ref: LM-LP3400-001.00, Hartley Bridge, has been subject to a Stage 1 Structural Assessment. Each component of the structure has been assessed for the effects of the 40 tonne Assessment Loading at the Ultimate Limit State.

7.2. The results of the assessment are summarised as follows:

7.2.1. Deck Slab

The deck slab component of the structure fails 40tonne Assessment Loading for Single Wheel Loading. The critical failure mode is hogging bending moment and the calculated maximum Assessment Rating for this component is **3.97**. The deck slab cannot sustain the effects of the 40 tonnes Assessment loading and a reduced assessment live load capacity of < 3 tonnes has been calculated for this component.

7.2.2. Transverse Deck Beam

The transverse deck beam component of the structure fails 40t Assessment Loading for HA (UDL+KEL) and Single Axle Loading. The critical failure mode is shear and the calculated maximum Assessment Rating for this component is **3.90**. The transverse deck beam cannot sustain the effects of the 40 tonnes Assessment loading and a reduced assessment live load capacity of < 3 tonnes has been calculated for this component.

7.2.3. Parapet Beam

The parapet beam component of the structure fails 40t Assessment Loading for HA (UDL+KEL) and Single Axle Loading. Of these, the critical failure mode was shear in both load conditions and the calculated maximum Assessment Rating is **2.77**. The parapet beam cannot sustain the effects of the 40 tonnes Assessment loading and a reduced assessment live load capacity of < 3 tonnes has been calculated for this component.

7.2.4. Column

The Columns of the structure fail 40t Assessment Loading for HA (UDL+KEL). The columns were assessed for combined bending moment and axial capacity. The calculated maximum Assessment Rating for this component is **1.41**.

7.2.5. Diagonal Brace

The diagonal braces, which connect adjacent columns of the structure, failed the 40t Assessment Loading for HA (UDL+KEL). The columns were assessed for combined bending moment and axial capacity. The calculated maximum Assessment Rating for this component is **1.19**.

7.2.6. Horizontal Tie

The horizontal ties, which connect adjacent columns of the structure, passed the 40t Assessment Loading for HA (UDL+KEL). The calculated maximum Assessment Rating is **0.81**.

7.2.7. Summary

In its current condition Hartley Bridge fails the Stage 1 Structural Assessment for 40 tonne Assessment Loading. Only the horizontal tie element of the bridge can support the 40 tonne Assessment Loading.

The reduced live load carrying capacity of Hartley Bridge was calculated to be **< 3 tonnes**.

7.3. The two-span section of the bridge was not assessed in this Structural Assessment, further details and investigation of this section of the structure would be required to attain the necessary data to complete a structural assessment.

7.4. The abutments are deemed adequate, based on their condition.

8.0 RECOMMENDATIONS

The following works are recommended for this structure:

8.1 More comprehensive opening up works to determine reinforcement in the structural elements of both the main six-span structure and the separate two-span structure.

8.2 More comprehensive materials testing in each structural element.

8.3 A Stage 2 Assessment, based on the findings of the above. This should include the separate two-span structure.

Campbell Davis
Technical Director
Doran Consulting
January 2016
Our Ref: aig/121065B

David Whiteside
Associate
Doran Consulting

APPENDIX A

Photographs

Photograph 1: Carriageway over.

Photograph 2: Parapet with bridge reference plate.

Photograph 3: View along verge & parapet.

Photograph 4: West side abutment with earth revetment.

Photograph 5: Abutment and soffit.

Photograph 6: East side abutment.

Photograph 7: Soffit showing spalled concrete and exposed rebar.

Photograph 8: Soffit showing spalling.

Photograph 9: Soffit, exposed reinforcement.

Photograph 10: Elevation, showing columns.

Photograph 11: Height restriction sign.

Photograph 12: Bridge mid section, largest single span.

APPENDIX B

Site Investigation Results

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Appendix B not used

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APPENDIX C

Calculations

Calculations

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HARTLEY CANAL BRIDGE

LM-LP3400-001.00

STRUCTURAL ASSESSMENT

JOB No. 121065 B

JANUARY 2016

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A MATERIAL PROPERTIES.

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Project HARTLEY BRIDGE – SAR			Job No. 121065B
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1.0 INTRODUCTION

DORAN CONSULTING HAVE BEEN COMMISSIONED BY LEITRIM COUNTY COUNCIL TO UNDERTAKE A STRUCTURAL ASSESSMENT OF HARTLEY CANAL BRIDGE, LM-LP3400-001.00.

HARTLEY BRIDGE, CONSTRUCTED IN 1915, CARRIES LOCAL ROAD LP3400 OVER THE RIVER SHANNON.

HARTLEY BRIDGE IS AN EIGHT-SPAN REINFORCED CONCRETE BRIDGE. THE BRIDGE IS MADE UP OF TWO DISTINCT SECTIONS: A SIX-SPAN CAST IN-SITU REINFORCED CONCRETE INTEGRAL STRUCTURE AND A TWO-SPAN RC STRUCTURE.

DORAN CONSULTING COMPLETED A PRINCIPAL INSPECTION OF HARTLEY BRIDGE ON 6 NOVEMBER 2012.

Comment

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DELIVERING ENGINEERING EXCELLENCE

Project HARTLEY BRIDGE			Job No. 121065B
Date JAN 16	Made by GW	Checked by	Page 2 of 88

2.0 ASSESSMENT INFORMATION

THE FOLLOWING DOCUMENTS WERE MADE AVAILABLE FOR THE ASSESSMENT:

- HARTLEY BRIDGE STRUCTURAL REPORT, ESB, MAY 1984
- LEITRIM COUNTY COUNCIL DRAWING No. 214/24, Hartley BRIDGE CARRICK-ON-SHANNON, 05/05/1986
- PRINCIPAL INSPECTION REPORT, HARTLEY CANAL BRIDGE, LM-LP3400-001.00, OCTOBER 2013

Comment

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3.0 BRIDGE DETAILS

A STRUCTURAL ASSESSMENT WILL BE COMPLETED FOR EACH BRIDGE ELEMENT, WHICH ARE LISTED AS FOLLOWS:

- TYPE 1 MEMBER : COLUMN
- TYPE 2 MEMBER : DIAGONAL BRACE
- TYPE 3 MEMBER : TIE
- TYPE 4 MEMBER : PARAPET BEAM
- TYPE 5 MEMBER : DECK BEAM
- TYPE 6 MEMBER : CROSS BEAM AT PIER A.

Comment

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Project HARTLEY BRIDGE - SAR			Job No. 121065B
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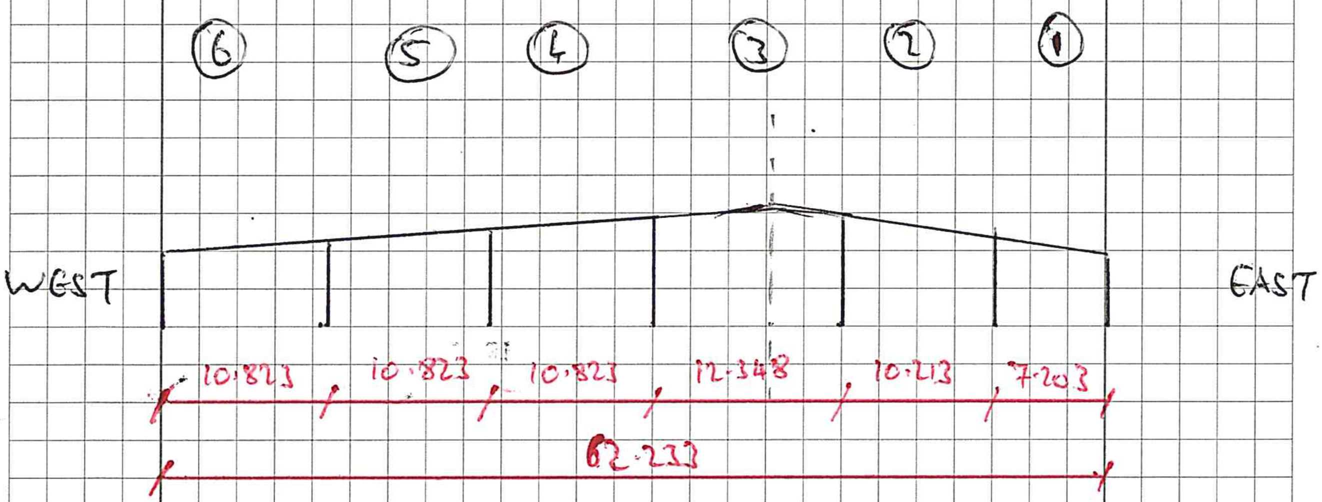
3.0 BRIDGE DETAILS.

HARTLEY BRIDGE WILL BE ASSESSED USING THE ESB 1984 DIMENSIONS.



Comment

Calculations

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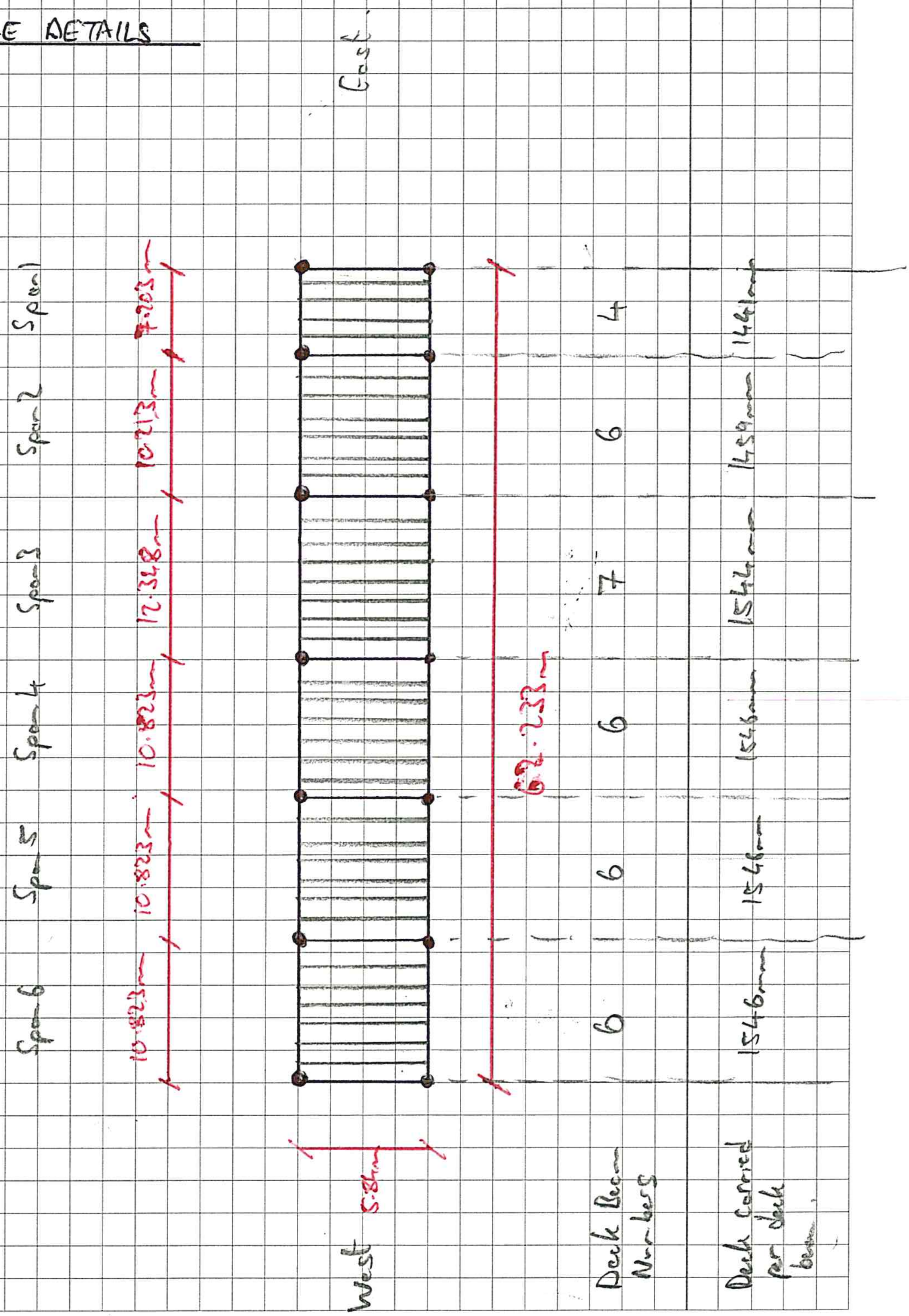
Project	HARTLEY BRIDGE - SAR	Job No.	121065B
Date JAN 16	Made by GW	Checked by	Page 5 of 88

3.0 BRIDGE DETAILS



Comment

3.0 BRIDGE DETAILS

6 of 88

5.243×10^11

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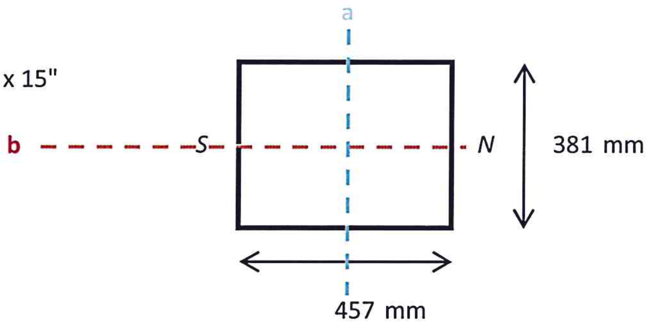
	Job Number:	121065B
	Date:	Jul-14
	Made By	AIG
	Checked By:	SJQ
	Calculation:	Member Properties

References	Calculation	Notes

Type 1 Member: **Column**

18" x 15"



Moment of Area

Iaa $I = \dfrac{bd^3}{12}$

b	=	381	mm
d	=	457.2	mm
Iaa	=	3.034E+09	mm^4 ✓

Ibb $I = \dfrac{bd^3}{12}$

b	=	457.2	mm
d	=	381	mm
Iaa	=	2.107E+09	mm^4 ✓

Area, A

b	=	457.2	mm
d	=	381	mm
A	=	174193.2	mm^2 ✓

Torsional Moment of Inertia, I_E

$$I_E \approx db^3\left(\frac{1}{3} - 0.21\frac{b}{d}\left(1 - \frac{b^4}{12d^4}\right)\right)$$

gives I_E to an accuracy of an error not greater than 4%
where b is the shorter length & d the longer

$I_G = 457.2 \times 381^3\left(\frac{1}{3} - 0.21 \times \frac{381}{457.2}\left(1 - \frac{381^4}{12 \times 457^4}\right)\right)$

$= 2.529 \times 10^{10}\left(\frac{1}{3} - 0.175\left(0.9598\right)\right)$

$I_G = 4.182 \times 10^9$

b	=	381	mm
d	=	457.2	mm
I_E	=	4.181E+09	mm^4 ✓

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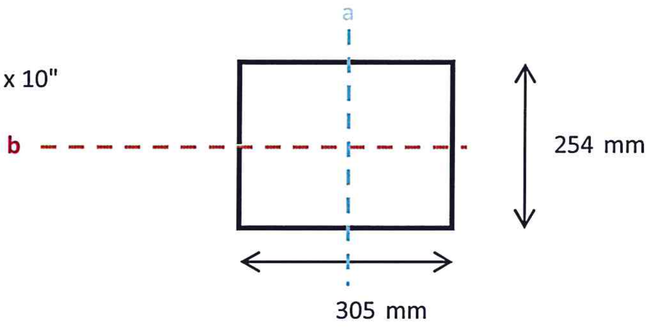
	Job Number:	121065B
	Date:	Jul-14
	Made By	AIG
	Checked By:	SJQ
	Calculation:	Member Properties

References	Calculation	Notes

Type 2 Member: Diagonal Brace

12" x 10"



Moment of Area

Iaa $I = \frac{bd^3}{12}$

b = 254 mm
d = 304.8 mm

Iaa = 599373253 mm^4

Ibb $I = \frac{bd^3}{12}$

b = 304.8 mm
d = 254 mm

Iaa = 416231426 mm^4

Area, A

b = 304.8 mm
d = 254 mm

A = 77419.2 mm^2

Torsional Moment of Inertia, I_E

$$I_E \approx db^3\left(\frac{1}{3} - 0.21\frac{b}{d}\left(1 - \frac{b^4}{12d^4}\right)\right)$$

gives I_E to an accuracy of an error not greater than 4%
where b is the shorter length & d the longer

b = 254 mm
d = 304.8 mm

I_E = 825967264 mm^4

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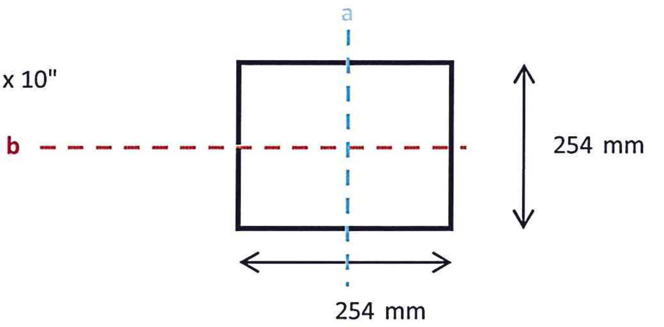
	Job Number:	121065B
	Date:	Jul-14
	Made By	AIG
	Checked By:	SJQ
	Calculation:	Member Properties

References	Calculation	Notes

Type 3 Member: Tie

10" x 10"



Moment of Area

Iaa $I = \dfrac{bd^3}{12}$

b = 254 mm
d = 254 mm

Iaa = 346859521 mm^4 ✓

Ibb $I = \dfrac{bd^3}{12}$

b = 254 mm
d = 254 mm

Iaa = 346859521 mm^4 ✓

Area, A

b = 254 mm
d = 254 mm

A = 64516 mm^2 ✓

Torsional Moment of Inertia, I_E

$$I_E \approx db^3\left(\frac{1}{3} - 0.21\frac{b}{d}\left(1 - \frac{b^4}{12d^4}\right)\right)$$

gives I_E to an accuracy of an error not greater than 4%
where b is the shorter length & d the longer

b = 254 mm
d = 254 mm

I_E = 586192591 mm^4

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Date:	Jul-14
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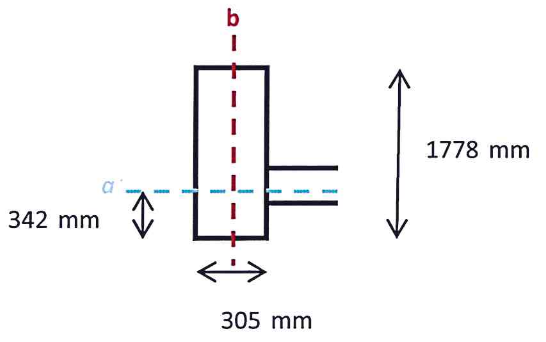
Checked By:	SJQ
Calculation:	Member Properties

References	Calculation	Notes

Type 4 Member: **Parapet Beam**



Moment of Area

Iaa $I = \frac{bd^3}{12}$

b = 1778 mm
d = 304.8 mm

Iaa = 4.196E+09 mm^4

Ibb $I = \frac{bd^3}{12}$

b = 304.8 mm
d = 1778 mm

Iaa = 1.428E+11 mm^4

Area, A

b = 304.8 mm
d = 1778 mm

A = 541934.4 mm^2

Torsional Moment of Inertia, I_E

$$I_E \approx db^3\left(\frac{1}{3} - 0.21\frac{b}{d}\left(1 - \frac{b^4}{12d^4}\right)\right)$$

gives I_E to an accuracy of an error not greater than 4%
where b is the shorter length & d the longer

b = 304.8 mm
d = 1778 mm

I_E = 1.497E+10 mm^4

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Date:	Jul-14
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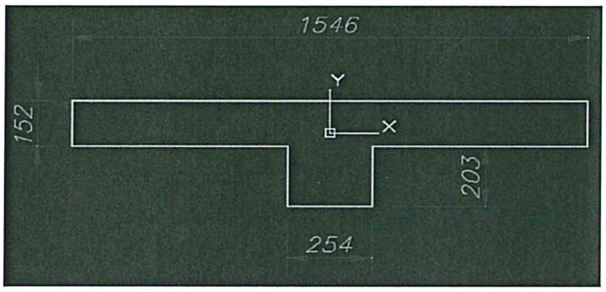
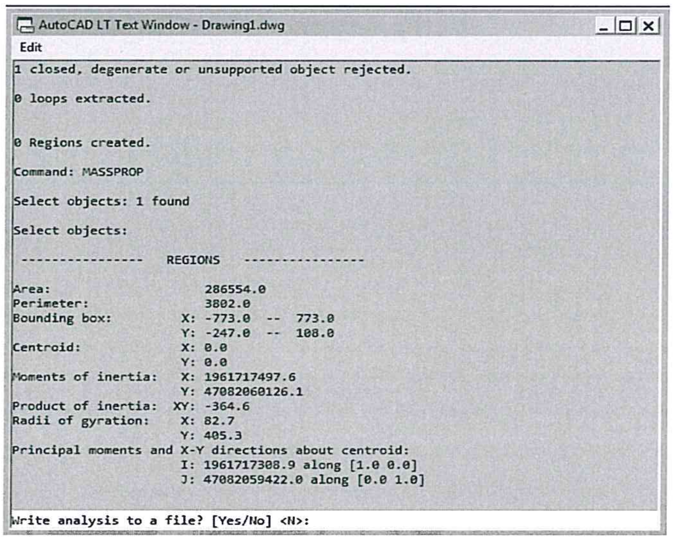
Calculation:	Member Properties

References	Calculation	Notes

Type 5 Member: Deck Beam

Using AutoCAD to determine section properties





Depth to centroid, $\dot{x}$

from AutoCAD drawing: $\dot{x}$ = 250 mm

Moment of Area

from AutoCAD drawing: Iaa = 1,961,717,308.0 mm^4

Iaa = 47,082,059,422.0 mm^4

Torsional Moment of Inertia, I_E

for top section: I_{E1} = **1,697,655,684.2** mm^4

b= 152

d= 1546

for bottom section: I_{E2} = **413,307,111.3** mm^4

b= 254

d= 203 **additional section (I_{E3}) = 937,904,451.0** mm^4

$\sum I_E$ = 3,048,867,246.5 mm^4

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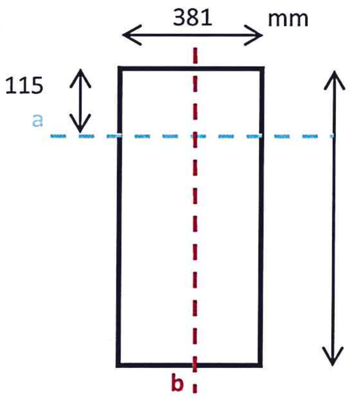
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Member Properties

References	Calculation	Notes

Cross Beam at Pier A

2'6" x 15"



Area, A

b	=	381	mm
d	=	762	mm
A	=	290322	mm^2

Moment of Area

Iaa

$$I = \frac{bd^3}{12} + A \cdot \left[\left(\frac{d}{2} - 115\right)\right]^2$$

p1 p2 p3

b	=	381	mm
d	=	762	mm
p1	=	1.405E+10	mm^4
p2	=	290322	mm^2
p3	=	70756	mm^2
Iaa	=	3.459E+10	mm^4

$= \left(\frac{762}{2} - 115\right)^2$

Ibb $I = \frac{bd^3}{12}$

b	=	762	mm
d	=	381	mm
Iaa	=	3.512E+09	mm^4

Torsional Moment of Inertia, I_E

$$I_E \approx db^3\left(\frac{1}{3} - 0.21\frac{b}{d}\left(1 - \frac{b^4}{12d^4}\right)\right)$$

gives I_E to an accuracy of an error not greater than 4%
where b is the shorter length & d the longer

b	=	381	mm
d	=	762	mm
I_E	=	9.646E+09	mm^4

4.0 Reinforcement Details

Report ref. MIB 306

Sheet no. 2

Introduction:

Four samples of steel, detailed below were received on January 10, 1984 from Leitrim County Council. It was requested by the client that tensile tests be carried out on each sample.

This report confirms results passed by telephone to Mr. C.C. Murphy (Consulting Engineer, E.S.B.) on February 16, 1984.

The samples received were as follows:

1 off : 12.5 mm diameter x 0.7 m long plain round steel bar
I.I.R.S. Referenced 'A'

1 off : 16 mm diameter x 0.7 m long plain round steel bar
I.I.R.S. Referenced 'B'

1 off : 3.5 mm Thick x 25 mm Wide x 0.6 m long flat bar
I.I.R.S. Referenced 'C'

1 off : 0.6 m length of Rail Section ("Moss Bar")
Nominal Weight 7.63 kg/m.
I.I.R.S. Reference 'D'.

Procedure:

Tensile tests were carried out in accordance with procedures specified in B.S. 18 : Part 2 : 1971 "Tensile Testing of Metals", using a Grade A (B.S. 1610) universal testing machine.

.../...

EXTRACT FROM
ESB 1984 Report

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Project HARTLEY BRIDGE			Job No. 121065B
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4.0 REINFORCEMENT DETAILS

0.6m length Moss Bar

Nominal weight 7.63 kg/m.

∴ 1m weighs 7.63kg.

Assuming Mild Steel = $78.5 kN/m^3$

$= 7850 kg/m^3$

Area × 1 × 7850 = 7.63

Area = $9.7197 \times 10^{-4} m^2$

$\pi d^2/4 = 9.7197 \times 10^{-4}$

$d^2 = 1.238 \times 10^{-3}$

d = 0.0352m

∴ Moss Bar Ø = 35.2mm Ø

As of 1No. Moss Bar = $\frac{\pi (35.2)^2}{4}$ = $973.1 mm^2$

Comment

Calculations

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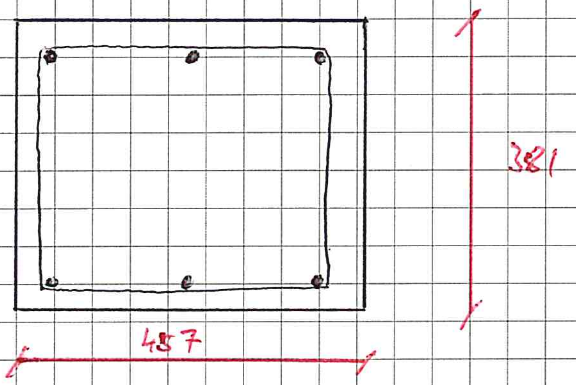
4.0 REINFORCEMENT DETAILS

COLUMN

TYPE 1

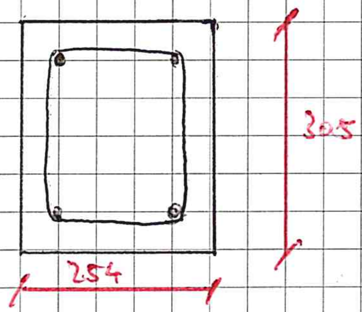


6No. 19mm Ø bars

3/16" (4.76mm) links @ 150crs.

DIAGONAL BRACE

TYPE 2

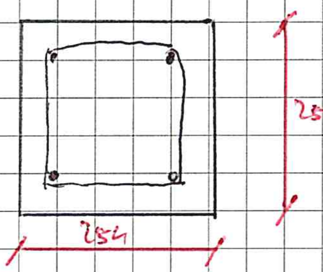


4No. 12mm Ø bars

4.7mm links @ 225mm c/s

HORIZONTAL TIE

TYPE 3



4No. 12mm Ø bars

4.7mm links @ 225mm links

Comment

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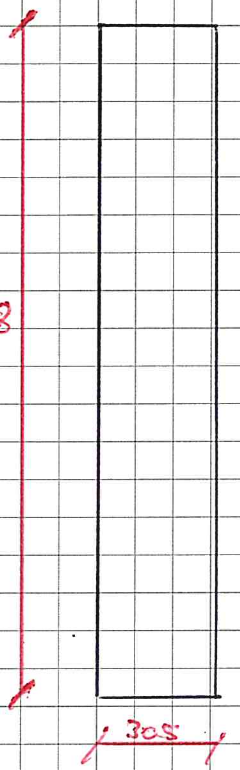
Date JAN 16	Made by CW	Checked by	Page 15 of 88

4.0 TYPE 4

REINFORCEMENT DETAILS
PARAPET BEAM SECTION

REINFORCEMENT



ESB 1984 Report notes the following reinforcement.

BOTTOM

2No. MOSS BARS Type 3
1No. MOSS BAR Type 1
3No. 25mm ø bars
1No. 22mm ø bar

Comment

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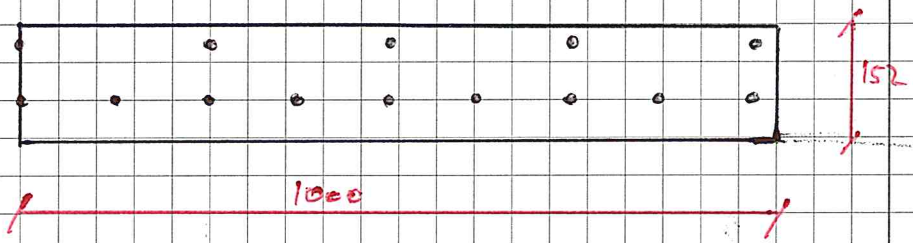
Project HARTLEY BRIDGE	Job No. 121065B
Date JAN 16 · Made by Cw · Checked by	Page 16 of 88

4.0 REINFORCEMENT DETAILS

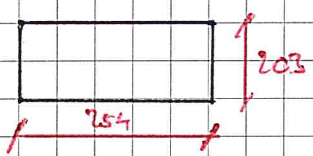
SLAB



BOTTOM STEEL : 12mm ø bars @ 121mm crs

TOP STEEL : 12mm ø bars @ 242mm crs.

DECK



A_{s1} = 2No. Moss Bars = 2×972mm²

A_{s2} = 1 No. 25mm ø bar.

Comment

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Project	HARTLEY BRIDGE		Job No. 121065B
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5.0 CAPACITY CALCULATIONS

+ DECK SLAB
+ DECK BEAM
+ PARAPET BEAM
+ COLUMN
+ DIAGONAL BRACE
+ HORIZONTAL TIE

Comment

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5.0 CAPACITY MATERIAL PROPERTIES

CONCRETE STRENGTH (f_{cu})

BD21/14

4.7 Use worst credible concrete strength from sample testing

BD44/14 Samples: 31.5 N/mm², 31.5 N/mm², 31.5 N/mm²

$\Sigma f_c = 94.5$

$$\text{Worst Credible Strength} = \frac{\Sigma f_c}{100\,n}\left(100 - \frac{20}{\sqrt{n}}\right)$$

$n = 3$ ∴ W.C.S. = 27.86 N/mm²

Conservatively ≃ 25 N/mm²

WCS = 25 N/mm²

4.3.3.3
Table 4A $\gamma_M = 1.2$

See Appendix A for further details of material properties based on 1984 Testing.

Comment

5.0 CAPACITY

Confidential Report

SUMMARY OF CORE TEST RESULTS

Report ref. R6/2232
TI03/50b/3497.8
Sheet no. 5

CLIENT: Leitrim County Council.

SITE: Hartley's Bridge - Carrick-on-Shannon.

DATE: December 12th, 1983.

Diameter (mm)	Honeycombing	Length (mm)	Density (Approx) Kgs/m^3	Estimated Cube Strength N/mm^2	Comment
150	None	310	2415	31.5	
150	None		2400	31.5	
150	None	261	2405	~~57.5~~ ≃ 31.5	

Notes:

EXTRACT FROM ESB 1984 REPORT

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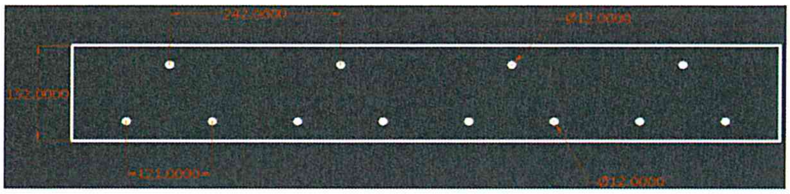
Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Deck Slab - Moment Capacity

References	Calculation			Notes
	Section			
				
	Slab depth (D)	152.00	mm	
	Reinforcement cover	25.00	mm	Different as smaller diameter
	Reinforcement Area (A)	113.10	mm^2	
	Reinforcement Diameter	12.00	mm	Changed from 12.7
	Steel reinforcement (f_y)	250.00	N/mm^2	
	Concrete strength (f_{cu})	25.00	N/mm^2	As recommended in section 4.7 of NRA BD 21/14
	Reinforcement Spacing (S)	121.00	mm	
BD 44/95	$\gamma_{m\ (steel)}$	1.15		
Table 4A	$\gamma_{m\ (concrete)}$	1.20		

Moment Capacity Calculation **Sagging**

Area of steel provided, As_{prov}

$$A_s = A \cdot \left(\frac{1000}{S}\right)$$

934.69 mm^2/m

Effective Depth (d)

$$d = D - \left(cover + \frac{bar\ \text{Ø}}{2}\right)$$

121.00 mm

NRA BD44/14 Eq 5

Lever arm, Z

$$z = \left[1 - \frac{0.84(f_y/\gamma_{ms})A_s}{(f_{cu}/\gamma_{mc})bd}\right]d$$

112.81 mm

where, b = 1000 mm

NRA BD44/14

Moment Capacity

Eq 1

$$M_u = (f_y/\gamma_{ms})A_s z$$

= 22.92 kNm/m

Eq 2

$$M_u = (0.225 f_{cu}/\gamma_{mc})bd^2$$

= 68.63 kNm/m

Moment Capacity, Mp
[Sagging]

Mp = 22.92 kNm

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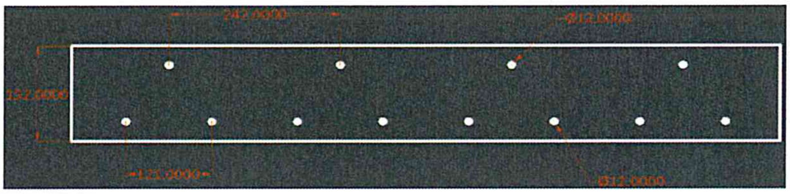
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Deck Slab - Moment Capacity

References	Calculation	Notes

Section



Slab depth (D)	152.00	mm
Reinforcement cover	25.40	mm
Reinforcement Area (A)	113.10	mm^2
Reinforcement Diameter	12.00	mm
Steel reinforcement (f_y)	250.00	N/mm^2
Concrete strength (f_{cu})	25.00	N/mm^2
Reinforcement Spacing (S)	242.00	mm
γ_m (steel)	1.15	
γ_m (concrete)	1.20	

Moment Capacity Calculation **Hogging**

Area of steel provided, $A_{s\ prov}$

$$A_s = A \cdot \left(\frac{1000}{S}\right)$$ 467.34 mm^2/m

Effective Depth (d)

$$d = D - \left(cover + \frac{bar\ Ø}{2}\right)$$ 120.60 mm

BD44/95 Eq 5 — Lever arm, Z

$$z = \left[1 - \frac{0.84(f_y/\gamma_{ms})A_s}{(f_{cu}/\gamma_{mc})bd}\right]d$$ 116.50 mm

where, b = 1000 mm

BD44/95 — Moment Capacity

Eq 1: $$M_u = (f_y/\gamma_{ms})A_s z$$ = 11.84 kNm/m

Eq 2: $$M_u = (0.225 f_{cu}/\gamma_{mc})bd^2$$ = 68.18 kNm/m

Moment Capacity, Mp
[Hogging]

Mp = 11.84 kNm

5.1 DECK SLAB

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Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Deck Slab - Shear Capacity

References	Calculation	Notes

Shear Capacity Calculation

As	934.69	mm^2/m
b_w	1000	mm
d	121.00	mm
f_{cu}	25.00	N/mm^2
γ_{mv}	1.15	
$\gamma_{m\,(concrete)}$	1.20	

BD44/95
5.3.3.2

$$\xi_s = \left(\frac{550}{d}\right)^{1/4} ; but \nless 0.7$$

ξ_s = 1.46
ξ_s to be not less than 0.7
CHECK! 1.46

$$v_c = \frac{0.24}{\gamma_{mv}} \cdot \left(\frac{100A_s}{b_w d}\right)^{1/3} \cdot (f_{cu})^{1/3}$$

p1 p2 p3

part 1	0.21
part 2	0.92
part 3	2.92
v_c	0.56

$\xi_s v_c$ not greater than the lesser of $0.92(f_{cu}/\gamma_{mc})$^0.5 or $7/(\gamma_{mc}$^0.5)

$0.92(f_{cu}/\gamma_{mc})$^0.5 = 4.378
$7/(\gamma_{mc})$^0.5 = 6.390

Min 4.378

$\xi_s v_c$ = 0.82

Shear Capacity, Vu

$$V_u = \xi_s v_c b_w d$$

V_u = 98.92 kN

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Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Deck Slab - Summary

References	Calculation	Notes

Deck Slab

Load Capacity **(as designed)**

Moment (Hogging) =	11.84	kNm
Moment (Sagging) =	22.92	kNm
Shear =	98.92	kN

Load Capacity **(in current condition)**

Condition Factor = **0.80**

Moment (Hogging) =	9.47	kNm
Moment (Sagging) =	18.34	kNm
Shear =	79.14	kN

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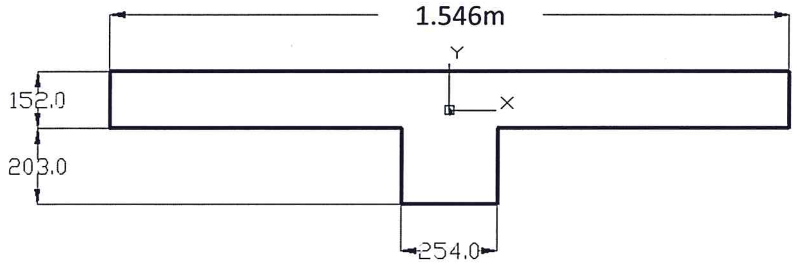
		Job Number:	121065B
		Date:	Jul-14
		Made By	AIG
		Checked By:	
		Calculation:	Deck Beam / Transverse Beam

References	Calculation	Notes

Deck Beam

Section



Reinforcement:

2 x 'Moss' bars
1 x 25mm bar

Area of steel (As)

Moss Bars

As of Moss bar =	972	mm^2
x	2	
Moss Bars (As 1) =	1944	mm^2

25mm Bar

d =	25.4	
Bar (As 2) =	506.707	mm^2
As Total =	2450.707	mm^2

Moss bar = 972 mm^2
Equivilant dia = 35.2 mm

Average bar = 32.3 mm

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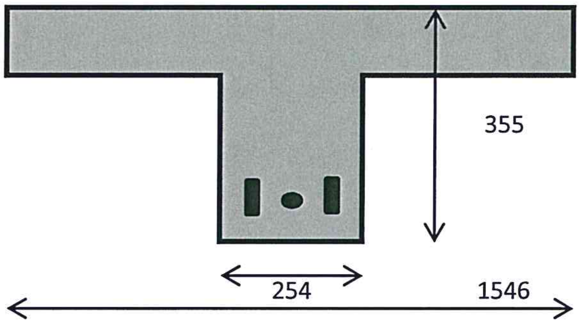
Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Deck Beam - Moment Capacity

References	Calculation	Notes

Taking Deck beam as a simplified beam as follows:



Beam depth (D)	=	355.00	mm
Breadth (b)	=	1546.00	mm
Reinforcement cover	=	25.00	mm
Reinforcement Area (As)	=	2450.71	mm^2
Reinforcement Diameter	=	32.25	mm
Steel reinforcement (f_y)	=	250.00	N/mm^2
Concrete strength (f_{cu})	=	25.00	N/mm^2
$\gamma_{m\,(steel)}$	=	1.15	
$\gamma_{m\,(concrete)}$	=	1.20	

Effective Depth (d)

$$d = D - \left(cover + \frac{bar\ \emptyset}{2}\right)$$

= 313.87 mm

Lever arm, Z

BD44/95
Equation 5

$$z = \left[1 - \frac{0.84(f_y/\gamma_{ms})A_s}{(f_{cu}/\gamma_{mc})bd}\right]d$$

= 299.98 mm

Moment Capacity

BD44/95
Equation 1

$$M_u = (f_y/\gamma_{ms})A_s z$$

= 159.82 kNm/m

BD44/95
Equation 2

$$M_u = (0.225 f_{cu}/\gamma_{mc})bd^2$$

= 713.94 kNm/m

Moment Capacity, Mu

Mu = 159.82 kNm

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Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Deck Beam - Shear Capacity

References	Calculation	Notes

Shear Capacity Calculation

At Supports

As	2450.71	mm^2
b_w	254	mm
d	313.87	mm
f_{cu}	25.00	N/mm^2
γ_{mv}	1.15	
$\gamma_{m\,(concrete)}$	1.20	

BD44/95

5.3.3.2

$$\xi_s = \left(\frac{550}{d}\right)^{1/4} ; but \nless 0.7$$

ξ_s = 1.15

ξ_s to be not less than 0.7

CHECK 1.15

$$v_c = \frac{0.24}{\gamma_{mv}} \cdot \left(\frac{100A_s}{b_w d}\right)^{1/3} \cdot (f_{cu})^{1/3}$$

p1 p2 p3

part 1 0.21

part 2 1.45

part 3 2.92

v_c = 0.89

$\xi_s v_c$ not greater than the lesser of $0.92(f_{cu}/\gamma_{mc})$^0.5 or $7/(\gamma_{mc}$^0.5)

$0.92(f_{cu}/\gamma_{mc})$^0.5 = 4.199

$7/(\gamma_{mc})$^0.5 = 6.390

Min 4.199

$\xi_s v_c$ = 1.02

Shear Capacity, Vu

$$V_u = \xi_s v_c b_w d$$

V_u = 81.39 kN

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Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Deck Beam - Shear Capacity

References	Calculation	Notes

Deck Beams

Load Capacity (As designed)

Moment =	159.82	kNm
Shear =	81.39	kN

Load Capacity (In current condition)

Condition Factor **0.80**

Moment =	127.85	kNm
Shear =	65.11	kN

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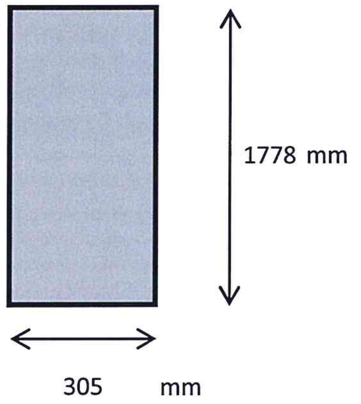
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Parapet Beams - Supports

References	Calculation	Notes

Parapet Beam



Mid span reinforcement details:

Top (Compression)	2 x Moss Bars Type 1 2x 7/8" bars
Bottom (Tension)	2x Moss Bars Type 3 1x Moss Bars Type 1 2x 1" bars 2x 7/8" bars

Spport reinforcement details:

Top (Tension)	2x Moss Bars Type 1
Bottom (Compression)	Unknown

NOTE : INFORMATION FROM PREVIOUS REPORT REFERES TO THREE TYPES OF MOSS BAR, HOWEVER, DETAILS ARE ONLY PROVIDED FOR ONE TYPE - ASSUME THAT ALL MOSS BARS ARE SIMILAR

Moss bar		7.63	kg/mm
steel		7850	kg/m^3
Area of steel (As) of a Moss bar	=	972	mm^2
Equivilant dia	=	35.2	mm

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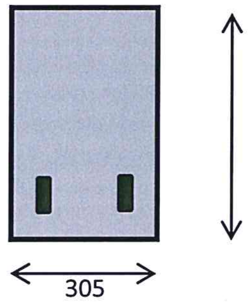
		Project:	Hartley Bridge
		Job Number:	121065B
		Date:	Jul-14
		Made By	AIG
		Checked By:	
		Calculation:	Parapet Beams

References	**Calculation**	**Notes**
At Supports	**Parapet Beam, Moment Capacity**	

Reinforcement:

2 x Moss bars



	Beam breadth (b)	=	305	mm	
	Beam depth (D)	=	1778.00	mm	
	Reinforcement cover	=	25.00	mm	
	Reinforcement Area (As)	=	1943.95	mm^2	
	Reinforcement Height/ Diameter	=	35.18	mm	← assumption
	Steel reinforcement (f_y)	=	250.00	N/mm^2	
	Concrete strength (f_{cu})	=	25.00	N/mm^2	
	$\gamma_{m\ (steel)}$	=	1.15		
	$\gamma_{m\ (concrete)}$	=	1.20		

Effective Depth (d)

$$d = D - \left(cover + \frac{bar\ \varnothing}{2}\right)$$ = 1735.41 mm

BD44/95
Equation 5

Lever arm, Z

$$z = \left[1 - \frac{0.84(f_y/\gamma_{ms})A_s}{(f_{cu}/\gamma_{mc})bd}\right]d$$ = 0.97 d — Use 0.95

Z = 1649 mm

Moment Capacity

BD44/95
Equation 1

$$M_u = (f_y/\gamma_{ms})A_s z$$ = 696.71 kNm/m

BD44/95
Equation 2

$$M_u = (0.225 f_{cu}/\gamma_{mc})bd^2$$ = 4305.72 kNm/m

Moment Capacity, Mu

$$M_p = Z \times Tension\ force$$ Mp = 696.71 kNm

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Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Parapet Beams - Mid Span

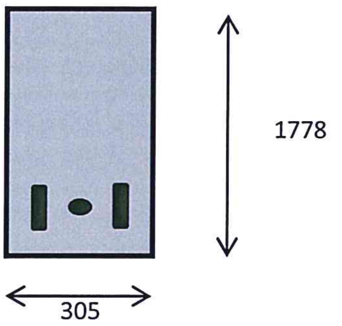
References	Calculation	Notes
At Mid - span	**Parapet Beam, Moment Capacity**	

Reinforcement:

3 x Moss bars 2916 mm^2

2 x 1" bars 1013 mm^2

2 x 7/8" bars 776 mm^2



References	Calculation		Value	Unit	Notes
	Slab depth (D)	=	1778.00	mm	
	Reinforcement cover	=	25.00	mm	
	Reinforcement Area (As)	=	4705.23	mm^2	
	Reinforcement Diameter	=	35.18	mm ←	from page 1
	Steel reinforcement (f_y)	=	250.00	N/mm^2	
	Concrete strength (f_{cu})	=	25.00	N/mm^2	
BD44/95	$\gamma_{m\ (steel)}$	=	1.15		
Table 4A	$\gamma_{m\ (concrete)}$	=	1.20		

Effective Depth (d)

$$d = D - \left(cover + \frac{bar\ \varnothing}{2}\right)$$ = 1735.41 mm

BD44/95
Equation 5

Lever arm, Z

$$z = \left[1 - \frac{0.84(f_y/\gamma_{ms})A_s}{(f_{cu}/\gamma_{mc})bd}\right]d$$

= 0.92 d — Use 0.95

Z = 1597 mm

Moment Capacity

$$\frac{z}{d} \leq 0.95d;\ \ if\ not\ z = 0.95d$$

BD44/95
Equation 1

$$M_u = (f_y/\gamma_{ms})A_s z$$ = 1633.10 kNm/m

BD44/95
Equation 2

$$M_u = (0.225 f_{cu}/\gamma_{mc})bd^2$$ = 4305.72 kNm/m

Moment Capacity, Mu

Mu = 1633.10 kNm

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Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Parapet Beams - Shear Capacity

References	Calculation	Notes

Shear Capacity Calculation

At Supports

As	1943.95	mm^2
b_w	305	mm
d	1735.41	mm
f_{cu}	25.00	N/mm^2
γ_{mv}	1.15	
$\gamma_{m\ (concrete)}$	1.20	

BD44/95
5.3.3.2

$$\xi_s = \left(\frac{550}{d}\right)^{1/4} \text{; but } \nless 0.7$$

ξ_s = 0.75

ξ_s to be not less than 0.7

CHECK! = 0.75

Notes: ξ_s 0.75

$$v_c = \frac{0.24}{\gamma_{mv}} \cdot \left(\frac{100A_s}{b_w d}\right)^{1/3} \cdot (f_{cu})^{1/3}$$

p1 p2 p3

part 1 0.21
part 2 0.72
part 3 2.92
v_c = 0.44

Notes: v_c 0.44

$\xi_s v_c$ not greater than the lesser of $0.92(f_{cu}/\gamma_{mc})$^0.5 or $7/(\gamma_{mc}$^0.5)

$0.92(f_{cu}/\gamma_{mc})$^0.5 = 4.199
$7/(\gamma_{mc})$^0.5 = 6.390

Min 4.199

$\xi_s v_c$ = 0.33

Shear Capacity, Vu

$$V_u = \xi_s v_c b_w d$$

V_u = 173.55 kN

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Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Parapet Beams - Dead Loading

References	Calculation	Notes

Parapet Beams

Load Capacity (As designed)

Moment (supports) =	696.71	kNm
Moment (Mid point) =	1633.10	kNm
Shear (Supports) =	173.55	kN

Load Capacity (In current condition)

Condition Factor **0.80**

Moment (supports) =	557.37	kNm
Moment (Mid point) =	1306.48	kNm
Shear (Supports) =	138.84	kN

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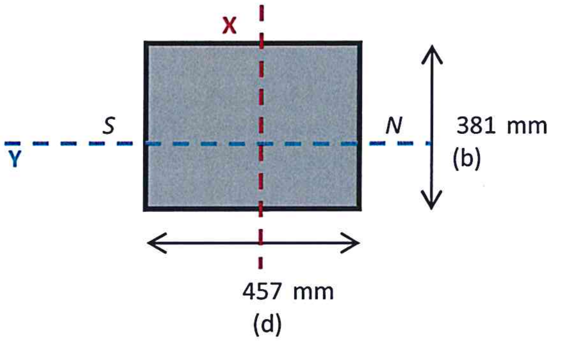
	Date:	Jul-14
	Made By	AIG
	Checked By:	
	Calculation:	Column - Specification

References	Calculation	Notes

Section:
18" x 15"



Reinforcement:

6 x 19.1 mm (3/4") bars
4.76mm (3/16") links at 150mm centres

BD44/95
5.5.1.1

Considered column if d ≤ 4b

4 x b = 1.524 m
d = 0.4572 m

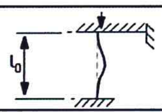
Therefore: **Column**

Column considered short if Le/h < 12

Effective Length, Le = β*Lo

Clear Length, Lo = 4.91 m

BD44/95
Table 11

Case	Idealised column and buckling mode	Restraints Location	Position	Rotation	Effective Height, l_e
1		Top	Full	Full	0.70 l_o
		Bottom	Full	Full	

Assuming Case 1 β = 0.7

Hence, Effective Length, Le = 3.437 m

X-X plane h = 0.381 m
Y-Y plane h = 0.457 m

Therefore: **Short**

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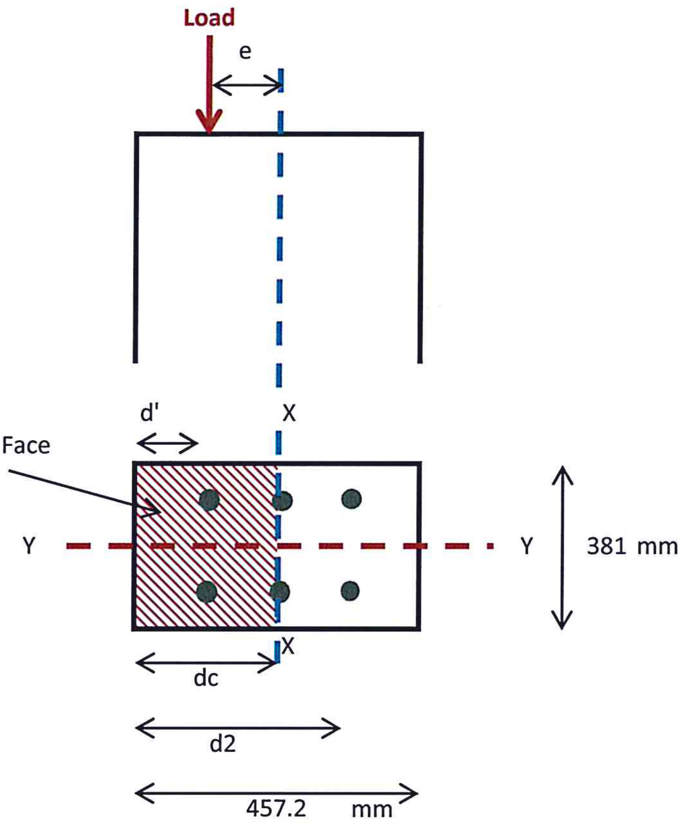
Checked By:	
Calculation:	Column - Loading

References	Calculation	Notes

Bending about Minor Axis (Y-Y)



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Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Column - Bending about Y-Axis

References	Calculation	Notes
BD44/95 5.5.3	**Short columns subject to bending about minor (Y-Y) axis**	
5.5.3.1	Assumed eccentricty, e, of Axial Load equal 0.05*h ≤ 20mm	
	h = 0.4572 m	
	e, 0.05h = 0.02 m	
5.5.3.2	Stress in Concrete in compression = 0.6 fcu / γmc	
Table 4A	→ → → → → → γ mc = 1.5	
	fcu = 25 N/mm²	
	0.6*fcu/γmc = 10 N/mm²	
5.5.3.4	**Assessment formulae for Rectangular Columns**	
	Ultimate Axial Load, Nu	
	Eq 14 $N_u = (0.6\ f_{cu}/\gamma_{mc})bd_c + f_{yc}A'_{sl} + f_{s2}A_{s2}$	
	part 1 *part 2* *part 3*	
	where: γ mc = 1.5	
	fcu = 25 N/mm²	
	breadth of section, b = 381 mm	
	depth of concrete in compression (2d'), dc = 228.6 mm	
	depth from surface to reinforcement in compressed face, d' = 25 mm	
	compressive strength of steel, fyc = 196.08 N/mm²	
	fy = 250 N/mm²	
	γ ms = 1.15	
	$\text{fyc} = \dfrac{f_y}{\gamma_{ms} + f_y/2000}$ Area of steel in compression face, Asl' = 855.07 mm²	
	stress in reinforcement in other face, fs2 = 173.91 N/mm²	using figure 2, BD44/95 p A/18
	Area of steel in other face, As2 = 855.07 mm²	
	$\text{fs2} = \dfrac{0.8 \times \text{fy}}{\gamma\text{ms}}$	

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		Job Number:	121065B
		Date:	Jul-14
		Made By	AIG
		Checked By:	
		Calculation:	Column - Bending about Y-Axis

References	Calculation	Notes
BD44/95		
5.5.3.4	Ultimate Axial Load, Nu (continued)	**Ultimate Axial Load: 1187.33 kN**
	part 1 = 870,966.0	
	part 2 = 167,660.6	
	part 3 = 148,707.6	
	Ultimate Axial Load, Nu = 1187.33 kN	
5.5.3.4	Ultimate Moment, Mu	

part1   part 2

$$M_u = (0.3\ f_{cu}/\gamma_{mc})bd_c(h\text{-}d_c) + f_{yc}\ A'_{s1}(\frac{h}{2} - d') - f_{s2}\ A_{s2}\ (\frac{h}{2} - d_2)$$

part 3

where:	overall depth of plane, h =	457.2	mm
	depth from surface to reinforcement in other face. d2 =	219.08	mm
	part 1 =	99,551,413.8	
	part 2 =	34,135,690.6	
	part 3 =	1,416,440.2	
	Ultimate Moment, Mu =	**132.27**	**kNm**

Notes: **Ultimate Moment: 132.27 kNm**

Columns

Load Capacity (as designed)

Ultimate Moment Capacity = 132.27 kNm

Load Capacity (in current condition)

Condition Factor = **0.80**

Moment Capacity = 105.82 kNm

Axial Capacity = 949.87 kN

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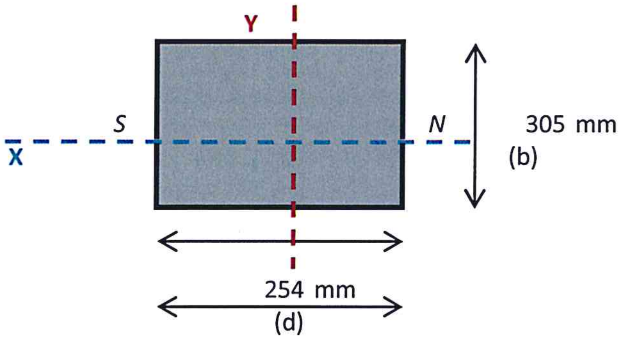
Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Diagonal Brace - Specification

References	**Calculation**	**Notes**

Section:
10" x 12"



Reinforcement:

4 x 12 mm bars
4.7mm (3/16") links at 225mm centres

BD44/95
5.5.1.1

Considered column if d ≤ 4b

4 x b = 1.22 m
d = 0.254 m

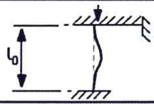
Therefore: **Column**

Column considered short if Le/h < 12

Effective Length, Le = β*Lo

Clear Length, Lo = 7.14 m

BD44/95
Table 11

Case	Idealised column and buckling mode	Restraints: Location	Position	Rotation	Effective Height, l_e
1		Top	Full	Full	$0.70\ l_o$
		Bottom	Full	Full	

Assuming Case 1 β = 0.7

Hence, Effective Length, Le = 4.998 m

X-X plane h = 0.305 m
Y-Y plane h = 0.254 m

Therefore: **Slender**

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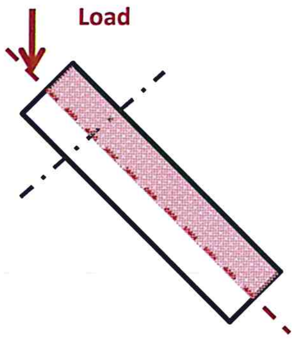
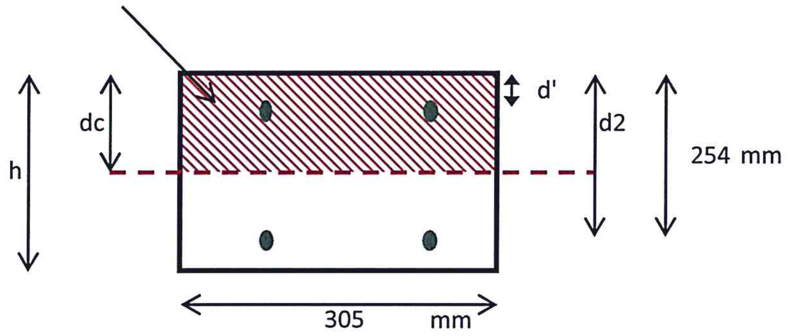
	Job Number:	121065B
	Date:	Jul-14
	Made By	AIG
	Checked By:	
	Calculation:	Diagonal Brace - Loading

References	Calculation	Notes

Bending about (Z) Axis



Compression Face



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W www.doran.co.uk	Calculation:	Brace - Bending about Z-Axis

References	Calculation	Notes
BD44/95 5.5.3	**Slender columns subject to bending about (Z) axis**	
5.5.3.1	Assumed eccentricty, e, of Axial Load equal 0.05*h ≤ 20mm	
	h = 0.254 m	
	e, 0.05h = 0.0127 m	
5.5.3.2	Stress in Concrete in compression = 0.6 fcu / γmc	
Table 4A	→ → → → → → γ mc = 1.5	
	fcu = 25 N/mm^2	
	0.6*fcu/γmc = 10 N/mm^2	
5.5.3.4	**Assessment formulae for Rectangular Columns**	
	Ultimate Axial Load, Nu	
	Eq 14 $$N_u = (0.6\ f_{cu}/\gamma_{mc})bd_c + f_{yc}A'_{sl} + f_{s2}A_{s2}$$ *part 1* *part 2* *part 3*	
	where: γ mc = 1.5	
	fcu = 25 N/mm^2	
	breadth of section, b = 305 mm	
	depth of concrete in compression (2d'), dc = 127 mm	
	depth from surface to reinforcement in compressed face, d' = 25 mm	
	compressive strength of steel, fyc = 196.08 N/mm^2	
	fy = 250 N/mm^2	
	γ ms = 1.15	
	fyc = $\dfrac{f_y}{\gamma_{ms} + f_y/2000}$ Area of steel in compression face, Asl' = 226.19 mm^2	
	stress in reinforcement in other face, fs2 = 173.91 N/mm^2	using figure 2
	Area of steel in other face, As2 = 226.19 mm^2	
	fs2 = $\dfrac{0.8 \times fy}{\gamma ms}$	

5.5 DIAGONAL BRACE

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Calculation:	Brace - Bending about Z-Axis

References	Calculation	Notes
BD44/95		
5.5.3.4	Ultimate Axial Load, Nu (continued)	**Ultimate Axial Load:**
	part 1 = 387,350.0	
	part 2 = 44,351.9	**471.04**
	part 3 = 39,338.2	**kN**
	Ultimate Axial Load, Nu = 471.04 kN	
5.5.3.4	Ultimate Moment, Mu	
	$$M_u = (0.3 f_{cu}/\gamma_{mc}) b d_c (h - d_c) + f_{yc} A'_{sl}(\frac{h}{2} - d') - f_{s2} A_{s2} (\frac{h}{2} - d_2)$$ (part1, part 2, part 3)	
	where: overall depth of plane, h = 254 mm	
	depth from surface to reinforcement in other face. d2 = 217.00 mm	
	part 1 = 24,596,725.0	**Ultimate Moment:**
	part 2 = 4,523,893.4	
	part 3 = -3,540,438.3	**32.66 kNm**
	Ultimate Moment, Mu = 32.66 kNm	

Diagonal Brace

Axial Capacity (in current condition)

Condition Factor = **0.80**

Axial Capacity = 376.83 kNm

Moment Capacity (in current condition)

Condition Factor = **0.80**

Moment Capacity = 26.13 kNm

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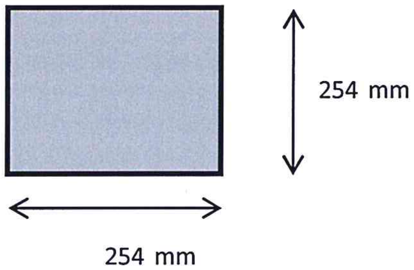
	Checked By:	
	Calculation:	Horizontal Tie - Capacity

References	Calculation	Notes

Section:

10" x 10"



Reinforcement:

4 x 12 mm bars
4.7mm links at 225mm centres

Axial Strength:

Area of steel reinforcement, As	=	452.39	mm^2
Steel yield strength, fy	=	250	N/mm^2
$\gamma_{m\ (steel)}$	=	1.15	

Assumption that all axial forces are resisted by the steel only.

Hence axial strength of the horizontal tie:

$$\textbf{Axial Capacity} = \frac{f_y A_s}{\gamma_s}$$

	=	98.35	kN
Condition Factor	=	0.80	
Axial Capacity	**=**	**78.68**	**kN**

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Project: HARTLEY BRIDGE : SECTION CAPACITIES			Job No. 121065B
Date: JAN'16	Made by: AIG	Checked by:	Page 42 of 88

5.7 SECTION CAPACITIES SUMMARY

Note bridge has been divided into 6 elements. A condition factor of 0.8 has been applied to the capacity of all these elements.

DECK SLAB :	Moment Sagging	= 9.47 kNm
	Moment Hogging	= 18.34 kNm
	Shear	= 79.14 kN
DECK BEAM :	Moment	= 127.85 kNm
	Shear	= 65.11 kN
PARAPET BEAM :	Moment Sagging	= 1306.48 kNm
	Moment Hogging	= 557.37 kNm
	Shear	= 138.84 kN
Column :	Moment	= 105.82 kNm
	Axial	= 949.87 kN
BRACE :	Moment	= 26.13 kNm
	Axial	= 376.83 kN
TIE : (Steel only)	Axial	= 76.68 kN

Comment

Calculations

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Project: HARTLEY BRIDGE			Job No. 121065B
Date: JAN '16	Made by: AIG	Checked by	Page 43 of 88

6.0 ASSESSMENT CALCULATIONS

- DECK SLAB
- DECK BEAM
- PARAPET BEAM
- COLUMN
- DIAGONAL BRACE
- HORIZONTAL TIE

(COLUMN, DIAGONAL BRACE, HORIZONTAL TIE } PIER STRUCTURE)

Comment

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	Job Number:	121065B
	Date:	Jul-14
	Made By	AIG
	Checked By:	SJQ
	Calculation:	Deck slab Loading - Dead Load

References	Calculation	Notes

Loading - Deck Slab

Typical span = 10.77 m

Dead Loading

References					
BD21/14					
Table 4.1	Concrete →	γ_{conc}	=	24	kN/m^3
Table 4.1	Surfacing →	$\gamma_{surface}$	=	25.6	kN/m^3

Depth of layer:

Concrete →	=	152	mm
Surfacing →	=	75	mm

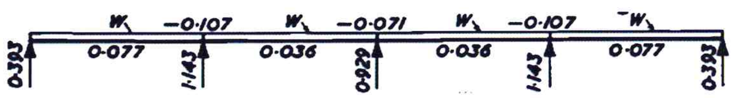
Load:

Concrete →	=	3.648	kN/m/m width
Surfacing →	=	1.92	kN/m/m width

References	*Factored Load:*	γ_F		w_1	
BD21/14					
Table 3.1	Concrete →	1.15	=	4.195	kN/m/m width
Table 3.1	Surfacing →	1.75	=	3.360	kN/m/m width

Total Dead Load (w_1) → = 7.555 kN/m/m width

Steel Designers Manual, p 1102



where $W = w_1 \times l$

here l = L / (no. of spans) — spans = 7

therefore: l = 1.54 m

Hence: **W = 11.624 kN/m width**

Max Moments:

Moment = coefficient x W x l

Hogging -

coefficient = 0.107

Moment Hog = 1.914 kNm/m width

Sagging -

coefficient = 0.077

Moment Sag = 1.377 kNm/m width

Max Reaction:

Reaction = coefficient x W

coefficient = 1.143

Reaction = 13.286 kN/m width

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Calculation:	Deck slab Loading - Single wheel

References	Calculation	Notes

Live Loading - Single Wheel

BD21/14

5.9 "For loaded lengths less than 2m the single axle load and the single wheel load shall be used. "

5.22 Traffic Flow: medium

5.23 Road surface: low

Assuming 1m width of slab, use Single Wheel loading.

5.34 Pressure below wheel to be 1.1 N/mm^2

Highest wheel load 100 kN

Equlivilant size 301.5 x 301.5 mm

Load spread is loaded length + 2 x total depth 756 mm

Max Moment

Assume Simply supported

Max shear

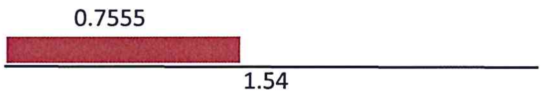

Table 3.1 Partial Factor 1.5

Assessment Love Loading	Lg (kN)	Applied Moment (kNm)	Applied Shear (kN)
40 Tonne	82	35.7	92.8
26 Tonne	82	35.7	92.8
18 Tonne	82	35.7	92.8
7.5 Tonne	41	17.8	46.4
3 Tonne	19	8.3	21.5
FE Group 1	50	21.8	56.6
FE Group 2	25	10.9	28.3

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Calculation:	Deck slab Loading - Single Wheel

References	Calculation	Notes

Single Wheel Loading Assessmnet

Sagging

Load Case	Applied Moment			Capacity (Reduced)	Pass / Fail	AI
	Dead	Live	Total			
40 Tonne	1.38	35.7	37.1	18.34	Fail	2.02
26 Tonne	1.38	35.7	37.1	18.34	Fail	2.02
18 Tonne	1.38	35.7	37.1	18.34	Fail	2.02
7.5 Tonne	1.38	17.8	19.2	18.34	Fail	1.05
3 Tonne	1.38	8.3	9.7	18.34	Pass	0.53
FE Group 1	1.38	21.8	23.2	18.34	Fail	1.26
FE Group 2	1.38	10.9	12.3	18.34	Pass	0.67

Notes: Capacity reduced by Condition factor

Hogging

Load Case	Applied Moment			Capacity (Reduced)	Pass / Fail	AI
	Dead	Live	Total			
40 Tonne	1.9	35.7	37.6	9.47	Fail	3.97
26 Tonne	1.9	35.7	37.6	9.47	Fail	3.97
18 Tonne	1.9	35.7	37.6	9.47	Fail	3.97
7.5 Tonne	1.9	17.8	19.7	9.47	Fail	2.08
3 Tonne	1.9	8.3	10.2	9.47	Fail	1.08
FE Group 1	1.9	21.8	23.7	9.47	Fail	2.50
FE Group 2	1.9	10.9	12.8	9.47	Fail	1.35

Shear

Load Case	Applied Shear			Capacity (Reduced)	Pass / Fail	AI
	Dead	Live	Total			
40 Tonne	13.3	92.8	106.1	79.14	Fail	1.34
26 Tonne	13.3	92.8	106.1	79.14	Fail	1.34
18 Tonne	13.3	92.8	106.1	79.14	Fail	1.34
7.5 Tonne	13.3	46.4	59.7	79.14	Pass	0.75
3 Tonne	13.3	21.5	34.8	79.14	Pass	0.44
FE Group 1	13.3	56.6	69.9	79.14	Pass	0.88
FE Group 2	13.3	28.3	41.6	79.14	Pass	0.53

Summary

Deck slab fails assessment

Assessment rating: **No rating**

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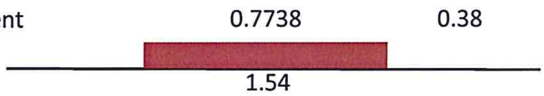
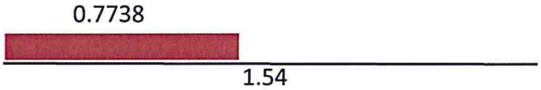
Calculation:	Deck slab Loading - HB

References	Calculation	Notes
HB	**Live Loading**	
BD21/14 5.9	Check for HB Loading - Using NRA BD37/14 for loading and partial factors	
5.22	Traffic Flow: medium	
5.23	Road surface: good	
	Assuming 1m width of slab, use Single Wheel loading.	
5.34	Pressure below wheel to be 1.1 N/mm^2 Highest wheel load 112.5 kN Equlivilant size 320 x 319.8 mm	
	Load spread is loaded length + 2 x total depth 774 mm	
	Max Moment	Assume Simply supported



Max shear



References	Calculation
BD 37/14 Table 1	Partial factor 1.5

Assessment Love Loading	HB (kN)	Partial Factor	Applied Moment (kNm)	Applied Shear (kN)
1 unit HB	2.5	1.3	0.9	2.5
5 unit HB	12.5	1.3	4.7	12.3
9 unit HB	22.5	1.3	8.5	22.1
10 unit HB	25	1.3	9.4	24.5
15 unit HB	37.5	1.3	14.1	36.8
20 unit HB	50	1.3	18.9	49
28 unit HB	70	1.3	26.4	68.7
35 unit HB	87.5	1.3	33	85.8
40 unit HB	100	1.3	37.7	98.1
45 unit HB	112.5	1.3	42.4	110.3

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		Calculation:	Deck slab Loading - HB

References	Calculation	Notes

HB Loading Assessmnet

Sagging

Load Case HB Units	Applied Moment Dead	Live	Total	Capacity (Reduced)	Pass / Fail	AI
1	1.38	0.9	2.3	18.34	Pass	0.12
5	1.38	4.7	6.1	18.34	Pass	0.33
9	1.38	8.5	9.9	18.34	Pass	0.54
10	1.38	9.4	10.8	18.34	Pass	0.59
15	1.38	14.1	15.5	18.34	Pass	0.84
20	1.38	18.9	20.3	18.34	Fail	1.11
28	1.38	26.4	27.8	18.34	Fail	1.51
35	1.38	33	34.4	18.34	Fail	1.87
40	1.38	37.7	39.1	18.34	Fail	2.13
45	1.38	42.4	43.8	18.34	Fail	2.39

Capacity reduced by Condition factor

Hogging

Load Case HB Units	Applied Moment Dead	Live	Total	Capacity (Reduced)	Pass / Fail	AI
1	1.9	0.9	2.8	9.47	Pass	0.30
5	1.9	4.7	6.6	9.47	Pass	0.70
9	1.9	8.5	10.4	9.47	Fail	1.10
10	1.9	9.4	11.3	9.47	Fail	1.19
15	1.9	14.1	16.0	9.47	Fail	1.69
20	1.9	18.9	20.8	9.47	Fail	2.20
28	1.9	26.4	28.3	9.47	Fail	2.99
35	1.9	33.0	34.9	9.47	Fail	3.69
40	1.9	37.7	39.6	9.47	Fail	4.18
45	1.9	42.4	44.3	9.47	Fail	4.68

Shear

Load Case	Applied shear Dead	Live	Total	Capacity (Reduced)	Pass / Fail	AI
1	13.3	2.5	15.8	79.14	Pass	0.20
5	13.3	12.3	25.6	79.14	Pass	0.32
9	13.3	22.1	35.4	79.14	Pass	0.45
10	13.3	24.5	37.8	79.14	Pass	0.48
15	13.3	36.8	50.1	79.14	Pass	0.63
20	13.3	49.0	62.3	79.14	Pass	0.79
28	13.3	68.7	82.0	79.14	Fail	1.04
35	13.3	85.8	99.1	79.14	Fail	1.25
40	13.3	98.1	111.4	79.14	Fail	1.41
45	13.3	110.3	123.6	79.14	Fail	1.56

Summary

Deck slab is limited in bending.

Deck slab can sustain the effects of 5 Units HB

6.2 DECK BEAM

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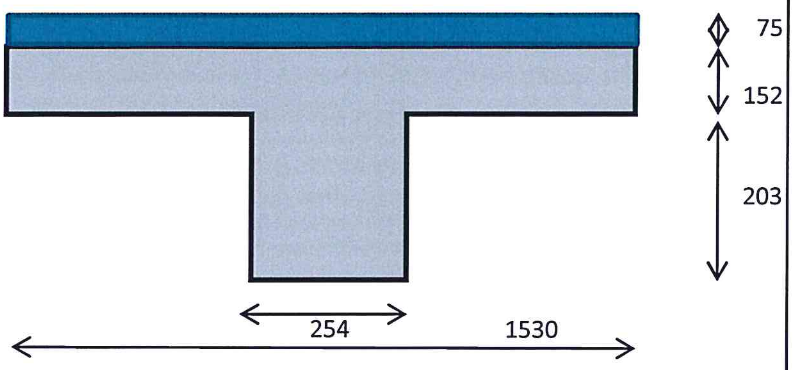
Calculation:	Deck beam Loading - DL

References	Calculation	Notes

Transverse Beam

Details
Section



References	Calculation					
BD21/14	Self weight					
Table 4.1	Concrete →		γ_{conc}	=	24	kN/m^3
Table 4.1	Surfacing →		$\gamma_{surface}$	=	25.6	kN/m^3
	Load					
	Conc. Deck	$0.284\ m^2$	w	=	6.82	kN/m^2
	surfacing	$0.115\ m^2$	w	=	2.94	kN/m^2
BD21/14	*Factored Load:*	γ_F			w_1	
Table 3.1	Concrete →	1.15		=	7.842	kN/m
Table 3.1	Surfacing →	1.75		=	5.141	kN/m
	Total Dead Load (w_1) →			=	12.983	kN/m
	Span			=	5.840	m
	Moment			=	55.3	kNm
	Shear			=	37.9	kN

Live Load Capacity

			Notes
Moment capacity	127.85	kNm	Reduced by Cf
DL moment applied	55.35	kNm	
LL moment capacity	72.51	kNm	
Shear Capacity	65.11	kN	Reduced by Cf
DL shear applied	37.91	kN	
LL shear capacity	27.20	kN	

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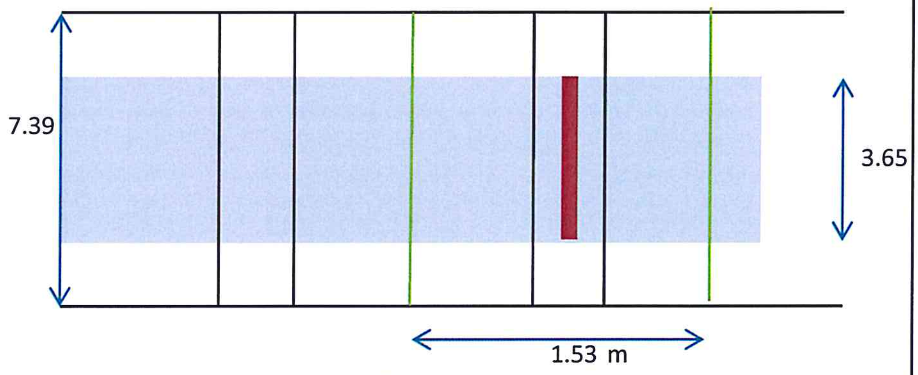
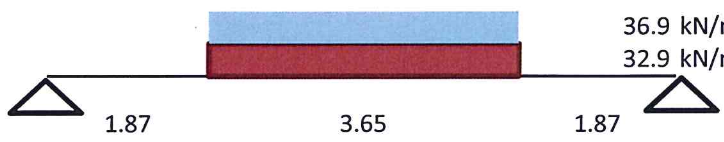
Made By	AIG
Checked By:	SJQ
Calculation:	Deck beam Loading - HA

References	Calculation	Notes
	HA - UDL & KEL	
BD 21/14	Carrigeway width = 3.97 m	
Table 5.1	Number of notonal lanes = 1	
5.6	Assume lane width of 3.65 m	
	Bridge Span length = 7.39 m	
5.22	Traffic Flow: low	
5.23	Road surface: good	
	Adjustment Factor Af	
5.20	k = 0.76	
5.24	al 3.65 — Af = 1.46	
	L <20	
5.18	w = 88 kN/m along length of bridge	acts over an area
	KEL = 120 kN transvers to beam	of 3.65m
3.8	Partial Factors 1.5	



Plan view



36.9 kN/m = (88 × 1.53) ÷ 3.65
32.9 kN/m = 120 ÷ 3.65

Total loading (before Af and partial factor) 69.75 kN/m = 36.9 + 32.9
Total loading (after Af and partial factor) 54.46 kN/m

Max Moment 277 kNm
Max Shear 149.7 kNm

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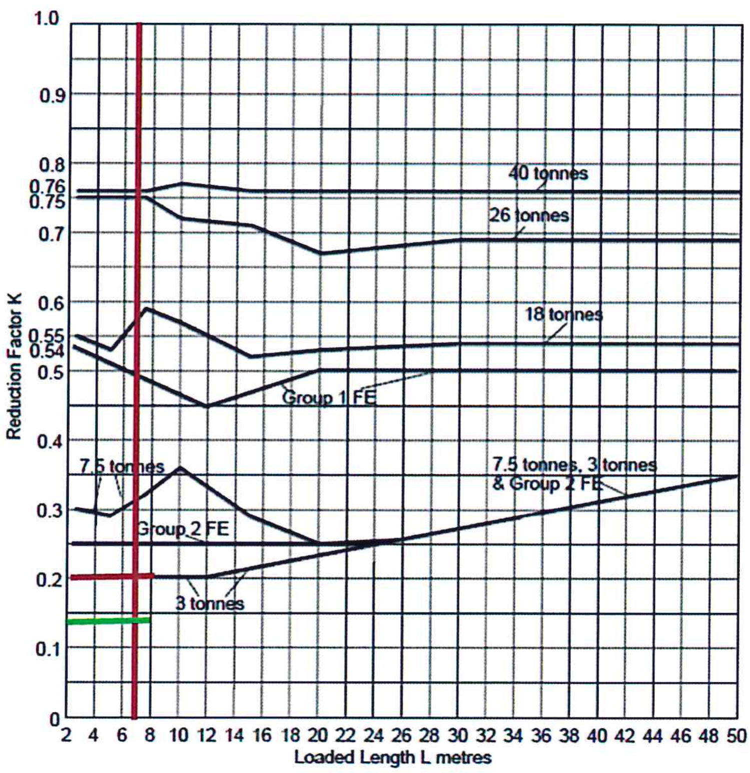
	Checked By:	SJQ
	Calculation:	Deck beam Loading - HA

References	Calculation	Notes
5.28	**C =** <u>Available live load capacity</u> / Live Load Capacity required for **Adjusted** HA loading	
	Moment live load capacity required = 363.91 kNm	
	Shear live load capacity required = 196.98 kN	
	Bending 0.20	
	Shear 0.14	
Fig 5.7		

HA & KEL Summary

Bending	3 Tonnes	&	NO FIRE ENGINES
Shear	FAIL		

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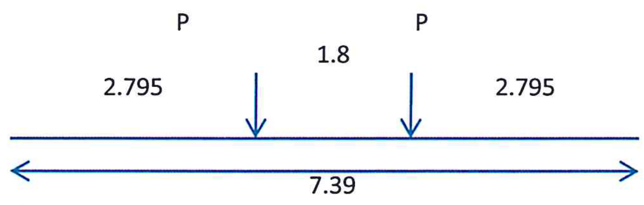
Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Deck beam Load - Single Axle

References	**Calculation**	**Notes**

Single Axle



Partial factor 1.5

Assessment Love Loading	Lg (kN)	Applied Moment (kNm)	Applied Shear (kN)
40 Tonne	82	343.79	216
26 Tonne	82	343.79	216
18 Tonne	82	343.79	216
7.5 Tonne	41	171.89	108
3 Tonne	19	79.66	50
FE Group 1	50	209.63	132
FE Group 2	25	104.81	66

Bending:

Load Case	Applied Moment			Capacity (Reduced)	Pass / Fail	AI
	Dead	Live	Total			
40 Tonne	55.35	344	399.1	127.85	**Fail**	**3.12**
26 Tonne	55.35	344	399.1	127.85	**Fail**	**3.12**
18 Tonne	55.35	344	399.1	127.85	**Fail**	**3.12**
7.5 Tonne	55.35	172	227.2	127.85	**Fail**	**1.78**
3 Tonne	55.35	80	135.0	127.85	**Fail**	**1.06**
FE Group 1	55.35	210	265.0	127.85	**Fail**	**2.07**
FE Group 2	55.35	105	160.2	127.85	**Fail**	**1.25**

Shear:

Load Case	Applied Shear			Capacity (Reduced)	Pass / Fail	AI
	Dead	Live	Total			
40 Tonne	37.9	216.0	253.9	65.11	**Fail**	**3.90**
26 Tonne	37.9	216.0	253.9	65.11	**Fail**	**3.90**
18 Tonne	37.9	216.0	253.9	65.11	**Fail**	**3.90**
7.5 Tonne	37.9	108.0	145.9	65.11	**Fail**	**2.24**
3 Tonne	37.9	50.1	88.0	65.11	**Fail**	**1.35**
FE Group 1	37.9	131.7	169.6	65.11	**Fail**	**2.61**
FE Group 2	37.9	65.9	103.8	65.11	**Fail**	**1.59**

Single Axle Summary

Bending - FAIL
Shear - FAIL

6.2 DECK BEAM

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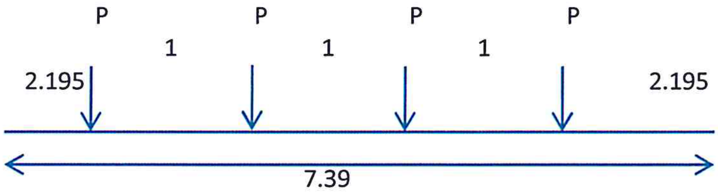
	Project:	Hartley Bridge
	Job Number:	121065B
	Date:	Jul-14
	Made By	AIG
	Checked By:	SJQ
	Calculation:	Deck beam Loading HB

References	**Calculation**	**Notes**

HB



Assessment Love Loading		HB (kN)	Partial Factor	Applied Moment (kNm)	Applied Shear (kN)
1	unit HB	2.5	1.3	9.61	6.5
2	unit HB	5	2.3	33.99	23
3	unit HB	7.5	3.3	73.16	49.5
5	unit HB	12.5	4.3	158.89	107.5
10	unit HB	25	5.3	391.67	265
20	unit HB	50	6.3	931.14	630
30	unit HB	75	7.3	1618.41	1095
35	unit HB	87.5	8.3	2146.8	1452.5
40	unit HB	100	9.3	2749.08	1860
45	unit HB	112.5	10.3	3425.27	2317.5

Bending:

Load Case HB Units	Applied Moment			Capacity (Reduced)	Pass / Fail	AI
	Dead	Live	Total			
1	55.35	9.61	65	127.85	Pass	0.51
2	55.35	33.99	89	127.85	Pass	0.70
3	55.35	73.16	129	127.85	Fail	1.01
5	55.35	158.9	214	127.85	Fail	1.68
10	55.35	391.7	447	127.85	Fail	3.50
20	55.35	931.1	986	127.85	Fail	7.72
30	55.35	1618	1674	127.85	Fail	13.09
35	55.35	2147	2202	127.85	Fail	17.22
40	55.35	2749	2804	127.85	Fail	21.93
45	55.35	3425	3481	127.85	Fail	27.22

Shear

Load Case	Applied Shear			Capacity (Reduced)	Pass / Fail	AI
	Dead	Live	Total			
1	37.9	7	44	65.11	Pass	0.68
2	37.9	23	61	65.11	Pass	0.94
3	37.9	50	87	65.11	Fail	1.34
5	37.9	108	145	65.11	Fail	2.23
10	37.9	265	303	65.11	Fail	4.65
20	37.9	630	668	65.11	Fail	10.26
30	37.9	1095	1133	65.11	Fail	17.40
35	37.9	1453	1490	65.11	Fail	22.89
40	37.9	1860	1898	65.11	Fail	29.15
45	37.9	2318	2355	65.11	Fail	36.18

HB Summary

Bending - 2 units
Shear - 2 unit

6.2 DECK BEAM

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Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	SJQ
Calculation:	Deck beam Loading HB

References	Calculation	Notes

Summary

HA LOADING

	Bending		Shear	
	Standard	Fire	Standard	Fire
UDL KEL	3 Tonne	FAIL	FAIL	FAIL
Single Axle	FAIL	FAIL	FAIL	FAIL

Limiting Value FAIL

HB LOADING

	Bending	Shear
HB	2 units	2 unit

Limiting Value 2 unit

6.3 PARAPET BEAM

SS f88

Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Deck beam Loading - DL

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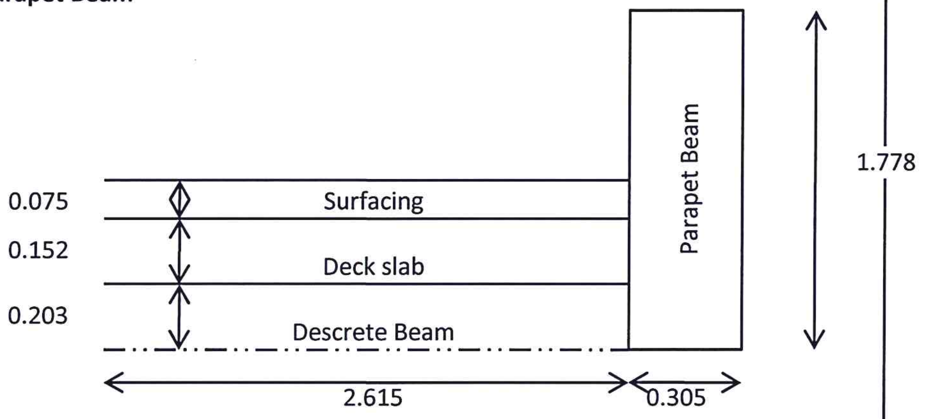
References	Calculation	Notes

Parapet Beam



Width Out/out 5.84 m
Width in/in 2.92 m

References					
BD21/14	Self weight				
Table 4.1	Concrete →	γ_{conc}	=	24	kN/m^3
Table 4.1	Surfacing →	$\gamma_{surface}$	=	25.6	kN/m^3

Area

Parapet Beam				0.54 m^2
Deck slab				0.40 m^2
Descrete Beam	0.25 m every	1.53 m		0.09 m^2
			Total	1.03 m^2
Surfacing				0.20 m^2

Loading

Concrete	24.67 kN/m
Surfacing	5.02 kN/m

References					
BD21/14	*Factored Load:*	γ_F		w_1	
Table 3.1	Concrete →	1.15	=	28.37	kN/m
Table 3.1	Surfacing →	1.75	=	8.79	kN/m
	Total Dead Load (w_1) →		=	37.16	kN/m

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Project	HARTLEY BRIDGE : PARAPET BEAM	Job No.	1210658
Date	JAN 16	Made by	AIG
Checked by		Page	56 of 88

6.3 PARAPET BEAM

Dead Loading Analysis:

2D Model (Tedds software)

Moment	Sagging	= 231.2	kNm	} see attached.
Moment	Hogging	= 464.4	kNm	
Shear		= 227	kN	

3D Model (Masterseries)

Moment	Sagging	= 285	kNm	} see attached.
Moment	Hogging	= 401	kNm	
Shear		= 204	kN	

Comment

Tedds Doran Consulting 2D Model (Tedds)	Project Hartley Bridge				Job no.	
	Calcs for Dead Loading				Start page no./Revision 1	
	Calcs by 3	Calcs date 21/08/2015	Checked by	Checked date	Approved by	Approved date

CONCRETE BEAM ANALYSIS

2D Analysis P'pet beam

Concrete beam dimensions:-

Beam width b = **0** mm

Beam depth h = **2** mm

Cross-section area $A = b \times h =$ **1** mm^2

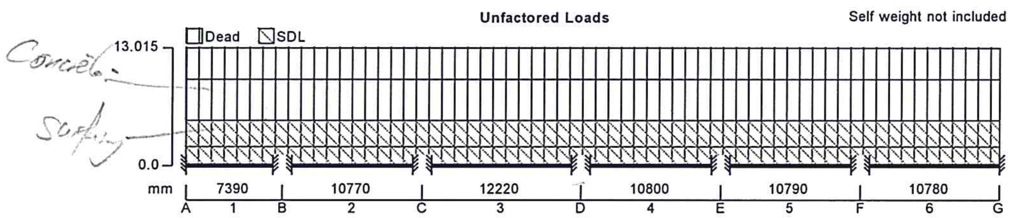
Major axis second moment of area $I_{xx} = b \times h^3 / 12 =$ **143.×10⁻³** mm^4

$f_{cu} =$ **25** N/mm^2

$E = 20\ kN/mm^2 + 200 \times f_{cu} =$ **25.0** kN/mm^2

Ref BS8110:1985:Pt 2 - Eq 17

$\rho = \rho_{C.norm} =$ **2400** kg/m^3



CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = **6**

Material Properties:

Modulus of elasticity = **25** kN/mm^2 Material density = **2400** kg/m^3

Support Conditions:

Support A	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support B	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support C	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support D	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support E	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support F	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support G	Vertically **"Restrained"**	Rotationally **"Restrained"**

Span Definitions:

Span 1	Length = **7390** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00×10⁶** mm^4
Span 2	Length = **10770** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00×10⁶** mm^4
Span 3	Length = **12220** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00×10⁶** mm^4
Span 4	Length = **10800** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00×10⁶** mm^4
Span 5	Length = **10790** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00×10⁶** mm^4
Span 6	Length = **10780** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00×10⁶** mm^4

LOADING DETAILS

Beam Loads:

Load 1	UDL Dead load **13.0** kN/m
Load 2	UDL Dead load **9.5** kN/m
Load 3	UDL Dead load **2.1** kN/m

Concrete

6.3 PARAPET BEAM

Tedds Doran Consulting	Project				Job no.	
	Calcs for				Start page no./Revision 2	
	Calcs by 3	Calcs date 21/08/2015	Checked by	Checked date	Approved by	Approved date

Load 4 UDL SDL load **5.0** kN/m surfacing

LOAD COMBINATIONS

Load combination 1 - Dead & SDL

Span 1 1.15×Dead + 1.75×SDL

Span 2 1.15×Dead + 1.75×SDL

Span 3 1.15×Dead + 1.75×SDL

Span 4 1.15×Dead + 1.75×SDL

Span 5 1.15×Dead + 1.75×SDL

Span 6 1.15×Dead + 1.75×SDL

CONTINUOUS BEAM ANALYSIS - RESULTS

Support Reactions - Combination Summary

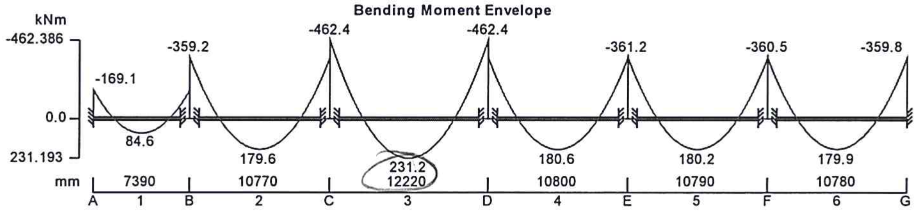
Support A	Max react = **-137.3** kN	Min react = **-137.3** kN	Max mom = **-169.1** kNm	Min mom = **-169.1** kNm
Support B	Max react = **-337.4** kN	Min react = **-337.4** kN	Max mom = **-190.1** kNm	Min mom = **-190.1** kNm
Support C	Max react = **-427.1** kN	Min react = **-427.1** kN	Max mom = **-103.2** kNm	Min mom = **-103.2** kNm
Support D	Max react = **-427.7** kN	Min react = **-427.7** kN	Max mom = **101.2** kNm	Min mom = **101.2** kNm
Support E	Max react = **-401.1** kN	Min react = **-401.1** kN	Max mom = **0.7** kNm	Min mom = **0.7** kNm
Support F	Max react = **-400.7** kN	Min react = **-400.7** kN	Max mom = **0.7** kNm	Min mom = **0.7** kNm
Support G	Max react = **-200.3** kN	Min react = **-200.3** kN	Max mom = **359.8** kNm	Min mom = **359.8** kNm

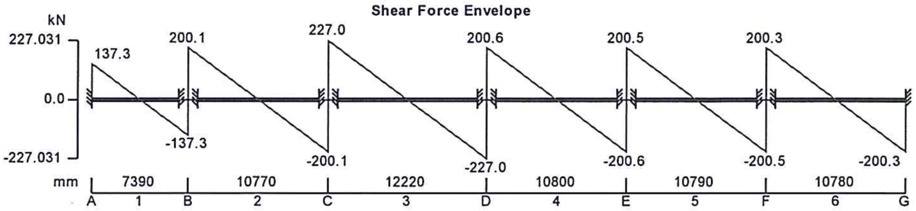
Beam Max/Min results - Combination Summary

Maximum shear = **227.0** kN Minimum shear F_{min} = **-227.0** kN

Maximum moment = **231.2** kNm Minimum moment = **-462.4** kNm

Maximum deflection = **86309.2** mm Minimum deflection = **0.0** mm





Max sag - 231 kNm

Max hog - 462 kNm

Max shear - 227 kN

N:\Drawings\Y2012\12-1xxx\121065B LEITRIM PI - ADDITIONAL DESIGN AND SI WORKS\02-CAD\HEARTLY BRIDGE sjq

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Ref. : , / , Date : 21/08/2015

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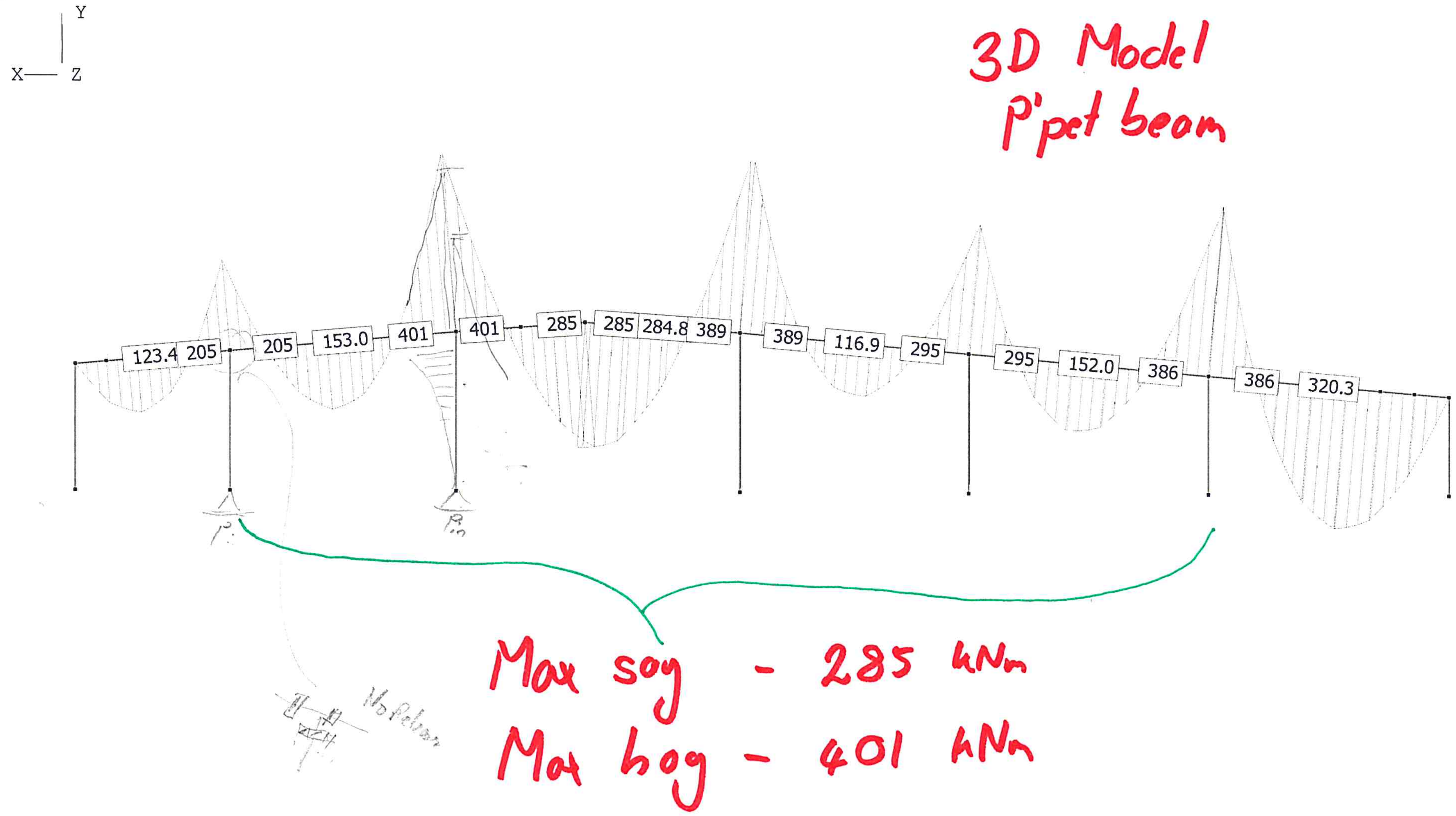

Load Case 001 : Dead plus Live (Ultimate)

Bending Moment Diagram (Major Axis) - (Front Elevation) - X+000 Y-176 Z+000

Bending Moment Values (kN.m)

Not to Scale

50 kN.m = 1m

6.3 PARAPET BEAM Hartley Bridge, Dead Loading 60 of

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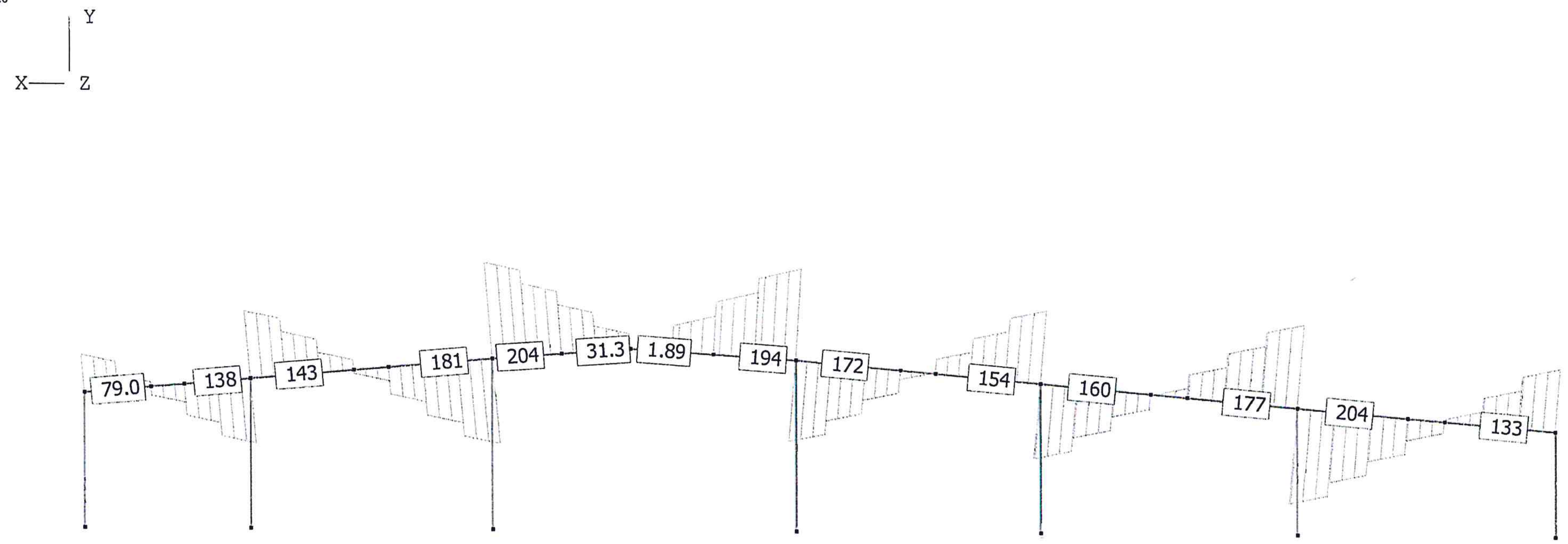

Max shear - 204 kN

Load Case 001 : Dead plus Live (Ultimate)

Shear Force Diagram (Major Axis) - (Front Elevation) - X+000 Y-176 Z+000

Shear Force Values (kN)

Not to Scale

50 kN = 1m

6.3 PARAPET BEAM

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		Job Number:	121065B
		Date:	Jul-14
		Made By	AIG
		Checked By:	
		Calculation:	Parapet Beams - Loading - 4 Middle

References	Calculation	Notes

No. Spans 6

Span length

1 →	7.39	m
2 →	10.77	m
3 →	12.22	m
4 →	10.80	m
5 →	10.79	m
6 →	10.78	m

Construction: Contiunous beam over columns. Cast in situ reinforced concrete

2D Analysis using Tedds Software

2D analysis results (Tedds)

	DL	Capacity	LL Capacity	AI	
Max Hogging Moment	462 kNm	557 kNm	95.369 kNm	0.83	
Mas Sagging Moment	231 kNm	1306.5 kNm	1075.5 kNm	0.18	
Max Shear	227 kN	138.8 kN	-88.16 kN	1.63	FAIL

3D Analysis using Masterseries Software

3D analysis results (Masterseries)

	DL	Capacity	LL Capacity	AI	
Max Hogging Moment	401 kNm	557 kNm	156.37 kNm	0.72	
Mas Sagging Moment	285 kNm	1306.5 kNm	1021.5 kNm	0.22	
Max Shear	204 kN	138.8 kN	-65.16 kN	1.47	FAIL

Theoretically, the structure, in its current condition, is unable to sustain the shear effects from its own selfweight

Check of structure with a condition factor of 1.0 applied

	DL	Capacity	LL Capacity	AI	
2D analysis results (Tedds)					
Max Shear	227 kN	173.6 kN	-53.45 kN	1.31	FAIL
3D analysis results (Masterseries)					
Max Shear	204 kN	173.6 kN	-30.45 kN	1.18	FAIL

Even when no condition factor is applied the structure is, theorectically, unable to sustain the shear effects of its own self weight.

6.3 PARAPET BEAM

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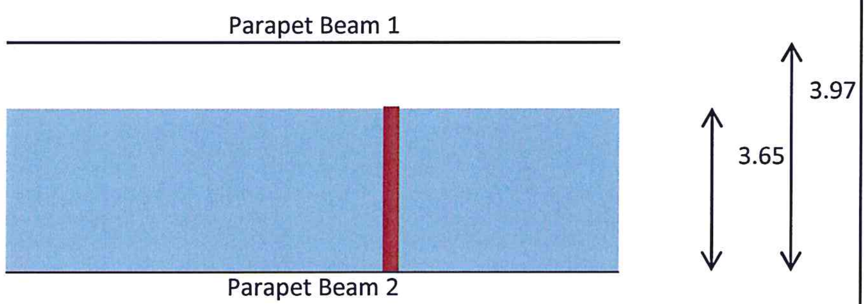
Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Parapet Beams - Loading - 4 Middle

References	Calculation	Notes
	HA - UDL & KEL	
BD 21/14	Carrigeway width = 3.97 m	
Table 5.1	Number of notonal lanes = 1	
5.6	Assume lane width of 3.65 m	
	Bridge Span length = 62 m	
5.22	Traffic Flow: low	
5.23	Road surface: good	
	Adjustment Factor Af	
5.20	k = 0.76	
5.24	al 3.65 Af = 1.46	
	L <20	
6.2.1 (BD37/01)	w = 23.8 kN/m along length of bridge	acts over an area
5.18	KEL = 120 kN transvers to beam	of 3.65m
Table 3.1 (BD 21/14)	Partial Factor (γ_f) = 1.5	
	Assume that the notional lane sits to one side of the structure, assume	



References	Calculation	Notes
	Parapet Beam 1 46% of the load	
	Parapet Beam 2 54% of the load	
	UDL to be applied to parapet beam **12.87** kN/m	Before adjustment
	KEL to be applied to parapet beam **64.84** kN	
	$Factored\ Load = \frac{Load}{A_f} \cdot k \cdot \gamma_f$	
	UDL to be applied to parapet beam **10.05** kN/m	After adjustment
	KEL to be applied to parapet beam **50.63** kN	and partial FoS
	Max Bending Moment (Sagging) **139.92** kNm = 184.1 x 0.76	
	Max Bending Moment (Hogging) **202.46** kNm = 266.4 x 0.76	FROM TEDDS
	Max Shear Force **112.02** kN = 147.4 x 0.76	

Tedds Doran Consulting	Project: Heartly Bridge			Job no.: 121065	
	Calcs for: Leitrim Co. Co.			Start page no./Revision: 1	
	Calcs by: SJQ	Calcs date: 24/08/2015	Checked by: AIG	Checked date:	Approved by:	Approved date:

HA UDL & KEL

Parapet Beam

CONCRETE BEAM ANALYSIS

Concrete beam dimensions:-

Beam width $b = \mathbf{0}$ mm

Beam depth $h = \mathbf{2}$ mm

Cross-section area $A = b \times h = \mathbf{1}$ mm^2

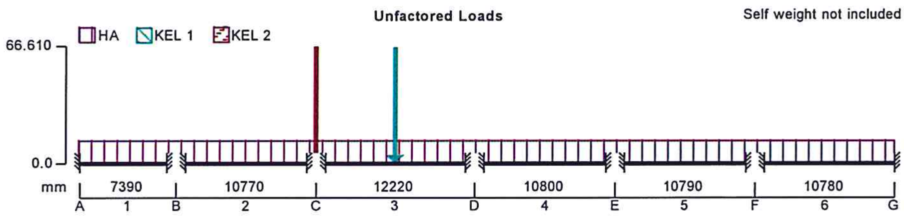
Major axis second moment of area $I_{xx} = b \times h^3 / 12 = \mathbf{143.\times10^{-3}}$ mm^4

$f_{cu} = \mathbf{25}$ N/mm^2

$E = 20$ kN/mm$^2 + 200 \times f_{cu} = \mathbf{25.0}$ kN/mm^2

Ref BS8110:1985:Pt 2 - Eq 17

$\rho = \rho_{C.norm} = \mathbf{2400}$ kg/m^3



CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = **6**

Material Properties:

Modulus of elasticity = **25** kN/mm^2 Material density = **2400** kg/m^3

Support Conditions:

Support A	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support B	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support C	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support D	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support E	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support F	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support G	Vertically **"Restrained"**	Rotationally **"Restrained"**

Span Definitions:

Span 1	Length = **7390** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 2	Length = **10770** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 3	Length = **12220** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 4	Length = **10800** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 5	Length = **10790** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 6	Length = **10780** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4

LOADING DETAILS

Beam Loads:

Load 1 UDL HA load **13.2** kN/m ✓

Span 3 loads: ✓

Load 1 Point KEL 1 load **66.6** kN at **6.110** m ✓

6.3 PARAPET BEAM

Tedds Doran Consulting	Project: Heartly Bridge			Job no.: 121065	
	Calcs for: Leitrim Co. Co.			Start page no./Revision: 2	
	Calcs by: SJQ	Calcs date: 24/08/2015	Checked by: AIG	Checked date:	Approved by:	Approved date:

Load 2 Point KEL 2 load **66.6** kN at **0.010** m

LOAD COMBINATIONS

Load combination 1 - KEL mid span

Span 1	1×HA + 1×KEL 1
Span 2	1×HA + 1×KEL 1
Span 3	1×HA + 1×KEL 1
Span 4	1×HA + 1×KEL 1
Span 5	1×HA + 1×KEL 1
Span 6	1×HA + 1×KEL 1

Load combination 2 - KEL at support

Span 1	1×HA + 1×KEL 2
Span 2	1×HA + 1×KEL 2
Span 3	1×HA + 1×KEL 2
Span 4	1×HA + 1×KEL 2
Span 5	1×HA + 1×KEL 2
Span 6	1×HA + 1×KEL 2

CONTINUOUS BEAM ANALYSIS - RESULTS

Support Reactions - Combination Summary

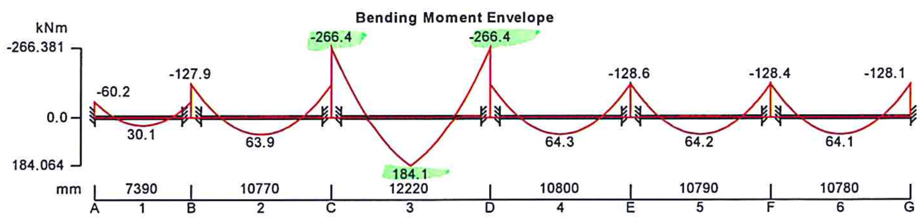
Support A	Max react = **-48.9** kN	Min react = **-48.9** kN	Max mom = **-60.2** kNm	Min mom = **-60.2** kNm
Support B	Max react = **-120.1** kN	Min react = **-120.1** kN	Max mom = **-67.7** kNm	Min mom = **-67.7** kNm
Support C	Max react = **-185.4** kN	Min react = **-218.7** kN	Max mom = **-37.4** kNm	Min mom = **-138.5** kNm
Support D	Max react = **-152.3** kN	Min react = **-185.6** kN	Max mom = **137.8** kNm	Min mom = **36.0** kNm
Support E	Max react = **-142.8** kN	Min react = **-142.8** kN	Max mom = **0.2** kNm	Min mom = **0.2** kNm
Support F	Max react = **-142.7** kN	Min react = **-142.7** kN	Max mom = **0.2** kNm	Min mom = **0.2** kNm
Support G	Max react = **-71.3** kN	Min react = **-71.3** kN	Max mom = **128.1** kNm	Min mom = **128.1** kNm

Beam Max/Min results - Combination Summary

Maximum shear = **147.4** kN Minimum shear F_{min} = **-114.1** kN

Maximum moment = **184.1** kNm Minimum moment = **-266.4** kNm

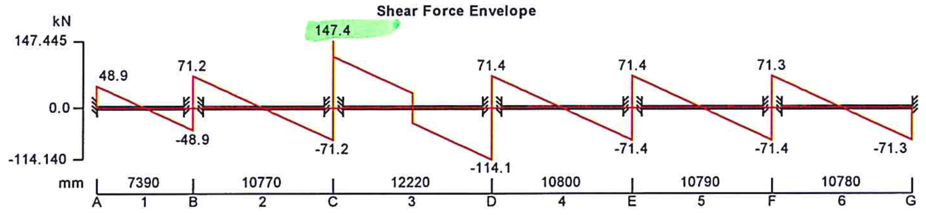
Maximum deflection = **56053574666.7** mm Minimum deflection = **0.0** mm



6.3 PARAPET BEAM

65f

Tedds Doran Consulting	Project: Heartly Bridge			Job no.: 121065	
	Calcs for: Leitrim Co. Co.			Start page no./Revision: 3	
Calcs by: SJQ	Calcs date: 24/08/2015	Checked by: [signature]	Checked date	Approved by	Approved date



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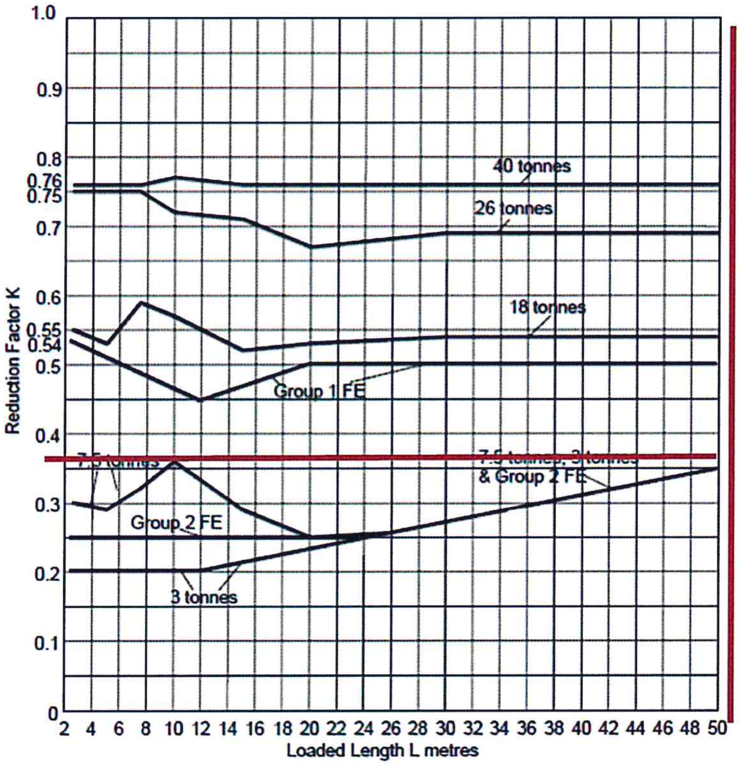
	Job Number:	121065B
	Date:	Jul-14
	Made By	AIG
	Checked By:	
	Calculation:	Parapet Beams - Loading - 4 Middle

References	Calculation	Notes
5.28	C = Available live load capacity / Live Load Capacity required for **Adjusted** HA loading	

Hogging	95.4	/	266.4	0.36
Sagging	1021	/	184.1	5.55
Shear	-88.2	/	147.4	-0.6

Fig 5.7



HA & KEL Summary

Bending	3 Tonnes	&	Group 2 Fire engine
Shear	N/A - FAILS IN SHEAR WITH SELF WEIGHT		

6.3 PARAPET BEAM 67 of

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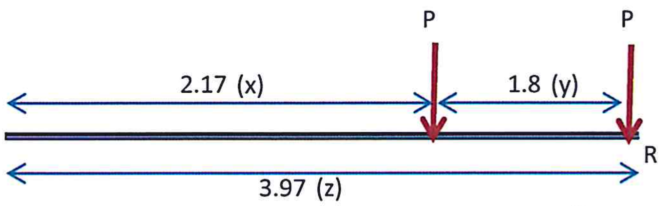
Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Parapet Beams - Loading - 4 Middle

References	Calculation	Notes

Single Axle



Partial Factor (α) = 1.5 (all in metres)

SAGGING

Assessment Love Loading	Lg (kN)	Applied force^ (kN)	Sagging Moment * (kNm)	Hogging Moment * (kNm)	Shear * (kN)
40 Tonne	82	145.4	222.3	222.3	145
26 Tonne	82	145.4	222.3	222.3	145
18 Tonne	82	145.4	222.3	222.3	145
7.5 Tonne	41	72.7	111	111	73
3 Tonne	19	33.7	51.5	51.5	34
FE Group 1	50	88.7	135.4	135.4	89
FE Group 2	25	44.3	67.8	67.8	44

** Moments & Shear forces from Tedds analysis (see attached)*
^ Applied force = { α . y + (2 . x)} x (Lg / z)

	Load Case	Applied Moment Dead	Live	Total	Capacity (Reduced)	Pass / Fail	AI
Sagging	40 Tonne	285	222	507	1306.48	Pass	0.39
Hogging		462	222	684	557.37	Fail	1.23
Sagging	26 Tonne	285	222	507	1306.48	Pass	0.39
Hogging		462	222	684	557.37	Fail	1.23
Sagging	18 Tonne	285	222	507	1306.48	Pass	0.39
Hogging		462	222	684	557.37	Fail	1.23
Sagging	7.5 Tonne	285	111	396	1306.48	Pass	0.30
Hogging		462	111	573	557.37	Fail	1.03
Sagging	3 Tonne	285	52	337	1306.48	Pass	0.26
Hogging		462	51.5	514	557.37	Pass	0.92
Sagging	FE Group 1	285	135	420	1306.48	Pass	0.32
Hogging		462	135	597	557.37	Fail	1.07
Sagging	FE Group 2	285	68	353	1306.48	Pass	0.27
Hogging		462	67.8	530	557.37	Pass	0.95

Load Case	Applied Shear Dead	Live	Total	Capacity (Reduced)	Pass / Fail	AI
40 Tonne	227	145	372	138.84	Fail	2.68
26 Tonne	227	145	372	138.84	Fail	2.68
18 Tonne	227	145	372	138.84	Fail	2.68
7.5 Tonne	227	73	300	138.84	Fail	2.16
3 Tonne	227	34	261	138.84	Fail	1.88
FE Group 1	227	89	316	138.84	Fail	2.27
FE Group 2	227	44	271	138.84	Fail	1.95

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Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Parapet Beams - Loading - 4 Middle

References	Calculation	Notes
	Single Axle Summary	
	Bending (Hogging) 3 Tonnes (<1% overstress) & Group 2 Fire engine	
	Bending (Sagging) 40 Tonnes & Group 1 Fire engine	
	Shear FAILS	

Tedds Doran Consulting	Project Heartly Bridge			Job no. 121065	
	Calcs for Leitrim Co. Co.			Start page no./Revision 1	
	Calcs by SJQ	Calcs date 24/08/2015	Checked by AIG	Checked date	Approved by	Approved date

CONCRETE BEAM ANALYSIS

SINGLE AXLE

Parapet Beam

Concrete beam dimensions:-

Beam width b = **0** mm

Beam depth h = **2** mm

Cross-section area $A = b \times h =$ **1** mm^2

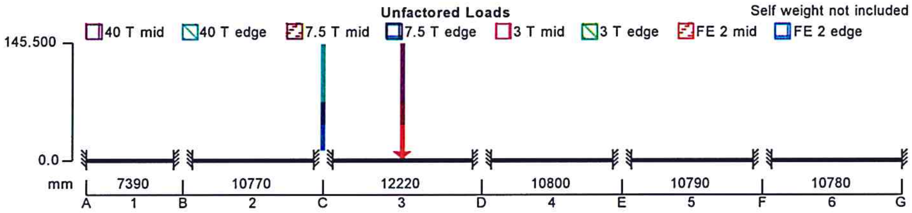
Major axis second moment of area $I_{xx} = b \times h^3 / 12 =$ **143.×10⁻³** mm^4

$f_{cu} =$ **25** N/mm^2

$E = 20\ kN/mm^2 + 200 \times f_{cu} =$ **25.0** kN/mm^2

Ref BS8110:1985:Pt 2 - Eq 17

$\rho = \rho_{C.norm} =$ **2400** kg/m^3



CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = **6**

Material Properties:

Modulus of elasticity = **25** kN/mm^2 Material density = **2400** kg/m^3

Support Conditions:

Support A	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support B	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support C	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support D	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support E	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support F	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support G	Vertically **"Restrained"**	Rotationally **"Restrained"**

Span Definitions:

Span 1	Length = **7390** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 2	Length = **10770** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 3	Length = **12220** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 4	Length = **10800** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 5	Length = **10790** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 6	Length = **10780** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4

LOADING DETAILS

Span 3 loads:

Load 1	Point 40 T mid load **145.5** kN at **6.110** m ✓
Load 2	Point 40 T edge load **145.4** kN at **0.010** m
Load 3	Point 7.5 T mid load **72.7** kN at **6.110** m

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Load 4 Point 7.5 T edge load **72.7** kN at **0.010** m

Load 5 Point 3 T mid load **33.7** kN at **6.110** m

Load 6 Point 3 T edge load **33.7** kN at **0.010** m

Load 7 Point FE 2 mid load **44.4** kN at **6.110** m

Load 8 Point FE 2 edge load **44.3** kN at **0.010** m

LOAD COMBINATIONS

Load combination 1 - 40 T bending

Span 3 1×40 T mid

Load combination 2 - 40T Shear

Span 3 1×40 T edge

Load combination 3 - 7.5 T Bending

Span 3 1×7.5 T mid

Load combination 4 - 7.5T Shear

Span 3 1×7.5 T edge

Load combination 5 - 3T Bending

Span 3 1×3 T mid

Load combination 6 - 3T Shear

Span 3 1×3 T edge

Load combination 7 - Group 2 FE Bending

Span 3 1×FE 2 mid

Load combination 8 - Group 2 FE Shear

Span 3 1×FE 2 edge

CONTINUOUS BEAM ANALYSIS - RESULTS

Support Reactions - Combination Summary

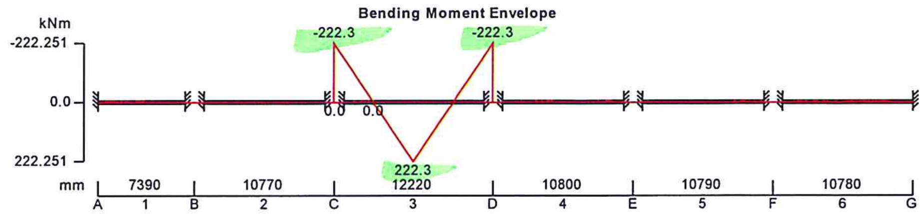
Support A	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support B	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support C	Max react = **-16.8** kN	Min react = **-145.4** kN	Max mom = **-0.3** kNm	Min mom = **-222.3** kNm
Support D	Max react = **0.0** kN	Min react = **-72.7** kN	Max mom = **222.3** kNm	Min mom = **0.0** kNm
Support E	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support F	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support G	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm

Beam Max/Min results - Combination Summary

Maximum shear = **145.4** kN Minimum shear F_{min} = **-72.7** kN

Maximum moment = **222.3** kNm Minimum moment = **-222.3** kNm

Maximum deflection = **55314039267.5** mm Minimum deflection = **0.0** mm



6.3 PARAPET BEAM

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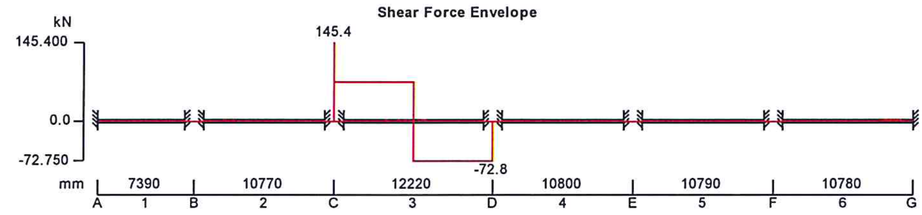
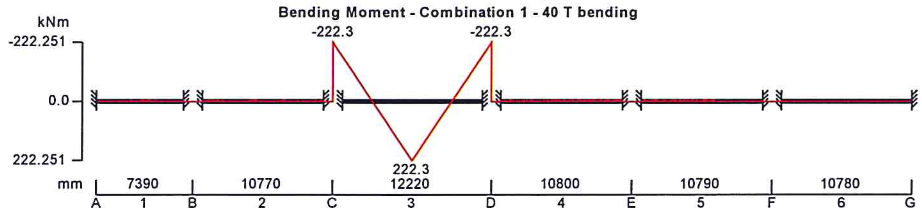
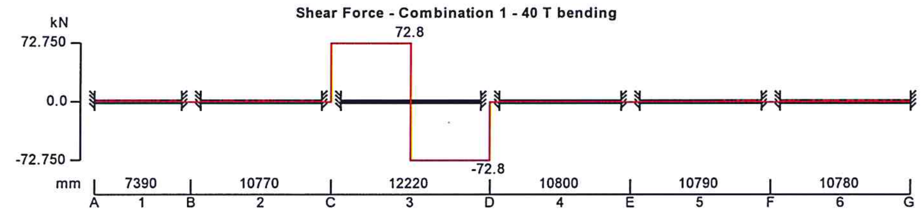
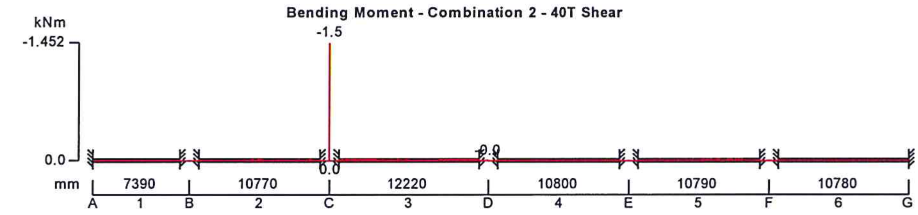
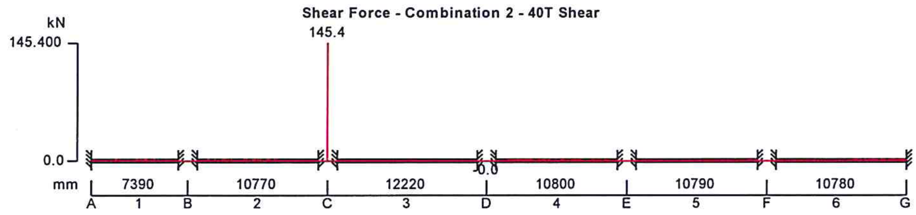
	Calcs by: SJQ	Calcs date: 24/08/2015	Checked by: AJG	Checked date:	Approved by:	Approved date:











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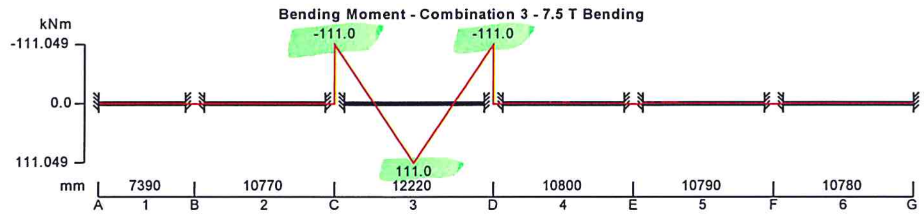
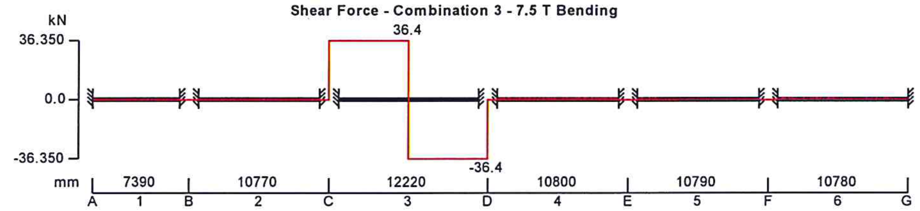
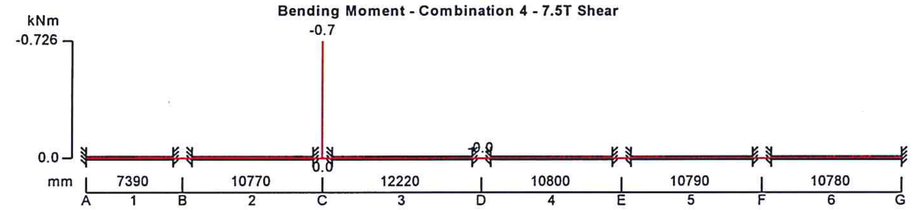
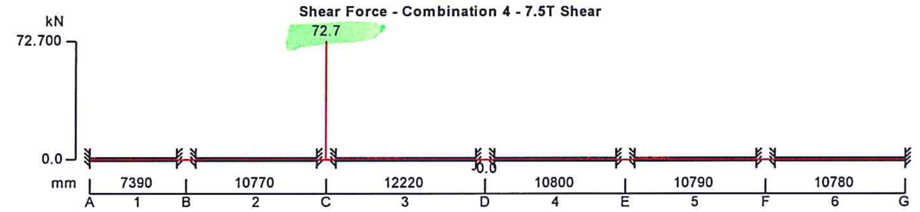
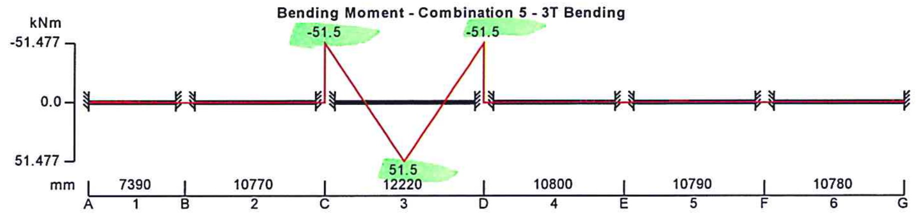
	Calcs by: SJQ	Calcs date: 24/08/2015	Checked by: AJG	Checked date	Approved by	Approved date











6.3 PARAPET BEAM

Tedds Doran Consulting	Project: Heartly Bridge			Job no.: 121065	
	Calcs for: Leitrim Co. Co.			Start page no./Revision: 5	
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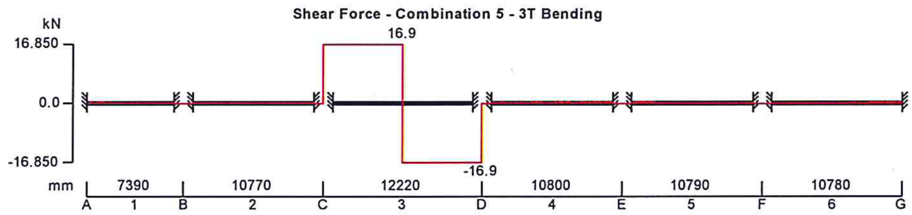

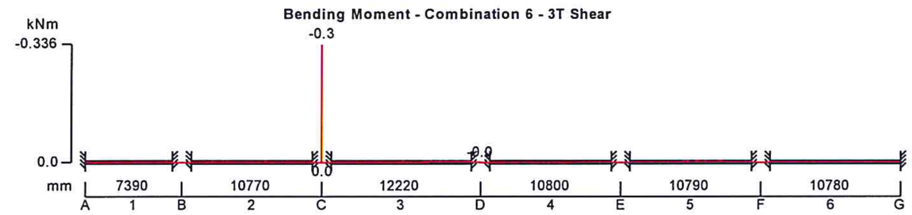

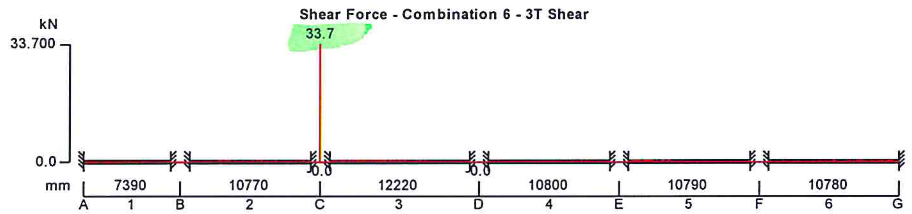

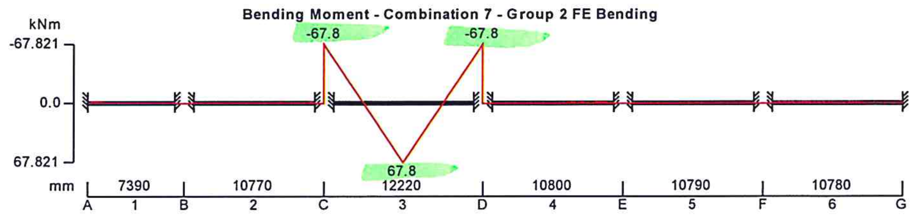

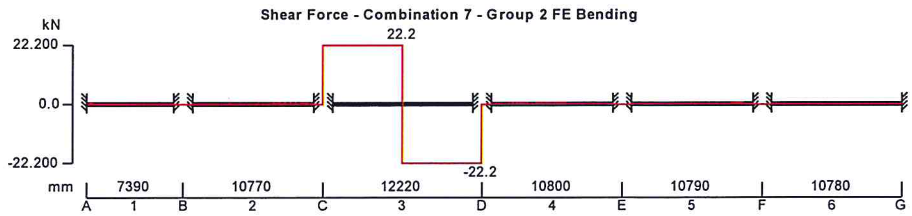

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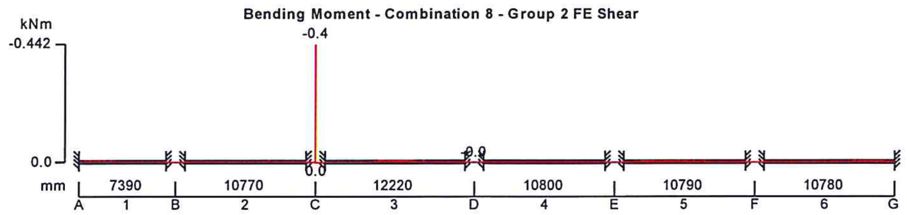

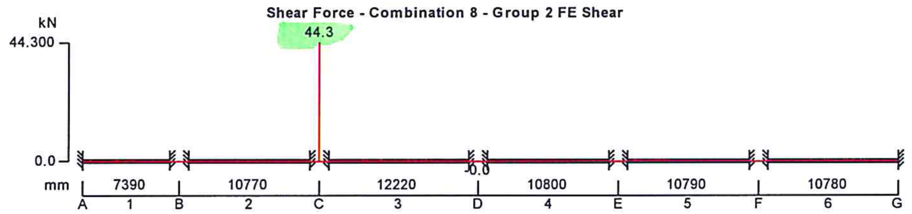

6.3 PARAPET BEAM

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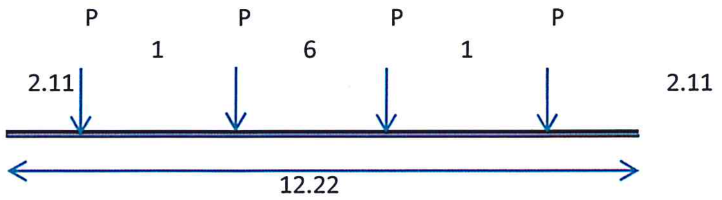
Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Parapet Beams - Loading - 4 Middle

References	Calculation	Notes

HB

or



Assessment Love Loading		HB (kN)	Partial Factor	Sagging Moment (kNm)	Hogging Moment (kNm)	Applied Shear (kN)
1	unit HB	2.5	1.3	*8*	*13.2*	*8.6*
5	unit HB	12.5	1.3	40	66	43
7	unit HB	17.5	2.3	56	92.4	60.2
15	unit HB	37.5	3.3	120	198	129
20	unit HB	50	4.3	160	264	172
25	unit HB	62.5	5.3	200	330	215
35	unit HB	87.5	6.3	280	462	301
45	unit HB	113	7.3	360	594	387

Highlighted *from Tedds analysis attached.*

Bending (hogging)

Load Case HB Units	Applied Moment Dead	Live	Total	Capacity (Reduced)	Pass / Fail	AI
1	462	13.2	475	557.37	Pass	0.85
5	462	66	528	557.37	Pass	0.95
7	462	92.4	554	557.37	Pass	0.99
15	462	198	660	557.37	Fail	1.18
20	462	264	726	557.37	Fail	1.30
25	462	330	792	557.37	Fail	1.42
35	462	462	924	557.37	Fail	1.66
45	462	594	1056	557.37	Fail	1.89

Bending (sagging)

Load Case HB Units	Applied Moment Dead	Live	Total	Capacity (Reduced)	Pass / Fail	AI
1	285	8	293	1306.48	Pass	0.22
5	285	40	325	1306.48	Pass	0.25
7	285	56	341	1306.48	Pass	0.26
15	285	120	405	1306.48	Pass	0.31
20	285	160	445	1306.48	Pass	0.34
25	285	200	485	1306.48	Pass	0.37
35	285	280	565	1306.48	Pass	0.43
45	285	360	645	1306.48	Pass	0.49

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Project:	Hartley Bridge
Job Number:	121065B
Date:	Jul-14
Made By	AIG
Checked By:	
Calculation:	Parapet Beams - Loading - 4 Middle

References	Calculation	Notes
	HB	
Shear		

Load Case	Applied Shear			Capacity (Reduced)	Pass / Fail	AI
	Dead	Live	Total			
1	227	9	236	138.84	Fail	1.70
5	227	43	270	138.84	Fail	1.94
7	227	60	287	138.84	Fail	2.07
15	227	129	356	138.84	Fail	2.56
20	227	172	399	138.84	Fail	2.87
25	227	215	442	138.84	Fail	3.18
35	227	301	528	138.84	Fail	3.80
45	227	387	614	138.84	Fail	4.42

HB Summary

Bending	7 units
Shear	FAIL

Tedds Doran Consulting	Project Heartly Bridge				Job no. 121065	
	Calcs for Leitrim Co. Co.				Start page no./Revision 1	
	Calcs by SJQ	Calcs date 24/08/2015	Checked by	Checked date	Approved by	Approved date

HB Loading

Parapet Beam

CONCRETE BEAM ANALYSIS

Concrete beam dimensions:-

Beam width b = **0** mm

Beam depth h = **2** mm

Cross-section area $A = b \times h =$ **1** mm^2

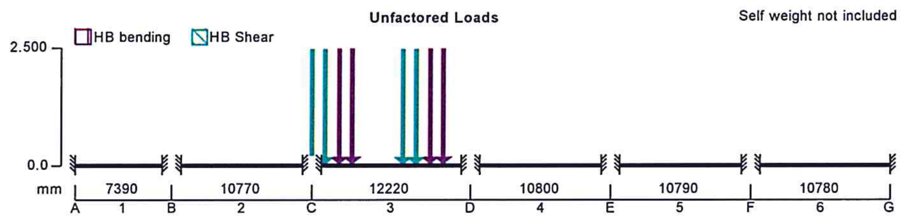
Major axis second moment of area $I_{xx} = b \times h^3 / 12 =$ **143.×10^{-3}** mm^4

f_{cu} = **25** N/mm^2

$E = 20$ kN/mm^2 $+ 200 \times f_{cu} =$ **25.0** kN/mm^2

Ref BS8110:1985:Pt 2 - Eq 17

$\rho = \rho_{C.norm}$ = **2400** kg/m^3



CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = **6**

Material Properties:

Modulus of elasticity = **25** kN/mm^2 Material density = **2400** kg/m^3

Support Conditions:

Support A	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support B	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support C	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support D	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support E	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support F	Vertically **"Restrained"**	Rotationally **"Restrained"**
Support G	Vertically **"Restrained"**	Rotationally **"Restrained"**

Span Definitions:

Span 1	Length = **7390** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 2	Length = **10770** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 3	Length = **12220** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 4	Length = **10800** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 5	Length = **10790** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4
Span 6	Length = **10780** mm	Cross-sectional area = **1** mm^2	Moment of inertia = **1.00** mm^4

LOADING DETAILS

Span 3 loads:

Load 1	Point HB bending load **2.5** kN at **2.110** m
Load 2	Point HB bending load **2.5** kN at **3.110** m
Load 3	Point HB bending load **2.5** kN at **9.110** m

Tedds Doran Consulting	Project: Heartly Bridge				Job no.: 121065	
	Calcs for: Leitrim Co. Co.				Start page no./Revision: 2	
	Calcs by: SJQ	Calcs date: 24/08/2015	Checked by	Checked date	Approved by	Approved date

Load 4 Point HB bending load **2.5** kN at **10.110** m

Load 5 Point HB Shear load **2.5** kN at **0.000** m

Load 6 Point HB Shear load **2.5** kN at **1.000** m

Load 7 Point HB Shear load **2.5** kN at **7.000** m

Load 8 Point HB Shear load **2.5** kN at **8.000** m

LOAD COMBINATIONS

Load combination 1 - HB Bending

Span 3 1.3×HB bending

Load combination 2 - HB Shear

Span 3 1.3×HB Shear

CONTINUOUS BEAM ANALYSIS - RESULTS

Support Reactions - Combination Summary

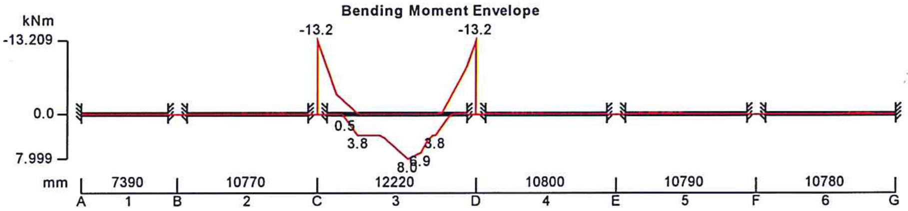
Support A	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support B	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support C	Max react = **-6.5** kN	Min react = **-8.6** kN	Max mom = **-10.0** kNm	Min mom = **-13.2** kNm
Support D	Max react = **-4.4** kN	Min react = **-6.5** kN	Max mom = **13.2** kNm	Min mom = **11.7** kNm
Support E	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support F	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support G	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm

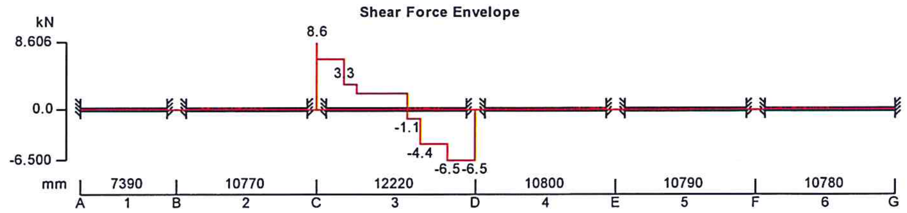
Beam Max/Min results - Combination Summary

Maximum shear = **8.6** kN — Minimum shear F_{min} = **-6.5** kN

Maximum moment = **8.0** kNm — Minimum moment = **-13.2** kNm

Maximum deflection = **2244922356.3** mm — Minimum deflection = **0.0** mm





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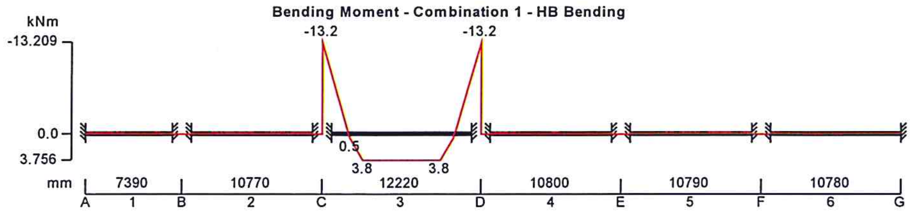
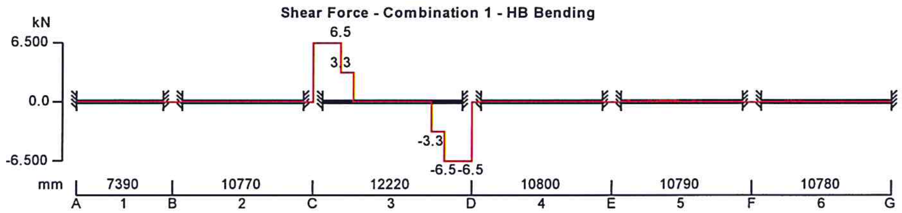
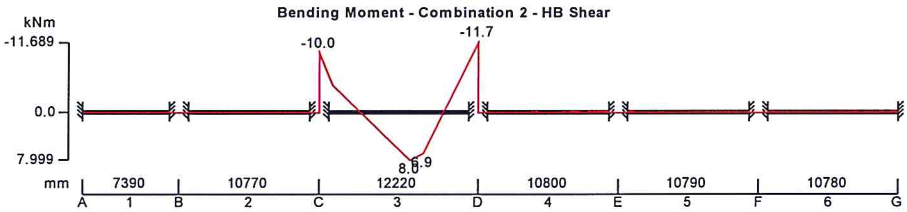
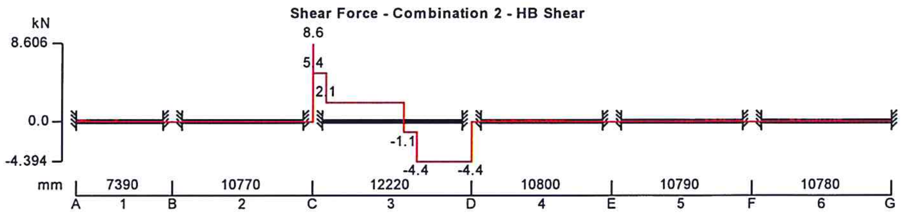
	Calcs for: Leitrim Co. Co.			Start page no./Revision: 3	
	Calcs by: SJQ	Calcs date: 24/08/2015	Checked by	Checked date	Approved by	Approved date









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Project	HARTLEY BRIDGE : PIER STRUCTURE		Job No. 121065B
Date JAN'16	Made by AIG	Checked by	Page 80 of 88

6.4 PIER STRUCTURE

The pier structure contains the following bridge elements:

- Column
- Diagonal Brace
- Horizontal Tie

These 3 elements will be assessed for HA (40 tonne) loading.

The pier structure has been assessed using a 3D Master series model.

Comment

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		Job Number:	121065B
		Date:	Jan-16
		Made By	AIG
		Checked By:	
		Calculation:	Pier Assessment

HA Loading (UDL + KEL) Assessment

Modelled using 3D Masterseries Masterframe model.

Loadings applied

Dead Load (applied as an area load) = **1.875** **kN/m2**

Note: self weight of concrete sections included within model.

HA Live Load (UDL)

notational lane width taken as 3.65 m

BD 37/01, section 5.18 w = 23.83 kN/m

therefore patch load = **6.53** **kN/m2**

HA Live Load (KEL)

notational lane width taken as 3.65 m

BD 37/01, section 5.18 KEL = 120.00 kN/m

therefore line load = **32.88** **kN/m2**

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Project:	Hartley Bridge
Job Number:	121065B
Date:	Jan-16
Made By	AIG
Checked By:	
Calculation:	Pier Assessment: Column

COLUMN

Masterseries 3D Frame model, output

Member Forces (Maximum Values Ultimate)

Mem ber No.	Node End1 End2	Axial Force (kN)	Torque Moment (kN.m)	Shear Force (kN) y-y	Shear Force (kN) z-z	Bending Moment (kN.m) y-y	Bending Moment (kN.m) z-z	Maximum Moment (kN.m @ m) y-y	Maximum Moment (kN.m @ m) z-z	Maximum Deflection (mm @ m)
167	1	327.08C	0.00	-28.82	6.33	0.00	0.00	-34.63		0.77
	2	322.75C	0.00	-28.82	6.33	-25.94	5.70	@ 0.900		@ 2.808
168	2	283.22C	-0.77	22.12	6.16	-34.63	4.21	-34.63		0.77
	5	265.92C	0.77	22.12	6.16	45.01	26.37	@ 0.900		@ 2.808
169	3	269.69C	0.00	21.84	4.75	0.00	0.00	22.70		0.74
	4	265.37C	0.00	21.84	4.75	19.66	4.27	@ 0.900		@ 2.700
170	4	258.83C	0.64	-16.58	4.55	22.70	4.09	22.70		0.74
	7	241.53C	-0.64	-16.58	4.55	-37.00	20.47	@ 0.900		@ 2.700
171	26	822.31C	0.00	-56.92	-1.62	0.00	0.00	-53.02		1.52
	27	817.98C	0.00	-56.92	-1.62	-51.22	-1.46	@ 0.900		@ 3.150
172	27	734.73C	-0.25	24.11	-1.53	-53.02	-0.85	-53.02		1.52
	30	713.10C	0.25	24.11	-1.53	55.48	-7.73	@ 0.900		@ 3.150
173	28	659.01C	0.00	42.91	-1.28	0.00	0.00	38.23		1.45
	29	654.68C	0.00	42.91	-1.28	38.62	-1.16	@ 0.891		@ 3.060
174	29	646.36C	0.37	-18.50	-1.23	38.14	-1.00	38.23		1.45
	32	624.74C	-0.37	-18.50	-1.23	-45.09	-6.54	@ 0.891		@ 3.060
175	51	703.74C	0.00	-48.35	-0.70	0.00	0.00	-48.40		1.98
	52	699.41C	0.00	-48.35	-0.70	-43.51	-0.63	@ 0.900		@ 3.843
176	52	614.11C	-0.43	19.61	-0.57	-48.40	-0.34	-48.40		1.98
	55	587.92C	0.43	19.61	-0.57	58.50	-3.42	@ 0.900		@ 3.843
177	53	566.04C	0.00	40.38	-0.56	0.00	0.00	36.08		1.81
	54	561.71C	0.00	40.38	-0.56	36.34	-0.50	@ 0.900		@ 3.734
178	54	553.60C	0.46	-15.14	-0.49	36.08	-0.37	36.08		1.81
	57	527.41C	-0.46	-15.14	-0.49	-46.42	-3.04	@ 0.900		@ 3.734

Taking the maximum values for Axial & Moment

Axial Load	=	822.31	kN	(Pi)	*refer to output above*
Moment	=	58.05	kNm	(Myi)	*refer to output above*
Axial Capacity	=	949.87	kN	(Pa)	
Moment Capacity	=	105.82	kNm	(Mya)	

Check!

$$\frac{\textit{Imposed Load}}{\textit{Allowable Load}} \equiv \frac{P_i}{P_a} + \frac{M_{y_i}}{M_{y_a}} + \frac{M_{z_i}}{M_{z_a}} \leq 1.0 \quad = \quad \mathbf{1.41}$$

Column fails HA (40 tonne) assessment loading

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Project:	Hartley Bridge
Job Number:	121065B
Date:	Jan-16
Made By	AIG
Checked By:	
Calculation:	Pier Assessment: Brace

DIAGONAL BRACE

Masterseries 3D Frame model, output

Member Forces (Maximum Values Ultimate)										
Mem ber No.	Node End1 End2	Axial Force (kN)	Torque Moment (kN.m)	Shear Force (kN)		Bending Moment (kN.m)		Maximum Moment (kN.m @ m)		Maximum Deflection (mm @ m)
				y-y	z-z	y-y	z-z	y-y	z-z	
202	77	136.37C	0.33	9.24	0.01	-21.22	-0.11	9.89		4.32
	82	140.83T	-0.33	-5.53	0.01	4.65	-0.09	@ 5.094		@ 4.662
203	52	109.46C	0.05	8.92	0.03	-18.53	0.13	8.48		3.15
	57	111.23T	-0.05	-5.39	0.03	3.75	0.33	@ 4.633		@ 4.314
204	27	120.39T	-0.26	9.09	0.05	-18.13	0.28	7.91		2.58
	32	130.01T	0.26	-5.72	0.05	3.35	0.45	@ 3.981		@ 3.834
205	2	55.55T	1.20	8.21	-0.06	-13.21	-0.43	6.06		1.57
	7	63.24T	-1.20	-5.49	-0.06	-3.07	-0.69	@ 3.842		@ 3.705
206	105	135.47C	-0.57	9.16	0.03	-20.88	0.24	9.65		4.21
	110	137.97T	0.57	-5.60	0.03	4.31	0.33	@ 5.090		@ 4.659
207	130	93.20C	-0.53	8.67	0.04	-17.23	0.21	8.04		2.92
	135	94.67T	0.53	-5.38	0.04	3.28	0.26	@ 4.633		@ 4.314
208	149	46.68T	-0.73	7.99	0.05	-13.40	0.30	6.77		2.12
	154	57.02T	0.73	-5.44	0.05	-3.38	0.47	@ 4.322		@ 4.094

Taking the maximum values for Axial & Moment

Axial Load	=	140.83	kN	(Pi)	*refer to output above*
Moment	=	21.22	kNm	(Myi)	*refer to output above*
Axial Capacity	=	376.83	kN	(Pa)	
Moment Capacity	=	26.13	kNm	(Mya)	

Check!

$$\frac{Imposed\ Load}{Allowable\ Load} \equiv \frac{P_i}{P_a} + \frac{M_{y_i}}{M_{y_a}} + \frac{M_{z_i}}{M_{z_a}} \leq 1.0 \quad = \quad 1.19$$

Brace fails HA (40 tonne) assessment loading

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Project:	Hartley Bridge
Job Number:	121065B
Date:	Jan-16
Made By	AIG
Checked By:	
Calculation:	Pier Assessment: Tie

HORIZONTAL TIE

Masterseries 3D Frame model, output

Member Forces (Maximum Values Ultimate)

Member No.	Node End1 End2	Axial Force (kN)	Torque Moment (kN.m)	Shear Force (kN) y-y	Shear Force (kN) z-z	Bending Moment (kN.m) y-y	Bending Moment (kN.m) z-z	Maximum Moment (kN.m @ m) y-y	Maximum Moment (kN.m @ m) z-z	Maximum Deflection (mm @ m)
195	77	63.72T	0.16	7.70	0.12	-12.88	0.33	6.68		0.98
	79	63.72T	-0.16	-9.09	0.12	-16.54	0.49	@ 0.701		@ 1.635
196	52	55.51T	-0.19	7.17	0.11	-11.22	0.36	4.80	0.07	0.82
	54	55.51T	0.19	-8.14	0.11	-13.79	0.46	@ 1.285	@ 0.000	@ 1.810
197	27	61.40T	-0.24	7.24	0.08	-11.43	0.30	5.14		0.86
	29	61.40T	0.24	-8.32	0.08	-14.30	0.37	@ 1.168		@ 1.752
198	105	62.03T	-0.15	7.61	-0.02	-12.60	-0.18	6.54		0.98
	107	62.03T	0.15	-9.02	-0.02	-16.31	-0.22	@ 0.759		@ 1.694
199	130	48.02T	-0.13	6.71	-0.01	-9.85	-0.13	4.15	-0.11	0.76
	132	48.02T	0.13	-7.70	-0.01	-12.52	-0.17	@ 1.518	@ 0.000	@ 1.869
200	149	29.78T	-0.16	5.77	-0.01	-6.97	-0.06	2.95		0.62
	151	29.78T	0.16	-6.61	-0.01	-9.30	-0.08	@ 2.102		@ 2.219
201	2	38.42T	0.34	5.98	0.20	-7.62	-0.53	2.89		0.61
	4	38.42T	-0.34	-6.54	0.20	-9.12	0.64	@ 2.161		@ 2.219

Taking the maximum values for Axial force only

Axial Load = 63.72 kN (Pi) *refer to output above*

Axial Capacity = 78.68 kN (Pa)

Check!

Utilisation ratio = 0.81

Tie passes assessment

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Project	HARTLEY BRIDGE : PIER STRUCTURE		Job No. 121065B
Date JAN '16	Made by AIG	Checked by	Page 85 of 88

6.4 PIER STRUCTURE ASSESSMENT

- Column : Fails 40 tonne assessment loading.
- Brace : Fails 40 tonne assessment loading.
- Tie : Passes 40 tonne assessment loading.

Comment

Calculations

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Project	HARTLEY BRIDGE : SECTION ASSESSMENTS		Job No. 121065B
Date JAN '16	Made by AIG	Checked by	Page 86 of 88

6.5 SECTION ASSESSMENT SUMMARY

- DECK SLAB:

  Loaded length < 2m so no 40t assessment.

  Single wheel Assessment failure with No rating.

  HB assessment achieved 5 units rating.

- Deck BEAM:

  HA Loading assessment achieved no rating.

  Single Axle assessment failure with no rating.

  2 Units of HB loading

- PARAPET BEAM:

  HA loading failure with no rating.

  Single Axle failure with no rating.

  HB failure with no rating.

Comment

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Project:	Hartley Bridge
Job Number:	121065B
Date:	Jan-16
Made By	AIG
Checked By:	
Calculation:	Assessment Summary

6.5 **Assessment Summary**

Bridge Element	**Loading**	**Assessment**	**Critical Component**
Deck Slab	HA UDL & KEL	Loaded length < 2m, thus does not apply.	N/A
	Single Wheel	No Rating	Bending (hogging)
	HB	5 units	Bending (hogging)
Deck Beam	HA UDL & KEL	No Rating	Shear
	Single Axle	No Rating	Bending & Shear
	HB	2 units	Bending & Shear
Parapet Beam	HA UDL & KEL	No Rating	Shear
	Single Axle	No Rating	Shear
	HB	No Rating	Shear
Column	HA UDL & KEL	Failure	Bending & Axial combined
Diagonal Brace	HA UDL & KEL	Failure	Bending & Axial combined
Horizontal Tie	HA UDL & KEL	Pass	Tension

Calculations

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Project HARTLEY BRIDGE - SAR			Job No. 121065B
Date JAN 16	Made by GW	Checked by	Page 88 of 88

7.0 SUMMARY

DORAN CONSULTING WERE COMMISSIONED BY LEITRIM COUNTY COUNCIL TO UNDERTAKE A STRUCTURAL ASSESSMENT OF HARTLEY CANAL BRIDGE, LM-LP3400-001.00.

THE SIX-SPAN SECTION HAS BEEN ASSESSED USING FEA AND THE ADOPTION OF ELASTIC BENDING CAPACITY FOR EACH REINFORCED CONCRETE SECTION.

IN ITS CURRENT CONDITION HARTLEY BRIDGE FAILS ASSESSMENT FOR HA LOADINGS.

THE REDUCED LIVE LOAD CARRYING CAPACITY OF HARTLEY BRIDGE IS NO RATING

Comment

Calculations

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Project			Job No.
Date	Made by	Checked by	Page of

APPENDIX A

MATERIAL PROPERTIES

Comment

4

IIRS

Concrete Strength

Leitrim County Council,
County Council Office,
Courthouse,
Carrick-on-Shannon,
Co. Leitrim.

Attention: Mr. John Colleran.

An Instituid Taighde
Tionscail agus Caighdeán

Institute for Industrial
Research and Standards

Ballymun Road,
Dublin 9, Ireland
Telephone (01) 370101
Telegrams "Research, Dublin"
Telex 25449

Comhairle Chonndae Liathdroma
15 DEC 1983
Oifig An Runaidhe

Our ref. R6/2232
TI03/50b/3497.83

Your ref.

December 12th, 1983

Re: Cutting and Testing 2 No. 150mm Diameter Concrete Cores.
Ex. Parapet Wall to Hartley's Bridge - Carrick-on-Shannon.

COMHAIRLE CHONTAE LIATHDROMA
15 DEC 1983
Oifig an Innealtora Chontae

Dear Sir,

We enclose herewith our report on the cutting and testing of 2 No. 150mm diameter Concrete Cores drilled from the parapet wall of the above bridge on November 29th, 1983.

The samples of reinforcing steel and river water have been handed to our Metallurgy and Water Environment Departments respectively and they will be reporting to you directly in due course.

Core Ref. No. 1 was drilled through the full thickness of the parapet wall and hence was sufficiently long to enable 2 specimens to be prepared for test from the one site drilled core.

The visual examination/description of these cores together with the conversion of the compressive strength to estimated in-situ cube strength has been undertaken in accordance with the requirements of B.S. 1881: Part 120: 1983.

We regret that printed core report sheets based on the format recommended in B.S. 1881: 1983 are not yet available. The layout of the attached typewritten sheets is however based on the format recommended in that document.

Please contact the undersigned if you require additional work to be undertaken or if you require further information in relation to matters contained in this report.

Yours faithfully,

P.M. Clarke.

P.M. Clarke,
Senior Civil Engineer,
Concrete Technology Department,
CONSTRUCTION INDUSTRY DIVISION

IIRS

iroup ....Manufacturing Technology
XXXXX/Dept. ....Concrete Technology

heet no. 1 of 5 sheets

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Institute for Industrial
Research and Standards

Dublin Office
Ballymun Road,
Dublin 9, Ireland
Telephone (01) 370101
Telegrams "Research, Dub
Telex 25449

Confidential Report

lient: Leitrim County Council,
County Council Offices,
Courthouse,
Carrick-on-Shannon,
Co. Leitrim.

Attention: Mr. John Colleran.

Title: Cutting and Testing 2 No. 150mm diameter concrete cores.
Ex. Parapet Wall to Hartley's Bridge - Carrick-on-Shannon.

ort ref.	R6/2232	Order no./ref.	
no.	1103/50b/3497.83	Report by	P.M. Clarke
e received		Approved by	
ies to		Date	December 12th, '

nditions

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lon-perishable samples received for testing or laboratory work shall be disposed of after three months from the date of receipt unless claimed, or unless instructions the contrary have been notified by the sender.

lo action or legal proceedings shall lie (except in the case of wilful neglect or default) against the Institute or the Board or any member of the Board or of any committee ppointed by the Board or any officer or servant of the Institute by reason of, or arising out of, the carrying out of any research, investigation, test or analysis in accordnce with the Industrial Research and Standards Act, 1961 or the publication of the results thereof in the name of the Institute.

INSTITUTE FOR INDUSTRIAL RESEARCH AND STANDARDS

CONCRETE SECTION. Telephone No:

REPORT ON CONCRETE CORES .... B.S. 1881: PART 120: 1983

: ......Leitrim County Council.......................... File No. 1103/50b/3497.83
......Courthouse, Carrick-on-Shannon - Co. Leitrim. .... R6/ ....2232..........
T: .Cutting and Testing 2 No. 150mm Diameter Concrete Cores.... Sheet No. 2 ....
.Ex. Parapet Wall to Hartley's Bridge - Carrick-on-Shannon.........................

nce Mark.	1. (Road Side)	1. (River Side).
f Drilling.	29.11.83	29.11.83
f Receipt in Laboratory.	30.11.83	30.11.83
f Test.	9.12.83	9.12.83
en Tested. (Days)	Not known	Not known
e Diameter (mm)	150	150
as Received (mm)	310 - 310	
Cut Off Top of Core (mm)	7	150
After Preparation (mm)	150	150
of End Preparation.	3 parts H.A.C: 1 part sand	3 parts H.A.C: 1 part sand
ate Size/Type (mm)	28mm chips	28mm chips
oneycombing/Cracks	None	None
istribution of Material	Even	Even
ize of Voids	Large/Medium/Small	Large/Medium/small
lassification of Voids	1.0%	1.0%
n Water Prior to Test (hrs)	48	48
rce[illegible]nt	None	None
f Fracture	Normal	Normal
y - As Received (Kgs/m3)	2415	2400
m Load (Kn)	55.5	55.5
ed Compressive Strength (N/mm2)	31.5	31.5
ted in-situ cube th (N/mm2)	31.5	31.5
s: illed full thickness of wall. Two no. specimens d for test from site cores.		

by: ......W. Roantree.................. C.C.
d by: [signature]
.............12.12.83..................

For "CONDITIONS OF TESTING" see over

INSTITUTE FOR INDUSTRIAL RESEARCH AND STANDARDS

CONCRETE SECTION. Telephone No:

REPORT ON CONCRETE CORES :::: B.S. 1881: PART 120: 1983

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Counthouse, Carrick-on-Shannon - Co. Leitrim. R6/ 2232

T: Cutting and testing 2 No. 150mm diameter concrete cores. Sheet No. 3

Ex. Parapet Wall to Hartley's Bridge - Carrick-on-Shannon.

nce Mark.	2. (location Unknown)	
f Drilling.	29.11.83	
f Receipt in Laboratory.	30.11.83	
f Test.	9.12.83	
en Tested. (Days)	Not known	
e D[illegible]meter (mm)	150	
as Received (mm)	272 - 250	
-Cut Off Top of Core (mm)	9	
After Preparation (mm)	150	
of End Preparation.	3 parts H.A.C: 1 part sand	3 parts H.A.C: 1 part sand
ate Size/Type (mm)	40mm chips	
oneycombing/Cracks	None	
istribution of Material	Even	
ize of Voids	Large/Medium/small	
lassification of Voids	1.0%	
n Water Prior to Test (hrs)	48	
rc[illegible]nt	See Overleaf	
f Fracture	Normal	
y - As Received (Kgs/m3)	2405	
m Load (Kn)	920	
ed Compressive Strength (N/mm2)	52.0	
ted in-situ cube th (N/mm2)	57.5	
s: broken off during on-site ing.	Steel bars 25mm x 4mm in core No. 2 when tested.	

by: W. Roantree

ed by: P.M.C.

12.12.83.

C.C.

For "CONDITIONS OF TESTING" see over

REINFORCEMENT

RE NO.	NO. OF BARS	DIAMETER (mm)	LENGTH (mm)	HEIGHT FROM TOP (mm)
2	1	20	140	71 (In core tested)
	1	25 x 4	148	24 (In core tested)
	1	25 x 4	104	102 (In core tested)
	1	12	80	158 (Not in core tested)
	1	20	151	255 " "
	1	25 x 4	144	228 " "

Confidential Report

SUMMARY OF CORE TEST RESULTS

Report ref. R6/2232
TT03/50b/3497.8
Sheet no. 5

CLIENT: Leitrim County Council.

SITE: Hartley's Bridge - Carrick-on-Shannon.

DATE: December 12th, 1983.

Diameter (mm)	Honeycombing	Length (mm)	Density (Approx) Kgs/m^3	Estimated Cube Strength N/mm^2	Comment
150	None	310	2415	31.5	
150	None		2400	31.5	
150	None	261	2405	57.5	
				Significantly different → assume 25 N/mm^2 as conservative estimate. (in line with 1984 ESB report)	

Notes:

Reinforcement Yeild strength

Process Technology

Dept. Mechanical & Physical Test

3 sheets

An Institiúid Taighde Tionscail agus Caighdeán

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Confidential Report

Leitrim County Council,
County Engineers Office,
Carrick-on-Shannon,
Co. Leitrim.

Title Tensile Tests on Steel Samples.

To: Electricity Supply Board,
Civil Works Dept.,
Stephen Court,
Stephens Green,
Dublin 2.

Attention: Mr. C.C. Murphy

Hartley Bridge,
Carrick-on-Shannon.

MIB 306	Order no./ref.	Letter dated 19/10/'83 Ref.JKC/RD	
R6/2232	Report by	B. McMahon	Barry McMahon
10/1/1984	Approved by	V. Hayes	
R6/2232 file; M & PTD file	Date	February , 1984	

ns Leitrim County Council,
County Engineers Office,
Carrick-on-Shannon,
Co. Leitrim.

Introduction:

Four samples of steel, detailed below were received on January 10, 1984 from Leitrim County Council. It was requested by the client that tensile tests be carried out on each sample.

This report confirms results passed by telephone to Mr. C.C. Murphy (Consulting Engineer, E.S.B.) on February 16, 1984.

The samples received were as follows:

1 off : 12.5 mm diameter x 0.7 m long plain round steel bar
I.I.R.S. Referenced 'A'

1 off : 16 mm diameter x 0.7 m long plain round steel bar
I.I.R.S. Referenced 'B'

1 off : 3.5 mm Thick x 25 mm Wide x 0.6 m long flat bar
I.I.R.S. Referenced 'C'

1 off : 0.6 m length of Rail Section ("Moss Bar")
Nominal Weight 7.63 kg/m. → 5.12 lb/ft. ≡ 15.35 lb/yd ⇐ V. light for rail, section!
I.I.R.S. Reference 'D'.

$$\frac{7.63\ kg/m}{7850\ kg/m^3} \times 10^6 = 972\,mm^2 \quad C.S.A.$$

(35.2mm Ø if assumed to be round bar)

Procedure:

Tensile tests were carried out in accordance with procedures specified in B.S. 18 : Part 2 : 1971 "Tensile Testing of Metals", using a Grade A (B.S. 1610) universal testing machine.

Results: - Tensile Test

Specimen Ref.	Upper Yield Stress N/mm^2	Tensile Strength N/mm^2	% Elongation on $5.65\sqrt{So}$
A	291	430	43
B	256	359	43
C	300	408	29
D1	249	412	29
D2	267	450	30

NOTE: Specimens referenced DI & D2 were machined from the web and flange of the rail section respectively.

Rebar (A-C) 256-300 N/mm^2

Say 250 N/mm^2

'Moss' bar (D_1-D_2) 249-267 N/mm^2

Say 250 N/mm^2

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APPENDIX D

Sub-standard Structure Summary

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Structure Name: LM-LP3400-001.00, Hartley Bridge

Assessment Stage	Structural Assessment	
Date:	January 2016	
Report Ref:	Doran Consulting Ltd, SAR, January 2016	
Assessed Capacity:	< 3 tonnes Assessment Live Load	
Sub-standard Status:	Low risk provisionally sub-standard structure	
Interim Measures Feasibility Assessment		
Date:	January 2016	
Is the structure an Immediate Risk Structure or a Low Risk Provisionally Sub-standard structure?	Low risk provisionally sub-standard structure	
Interim Measures Proposal		
Date:	N/A	
Recommendation:	No interim measures proposed	
Is structure monitoring appropriate?	No	
Interim Measures Approval		
Date:	N/A	
Approval/Rejection	N/A	
Actions Implementation Date		
Details/Ref:		
Provisional finish date for monitoring	Not required	
Removal date:	Not Required	
Additional Notes		

APPENDIX E

Interim Measures Feasibility Assessment

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1. General

1.1	Structure name and assessment reference:	Hartley Bridge LM-LP3400-001.00
1.2	Location, route and county/area:	
1.3	Assessing organisation:	Doran Consulting Ltd Assessed by: AIG Checked by: DJW Assessment Date: 01/16
1.4	Structure type/form/skew/span:	
1.5	Obstacle Crossed and facility Carried:	Crossed: Watercourse Carried: LP3400
1.6	Estimated cost of permanent strengthening works:	____

2 Assessment Progress

2.1	Level of assessment reached:	Stage 1 Structural Assessment
2.2	Assessed capacity:	<3 tonnes
2.3	Date of assessment:	January 2016
2.4	Assessment report Ref:	Doran Consulting Ltd, SAR, January 2016
2.5	Provisionally Sub-standard or Sub-standard?	Provisionally sub-standard structure

2.6 Description of anticipated mode of failure, including its progressions from local overstress to global collapse mechanism:

Yielding of steel reinforcement at mid span.

2.7 Description of distress:

Structural defects not evident currently.

3.0 Consideration of Risk Posed by Structure in Current State

3.1 Discussion

The Structural assessment has indicated that the bridge cannot sustain the effects of the 40 tonne assessment loading. Of the six components of the structure assessed, five failed to sustain the 40-tonne assessment loading. The worst component achieved a reduced live load carrying capacity of < 3 tonnes hence applying this worst case across the structure gives Hartley Bridge a reduced live load carrying capacity of < 3 tonnes.