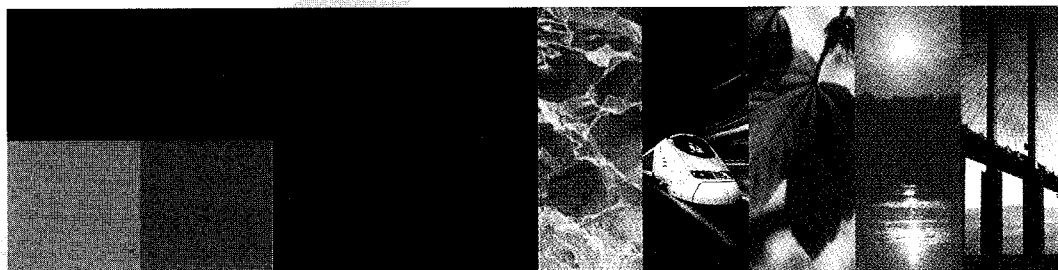


**Gloucestershire County Council**  
**Rail Property Ltd Bridge Assessments**

**The Stud Bridge FFD 86m 20ch**  
**Assessment and Inspection Report**  
**March 2003**



**Halcrow Group Limited**

***Halcrow***

# **Gloucestershire County Council**

## **Rail Property Ltd Bridge Assessments**

**The Stud Bridge FFD 86m 20ch  
Assessment and Inspection Report  
March 2003**

### **Halcrow Group Limited**

Document Ref No TB.2116.B560.Doc.01

Copy No. |

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**Gloucestershire County Council**  
Rail Property Ltd Bridge Assessments  
The Stud Bridge FFD 86m 20ch  
Assessment and Inspection Report

**Contents Amendment Record**

This report has been issued and amended as follows:

| Issue | Revision | Description | Date   | Signed |
|-------|----------|-------------|--------|--------|
| 1     | 0        | First Issue | Mar 03 | AW     |

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**Appendix A – Location Plan**  
– Drawing TB.2116.B560.SK02

**Appendix B – Form AA and Form AA/1**

# 1

## Executive Summary

### 1.1

#### *Background*

Halcrow Group Limited were commissioned by Gloucestershire County Council (GCC) to undertake an inspection and assessment of the Stud Bridge in accordance with Department of Transport Standard BD 21/01 "The Assessment of Highway Bridges and Structures"

The bridge is currently owned and maintained by Rail Property Ltd who are also the Technical Approval Authority. The bridge carries an unclassified county road over a disused railway line at FFD 86m 20ch and OS grid reference SP 210 006. A location plan is included in Appendix A.

This report provides a description and summary of the inspection and includes the results of the assessment.

### 1.2

#### *Assessment Capacity*

Based on the assumptions made in this report, the steel trough deck has a capacity of 40 tonnes Assessment Live Loading (ALL) in accordance with BD21/01. However, by observation, the west edge deck plate would fail under accidental wheel load to BD21/01.

A qualitative assessment of the abutments and wingwalls was carried out in accordance with BD21/01. There were no signs of distress visible so further assessment was not considered necessary.

The foundations were not inspected or assessed but there were no visible signs of movement or settlement of the substructure.

The existing parapets were not assessed but by observation they would not provide vehicular containment to meet current standards.

## 2

## Introduction

### 2.1

#### Structure Details

General information about the structure is contained in Table 1.

|   |  |
|---|--|
| <b>COUNTY BRIDGE NAME:</b>                          | The Stud Bridge  |
| <b>COUNTY BRIDGE No:</b>                            | 560  |
| <b>RAILTRACK PROPERTY LTD Ref:</b>                  |  |
| <b>BRIDGE ELR &amp; MILEAGE:</b>                    | FFD 86m 20ch   |
| <b>MAP REFERENCE:</b>                               | SP 210 006   |
| <b>DIMENSIONS</b>                                   |  |
| No of spans:  | 1  |
| Clear span:   | 3.900m (square)  |
| Skew:   | 12° (approx.)  |
| Width of carriageway:                               | 4.720m   |
| Width of verges:                                    | 0.860m (east), 0.550m (west)   |
| Headroom:   | 3.70m (approx)   |
| Total width between parapets:                       | 6.130m   |
| <b>LOADING</b>                                      |  |
| Is structure subject to a weight restriction order: | No   |
| If yes give details:                                | N/A date order made: N/A   |
| <b>CONSTRUCTION</b>                                 |  |
| General Construction:                               | The bridge is a single span, steel trough deck with stone abutments and brick wingwalls. |
| Trough deck:  | Steel (assumed)  |
| Bearings:   | N/A  |
| Parapet material:                                   | The parapets are of timber and corrugated metal sheets, with stone pilasters.            |
| Average depth of fill:                              | 0.176m   |
| Type of fill:                                       | Road surfacing (bituminous) approx. 120mm. Concrete infill.                              |

Table 1: General Details of The Stud Bridge, FFD 86m 20ch

## **2.2**

### ***History of Structure and Record Drawings***

Record drawings of the structure are not available, but a brief maintenance history was provided by Rail Property Ltd.

## **2.3**

### ***Current Loading***

The vehicular loading permitted on the structure is currently 38 tonne under the Construction & Use Regulations.

## 3 Inspection Details

### 3.1 *Introduction*

Halcrow Group Limited carried out the inspection of the Stud Bridge ( see Figure 1) on 20 May 2002. The weather was dry and sunny.

All accessible parts of the structure were visually examined within touching distance. A portable aluminium scaffold tower was used to access the steel trough deck and abutments.

The structure was inspected for defects and corrosion which may reduce the deck cross section and affect its load carrying capacity.



**Figure 1: The Stud bridge**

### 3.2 *Foundations*

The foundations were not inspected but there were no defects evident that would suggest failure or settlement.

### 3.3 *Wingwalls*

All visible parts of the wingwalls were in good condition with only localised areas of mortar loss. Large areas were covered in vegetation (see Figure 2), particularly along the coping stones. This had caused localised spalling of the brickwork and cracking in the coping stones.



**Figure 2: South- west wingwall**

### **3.4**

#### ***Abutments***

Both abutments are constructed in stonework but many repairs have been carried out in brickwork and concrete blockwork (see Figure 3). Generally the stonework and all repairs were in good condition.

The steel deck bears on a layer of brickwork at the top of each abutment. There were several vertical cracks up to 3mm wide running through this brick supporting layer and it is considered that this is a result of thermal movement of the trough deck.



**Figure 3: South abutment**

### 3.5

#### ***Steel Trough Deck***

Main recorded defects are shown on Drawing No TB.2116.B560.SK02.

The trough deck is built up in sections. The paint system was generally in reasonable condition except along the edges of the top and bottom plates (see Figure 4). Here there was heavy surface corrosion and delamination of the plate.



**Figure 4: General condition of trough deck**

Corrosion was most severe at the joint between each plate and the web where approximately 3mm of section loss was evident.

All webs were in good condition with the majority of the paint system in tact.

The rivet heads were generally in good condition although there were some isolated areas where corrosion had occurred.



**Figure 5: West side of trough deck**

At west side of the bridge the edge deck plate was severely corroded over its entire length (see Figure 5). Delamination of the plate had occurred with complete section loss in places. Exposed rivet holes (shown in Figure 5) at the edge of the plate had corroded away.

### **3.6**

#### ***Parapets***

Both parapets comprise timber frames supporting corrugated metal sheets. By observation it was apparent that they provide minimal containment. The corrugated metal panels were severely dented on the east side, probably caused by vehicular impact.

### 3.7

#### *Carriageway inspection*

The road surface was in good condition. There was a slight depression in the surfacing on both approaches behind each abutment. It is considered this is a result of settlement of the fill material (see Figure 6).



**Figure 6: Carriageway level**

### 3.8

#### *Summary of Inspection*

Generally the structure was in a reasonable condition except for the west edge deck plate which was severely corroded.

Areas of reduced sections due to corrosion and delamination of the trough deck were considered in the assessment.

## 4

## Public Utilities

### 4.1

#### *Services*

Initial service enquiries for The Stud Bridge were sent out in April 2002. Enquiry responses are as follows:

British Telecom

Reported no apparatus present.

Thames Water

Reported no apparatus present.

National Grid

Reported no apparatus present.

Scottish and Southern Energy plc

Reported no apparatus present.

Transco

Underground plant present.

Energis

Reported no apparatus present.

Cable and Wireless

Reported no apparatus present.

Readers of this report are reminded that the statutory bodies have supplied information with no guarantee of accuracy. Any person who uses information relating to apparatus does so at their own risk. Planners of future works are advised to verify the presence of statutory apparatus at that time.

## 5

# Assessment

### 5.1

#### *Assessment Details and Assumptions*

The steel trough deck was assessed in accordance with BD 21/01 and BD 56/96. Simple load distribution and dispersal techniques for trough decks were used in accordance with Chapter 6 of BD21/01.

An intrusive investigation carried out on the top of the bridge revealed the fill material comprised bituminous road surfacing and concrete fill. It was assumed this was representative across the entire bridge deck and remained of constant depth.

The following assumptions were also made:

- Dead and superimposed dead loads used in the assessment were determined from information collected during the inspection.
- The trough deck was laterally restrained along its full length by the infill concrete.
- All deck surfaces masked by the fill material were in similar condition to exposed surfaces. An intrusive investigation to expose the top plate and webs at one location indicated the masked surfaces were in reasonable condition.
- Web, top and bottom plate thickness were taken from maintenance record information provided by Rail Property Ltd.
- All trough sections were steel.

Areas of reduced section due to corrosion and delamination of the steel were considered in the assessment.

A qualitative assessment was carried out for all other parts of the structure.

## 5.2

### *Assessment results*

Based on the above assumptions the structure has the following capacity:-

#### *Steel Trough Deck*

|         |   |
|---------|---|
| Bending | 40 tonnes Assessment Live Loading (ALL) |
| Shear   | 40 tonnes Assessment Live Loading (ALL) |

By observation, the west edge deck plate would fail under accidental wheel load to BD21/01

#### *Other parts of structure*

A qualitative assessment of the abutments and wingwalls indicated no significant defects and these are assumed to be adequate with no further assessment considered necessary.

The foundations and parapets were not assessed.

## 6

## Conclusion

Based on the assumptions within this report the assessment capacity of the trough deck is 40 tonnes Assessment Live Loading (ALL) in accordance with Department of Transport Standard BD 21/01.

However, by observation the edge deck plate immediately adjacent to the west parapet, under the grass verge would fail under accidental wheel loading to BD 21/01. It is considered that this area of the deck is susceptible to traffic loading.

|   |               |   |                    |   |           |                       |              |
|---|---------------|---|--------------------|---|-----------|-----------------------|--------------|
| <b>Project Title</b>  |               | RAIL PROPERTY LTD BRIDGE ASSESSMENTS  |                    | <b>Project Code:</b>  |           | 95rc<br>B.2116. 560 . |              |
| <b>Calculation Title:</b>   |               | THE STUD BRIDGE; no. 560<br>FFD 86m 20c   |                    | <b>Serial No:</b>   |           |                       |              |
| <b>Project Manager</b>  |               | Andrew Waite  |                    | <b>No. of Sheets:</b>   |           | 43                    |              |
| <b>Status</b>   |               |   |                    | <b>Prepared by:</b>   |           | AC                    |              |
| Schematic <input type="checkbox"/>  |               | Preliminary <input type="checkbox"/>  |                    | <b>Date:</b>  |           | SEP 02                |              |
| Tender <input type="checkbox"/>   |               | Other (state) <input checked="" type="checkbox"/>                                     |                    | <b>Checked by:</b>  |           | JM                    |              |
| Final for Construction <input type="checkbox"/>   |               | ASSESSMENT  |                    | <b>Date:</b>  |           | 12/02                 |              |
| <b>Levels of Verification</b>   |               |   |                    | <b>Approved by:</b>   |           |                       |              |
| 1 Self-check by originator and approval <input type="checkbox"/>  |               | 3B Comparison with similar proven designs and approval <input type="checkbox"/>       |                    | <b>Date:</b>  |           |                       |              |
| 2 Calculation Review and approval <input type="checkbox"/>  |               | 4 External check and internal approval <input type="checkbox"/>                       |                    | <b>Computer Analysis:</b><br>Yes:                      No: None<br>Program(s):<br><br>Hardware: |           |                       |              |
| 3 Detailed check and approval <input type="checkbox"/>  |               | 5 Other verification as stated in Management Plan <input checked="" type="checkbox"/> |                    |   |           |                       |              |
| 3A Alternative calculations and approval <input type="checkbox"/>   |               | Cat I Client Req.   |                    |   |           |                       |              |
| <b>Contents</b> (continue on calculation sheet if necessary)  |               |   |                    |   |           |                       |              |
| 01 SECTION DETAILS<br>03 INTERNAL TROUGH SECTION (HALF SECTION)<br>04 ASSESSMENT LOADS<br>12 APPLIED MOMENT AND SHEAR<br>16 BENDING RESISTANCE OF THE SECTION<br>21 INTERNAL TROUGH SECTION<br>22 ASSESSMENT LOADS<br>28 APPLIED MOMENT AND SHEAR<br>31 BENDING RESISTANCE<br>34 SHEAR RESISTANCE<br>36 STRENGTH OF FASTENERS<br>37 EXTERNAL TROUGH SECTION<br>38 ASSESSMENT LOADS<br>41 APPLIED MOMENT AND SHEAR<br>43 SUMMARY |               |   |                    |   |           |                       |              |
| <b>NB: Calculations should state or refer to design input data and methodology</b>  |               |   |                    |   |           |                       |              |
| <b>CONTENTS AMENDMENT RECORD</b>  |               |   |                    |   |           |                       |              |
| <b>Rev</b>  | <b>Status</b> | <b>Date</b>   | <b>Description</b> | <b>Page</b>   | <b>By</b> | <b>Chk'd</b>          | <b>App'd</b> |
|   |               |   |                    |   |           |                       |              |

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By: AC

Date: 09/02

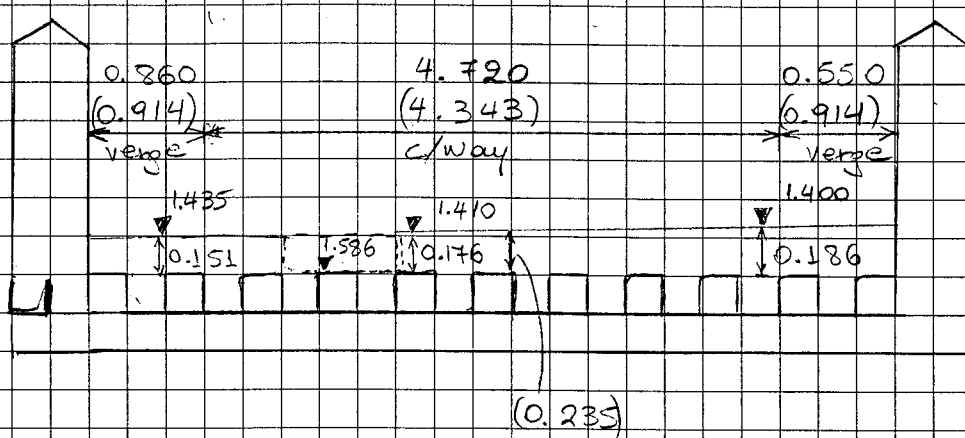
Subject: THE STUD BRIDGE no. 560

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### References/Results

### SECTION


Dimensions  
is m

Dimensions  
in brackets  
taken from  
original  
drawings

The difference in depths from surface to top of steel plates maybe due to resurfacing

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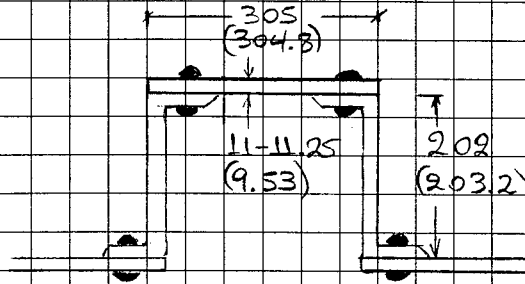
Subject: THE STUD BRIDGE no. 560

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### References/Results

### SECTION OF STEEL TROUGHING



Dimensions  
in mm.

Dimensions  
in brackets are  
taken from  
original  
drawings.

Project:

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Subject:

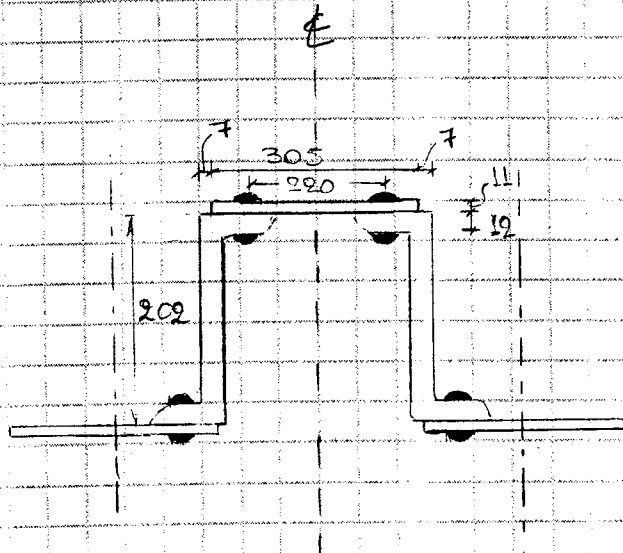
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References/Results

### SECTION OF STEEL TROUGHING



- All dimensions in mm.
- Rivet head 32 mm.  
Assume 19 mm diam of rivets.  
Allow 1.5 mm extra on hole diameter.
- Assume 120 mm as surfacing.
- From trial hole, All material concrete.
- Assume thickness of the angle section 12.7 mm.

Project:

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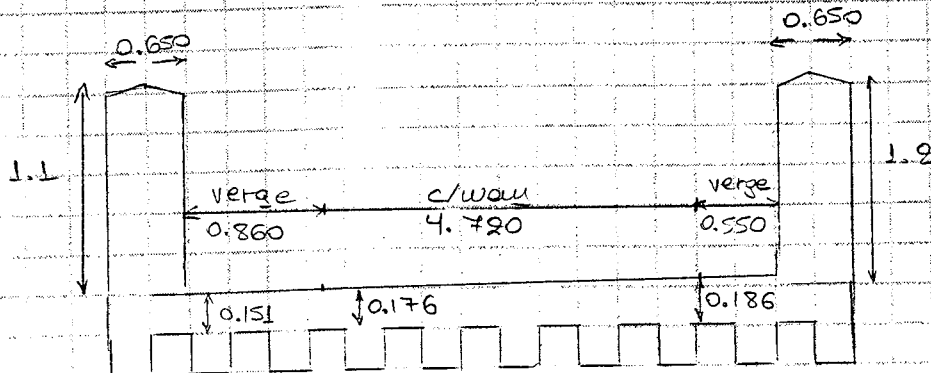
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INTERNAL TROUGH

SECTION

Consider half-section

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### ASSESSMENT LOADS

#### Dead Load

Plate Girder:

$$\text{Area} = (2 \times 305 \times 11) + (2 \times 4485.4)$$

$$= 15680.8 \text{ mm}^2$$

$$\text{Unit weight} = 7850 \text{ kg/m}^3$$

$$= 78.5 \text{ kN/m}^3$$

$$\text{Self-weight} = 0.0156808 \times 78.5$$

$$= 1.23 \text{ kN/m}$$

$$\text{For a half-section} = 1.23/2 = 0.62 \text{ kN/m}$$

BD 21/01

Tb 4.1

#### Superimposed Dead Load

Concrete Fill:

$$\text{Area} = 101202.4 \text{ mm}^2$$

$$\text{Unit weight} = 2300 \text{ kg/m}^3$$

$$= 23 \text{ kN/m}^3$$

$$\text{Self-weight} = 101202.4 \times 23 \times 10^{-6}$$

$$= 2.3 \text{ kN/m}$$

$$\text{For a half-section} = 2.3/2 = 1.15 \text{ kN/m}$$

Surfacing:

$$\text{Area} = 120 \times 612.6$$

$$= 73512 \text{ mm}^2$$

$$\text{Unit weight} = 2300 \text{ kg/m}^3$$

$$= 23 \text{ kN/m}^3$$

$$\text{Self-weight} = 73512 \times 23 \times 10^{-6}$$

$$= 1.7 \text{ kN/m}$$

$$\text{For a half-section} = 1.7/2 = 0.85 \text{ kN/m}$$

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#### Live Load

Length of beam = 4.002m (distance between abutments)

Depth of section = 0.202m

$$\text{Span} = 4.002 + \left(\frac{2}{3} \times 0.202\right) = 4.137\text{m}$$

#### HA LOADING

UDL:

$$W = 336 \left(\frac{1}{L}\right)^{0.67}$$

where L is the loaded length

$$\therefore W = 336 \left(\frac{1}{4.137}\right)^{0.67} = 129.8 \text{ kN/m}$$

BD 21/01  
CL. 5.18

Assessment live loading values shall be determined by the application of Reduction Factors in accordance with BD 21/01 CL 5.21

Hence, from Fig. 5.7, for a low traffic good surface road and a loaded length of 4.137m, Reduction factor  $k = 0.76$

BD 21/01  
CL. 6.11

Adjustment Factor for UDL:

For  $0 < L \leq 20$

$$AF = a_L / 2.5 \text{ where } a_L = 3.65\text{m}$$

$$\therefore AF = \frac{3.65}{2.5} = 1.46$$

$$\text{Adjusted UDL} = \frac{129.8}{1.46} = 88.9 \text{ kN/m}$$

BD 21/01  
CL. 5.23

Lane Factor  $r = 1.0$

BD 21/01  
CL. 5.24  
BPG121\_F01(Excel)

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### References/Results

UDL is applied over a 2.5m wide lane to occupy most onerous position.  
UDL is taken as two longitudinal strip loads applied in the notional lane.

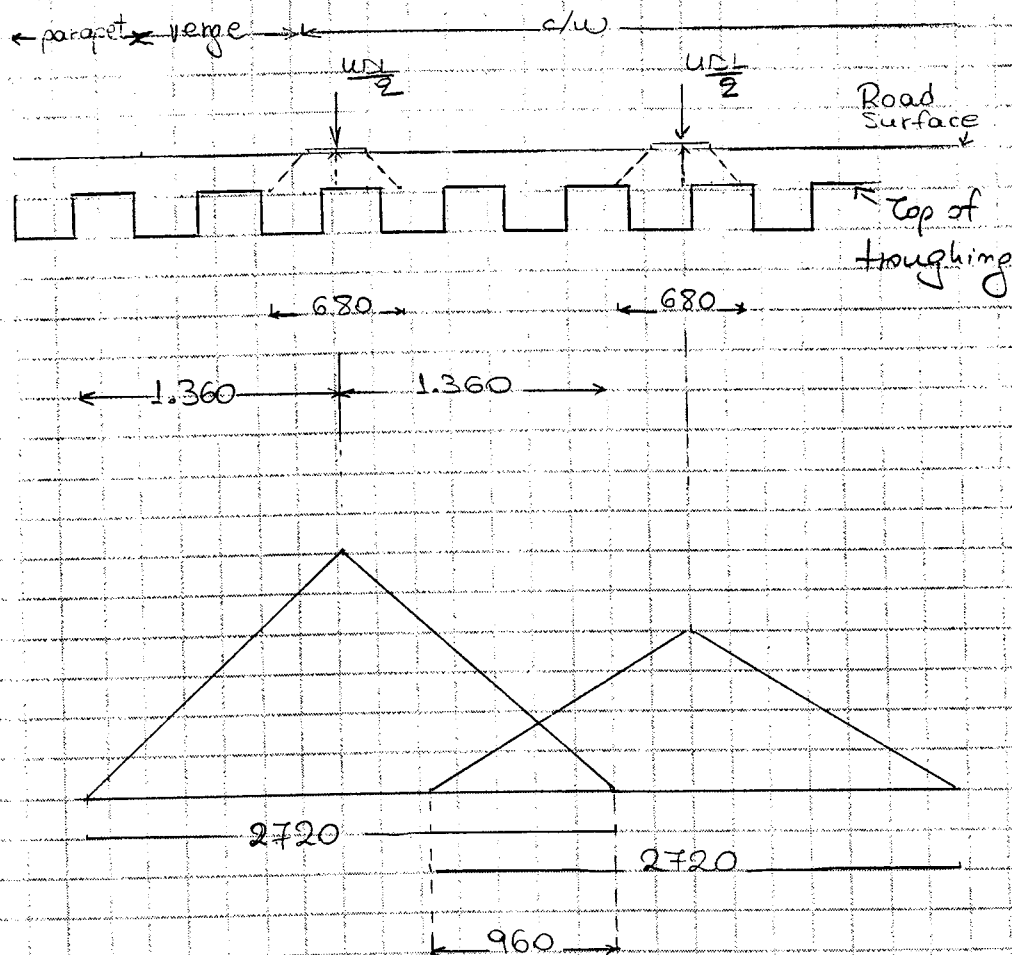
Each longitudinal strip load is applied over a transverse width of 0.3m with a 1.8m transverse spacing between the centre lines of the two strips.

Most onerous position at the edge of the carriageway, adjacent to the verge

BD 21/01  
CL 6.10

BD 21/01  
CL 6.11

### Distribution of Loads:


BD 21/01  
CL 6.14  
Fig. 6.9

Proportion of load taken by the half-section is:

$$\frac{44.45}{2.720} = 16.4 \text{ kN/m}$$

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### References/Results

The distribution diagram for the two adjacent strip loads overlaps, therefore the amount of load taken by the trough located within the overlap area is obtained by adding the individual loads.

Divide by 3, as three half-sections exist in the overlap area.

Therefore: 
$$\frac{16.4 \times 2}{3} = \underline{\underline{10.9 \text{ kN/m}}}$$

BD 21/01  
CL. 6.14

### KEL

KEL is taken as two wheel loads applied in the 2.5m wide national lane, by dividing KEL value of assessment live loading value, 120 kN, by 2.

BD 21/01  
CL. 6.10

Reduction Factor  $k = 0.76$

see page 5

Adjustment Factor for KEL:  
 $AF = 1.46$

see page 5

Therefore, adjusted  $KEL = \frac{120}{1.46} = 82.2 \text{ kN}$

Lane factor = 1.0

BD 21/01  
CL. 5.24

The wheel loads are applied over a  $0.3\text{m} \times 0.3\text{m}$  square contact area with a 1.8m transverse spacing between their centres

BD 21/01  
CL. 6.11

Worst case is at the edge of the carriageway, adjacent to the verge

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### DISTRIBUTION OF LOADS

See sketch on page 5

Proportion of KEL load taken by the trough deck is  $\frac{41.1}{2.720} = 15.1 \text{ kN/m}$

The distribution diagram for the two adjacent wheel loads overlaps, therefore the amount of load taken by the trough located within the overlap area is obtained by adding the individual loads.

Divide by 3, as three half-sections exist in the overlap area.

Therefore:  $\frac{15.1 \times 2}{3} = 10.1 \text{ kN}$

BD 21/01  
CL. 6.14

BD 21/01  
CL. 6.14

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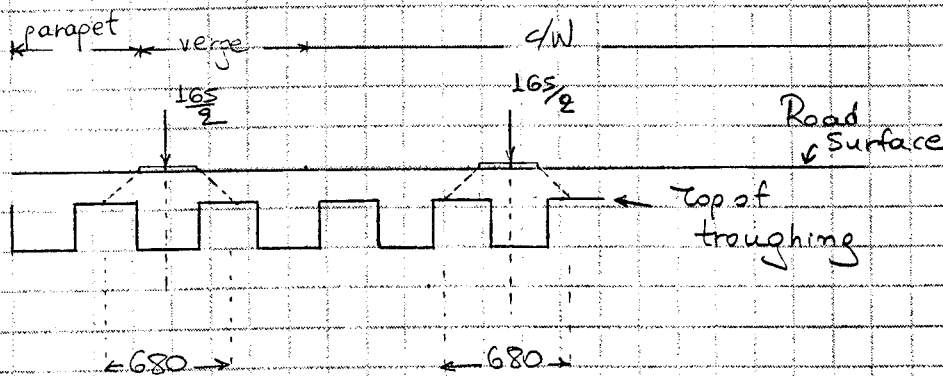
### References/Results

### Single Axle Load

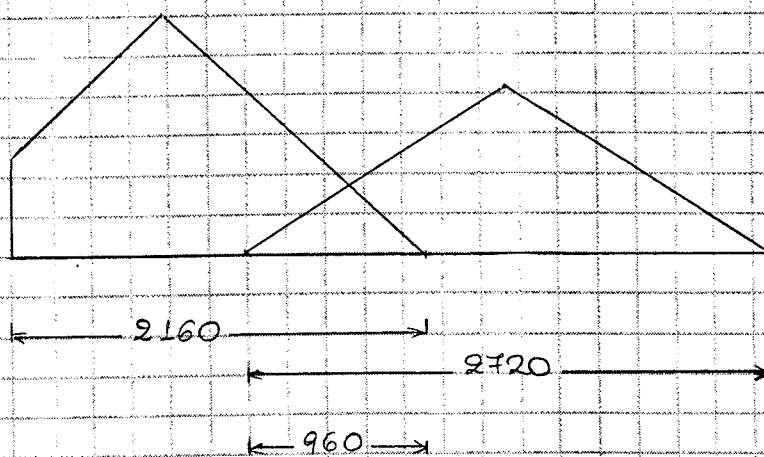
For Low Traffic Good Surface road  
Nominal Single Axle Load  $w = 165 \text{ kN}$   
Axle load is applied over a  $2.8 \text{ m}$  wide lane.  
Worst case is considered to be adjacent to the parapet.

BD 21/01  
CL. 5.3.1  
To 5.3.1

### Distribution of loads



BD 21/01  
CL. 6.1.4  
Fig. 6.2



The distribution diagram for the two adjacent wheel loads overlaps, therefore the amount of load taken by the 'trough' located within the overlap area is obtained by adding the individual loads.

$$\text{Hence: } \left( \frac{82.5}{2.160} + \frac{82.5}{2.720} \right) = 68.5 \text{ kN/m}$$

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### References/Results

Divide by 3 as three half-sections exist in the overlap area.

$$\text{Therefore: } \frac{68.5}{3} = 22.8 \text{ kN/m}$$

### Single Wheel Load

For low traffic Good Surface road  
Nominal Single Wheel Load  $W = 82 \text{ kN}$

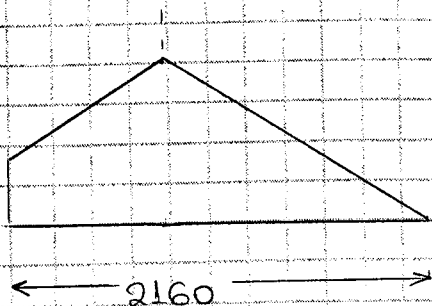
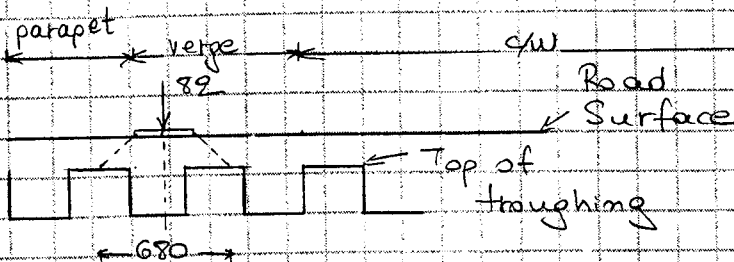
BD 21/01  
CL 5.32  
Tb 5.3.2

Wheel load is applied over a  $0.3 \text{ m} \times 0.3 \text{ m}$  square contact area.

Worst case is considered to be adjacent to the parapet.

### Distribution of loads.

BD 21/01  
CL 6.14  
Fig 6.2



The amount of load taken by the half-section is  $\frac{82/2.160}{7} = 5.4 \text{ kN/m}$

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### Partial Factor for Loads, $\gamma_F$

|               |              |        |
|---------------|--------------|--------|
| Steel Iron    | , $\gamma_F$ | = 1.05 |
| Concrete Fill | , $\gamma_F$ | = 1.20 |
| Surfacing     | , $\gamma_F$ | = 1.75 |
| Live          | , $\gamma_F$ | = 1.50 |

### Reduction factor for UDL and KEL, $k = 0.76$

#### Assessment Loads:

|                    |   |                    |   |                     |
|--------------------|---|--------------------|---|---------------------|
| Steel Plate Girder | = | $0.62 \times 1.05$ | = | $0.65 \text{ kN/m}$ |
| Concrete Fill      | = | $1.15 \times 1.20$ | = | $1.4 \text{ kN/m}$  |
| Surfacing          | = | $0.85 \times 1.75$ | = | $1.5 \text{ kN/m}$  |

Live:

#### (a) HA Loading

$$UDL = 10.9 \times 1.5 \times 0.76 = 12.4 \text{ kN/m}$$

$$KEL = 10.1 \times 1.5 \times 0.76 = 11.5 \text{ kN}$$

#### (b) Single Axle Load:

$$W = 22.8 \times 1.5 = 34.2 \text{ kN}$$

#### (c) Single wheel Load:

$$W = 5.4 \times 1.5 = 8.1 \text{ kN}$$

BD 21/01  
Tb 3.1

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### MOMENT and SHEAR

#### Dead Load

$$M = \frac{WL^2}{8} = \frac{0.65 \times 4.137^2}{8} = 1.4 \text{ kNm}$$

$$V = \frac{WL}{2} = \frac{0.65 \times 4.137}{2} = 1.35 \text{ kN}$$

#### Superimposed Dead Load

$$M = \frac{WL^2}{8} = \frac{(1.4 + 1.5) \times 4.137^2}{8} = 6.2 \text{ kNm}$$

$$V = \frac{WL}{2} = \frac{(1.4 + 1.5) \times 4.137}{2} = 6.0 \text{ kN}$$

#### Live Load

##### (a) HA Loading

$$M = \frac{WL^2}{8} + \frac{PL}{4} = \frac{12.4 \times 4.137^2}{8} + \frac{11.5 \times 4.137}{4} = 38.4 \text{ kNm}$$

$$V = \frac{WL}{2} + \frac{P}{2} = \frac{12.4 \times 4.137}{2} + \frac{11.5}{2} = 31.4 \text{ kN}$$

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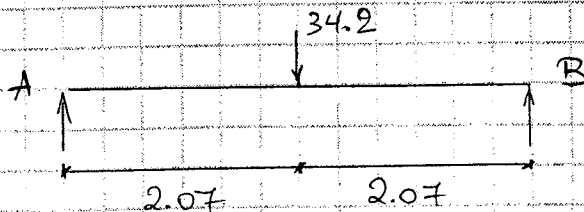
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(b) Single Axle Load:

 $M_{max}$  when 34.2 kN load at midspan


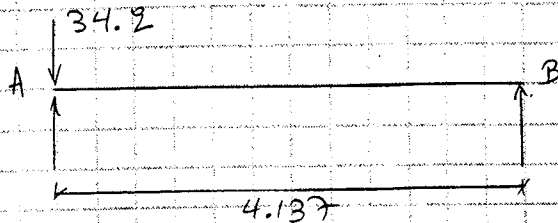
$$\sum M @ A: (34.2 \times 2.07) = R_B \times 4.137$$

$$R_B = 17.1 \text{ kN}$$

$$\therefore R_A = 17.1 \text{ kN}$$

$$M_{max} = 17.1 \times 2.07 = 35.4 \text{ kNm}$$

$$V = 17.1 \text{ kN}$$

 $V_{max}$  when 34.2 kN load at support:


$$V_{max} = 34.2 \text{ kN}$$

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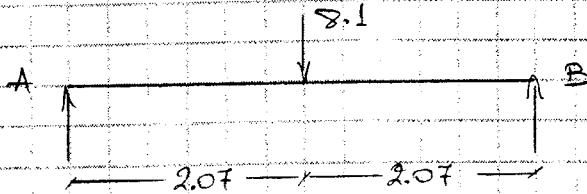
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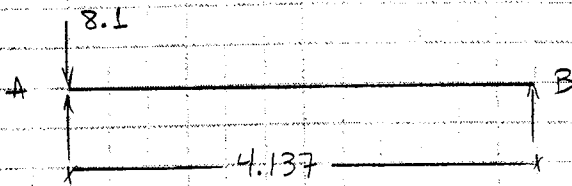
References/Results

c) Single wheel load:

 $M_{max}$  when 8.1 kN load at midspan


$$M_{max} = \frac{PL}{4} = \frac{8.1 \times 4.137}{4} = 8.4 \text{ kNm}$$

$$V = 4.05 \text{ kN}$$

 $V_{max}$  when 8.1 kN load at support


$$V_{max} = 8.1 \text{ kN}$$

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### LOAD COMBINATIONS

Maximum Moment with HA loading:

$$M_{max} = 1.4 + 6.2 + 38.4 = \underline{46 \text{ kNm}}$$

co-existent shear:

$$V = 1.35 + 6.0 + 31.4 = 38.75 \text{ kN}$$

Maximum Shear with Single Axle Load:

$$V_{max} = 1.35 + 6.0 + 34.2 = 41.55 \text{ kN}$$

co-existent moment:

$$M = 7.6 \text{ kNm}$$

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### BENDING RESISTANCE

For a compact section

Webs partly in compression and in tension:

Depth between the elastic neutral axis of the beam and the compressive edge of the web is:

$$95.5 - 12 = 83.5 \text{ mm}$$

and should not exceed  $28 t_w \sqrt{\frac{355}{\sigma_{yw}}}$

where  $t_w$  = the thickness of the web plate  
= 12.7 mm

$\sigma_{yw}$  = nominal yield stress of the web material.  
= 230 N/mm<sup>2</sup>

$$\text{Hence } 28 t_w \sqrt{\frac{355}{\sigma_{yw}}} = 28 \times 12.7 \times \sqrt{\frac{355}{230}} = 441.8 \text{ mm}$$

∴ ADEQUATE

### Compression flange outstands

Projection of the compression flange outstand:

$b_{fo} = 80 \text{ mm}$  and should not exceed

$$7 t_{fo} \sqrt{\frac{355}{\sigma_{yf}}}$$

where  $\sigma_{yf}$  = nominal yield stress of the flange material

$$= 230 \text{ N/mm}^2$$

$t_{fo}$  = mean thickness of the outstand  
= 12 mm

$$\therefore 7 t_{fo} \sqrt{\frac{355}{\sigma_{yf}}} = 7 \times 12 \times \sqrt{\frac{355}{230}} = 104.4 \text{ mm}$$

∴ Section is compact

BD 56/96

CL 9.3.7.2.1

BD 21/01

CL 4.3

BD 56/96

CL 9.3.7.3.1

CL 9.3.2.1

BD 56/96

CL 9.3.2.1

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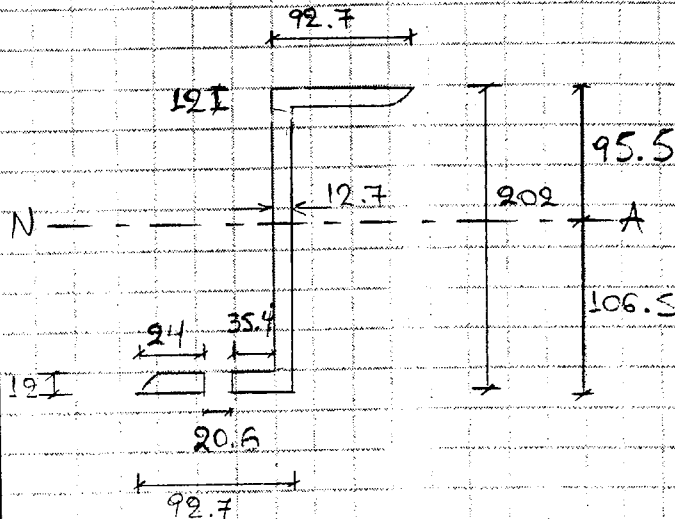
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### Lateral Torsional Buckling

#### References/Results

BD 56/96  
CL. 9.6.1


Allow 20.6mm deduction for holes in the tension zone,

BD 56/96  
CL. 9.4.2.2

Depth to neutral axis from bottom of section in x-y

$$\bar{y} = \frac{(92.7 \times 12 \times 196) + (178 \times 12.7 \times 101) + (72.1 \times 12 \times 6)}{(92.7 \times 12) + (178 \times 12.7) + (72.1 \times 12)}$$

$$= \frac{451572.2}{4238.2} = 106.5 \text{ mm}$$

$$I_{xx} = \left[ \frac{92.7 \times 12^3}{12} + (92.7 \times 12 \times 89.5^2) \right] +$$

$$\left[ \frac{12.7 \times 178^3}{12} + (12.7 \times 178 \times 5.5^2) \right] +$$

$$\left[ \frac{72.1 \times 12^3}{12} + (72.1 \times 12 \times 100.5^2) \right]$$

$$= 2.3710 \times 10^7 \text{ mm}^4$$

Depth to neutral axis from bottom of section in y-y direction:

$$\bar{y} = \frac{(24 \times 12 \times 160.7) + (35.4 \times 12 \times 110.4) + (202 \times 12.7 \times 86.35) + (80 \times 12 \times 47)}{(24 \times 12) + (35.4 \times 12) + (202 \times 12.7) + (80 \times 12)}$$

$$= \frac{252101.81}{4238.2} = 59.5 \text{ mm}$$

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### References/Results

$$\begin{aligned}
 I_{yy} &= \left[ \frac{(12 \times 24)^3}{12} + (12 \times 24 \times 77.4^2) \right] + \\
 &\quad \left[ \frac{(12 \times 35.4)^3}{12} + (12 \times 35.4 \times 27.1^2) \right] + \\
 &\quad \left[ \frac{(202 \times 12.7)^3}{12} + (202 \times 12.7 \times 3.05^2) \right] + \\
 &\quad \left[ \frac{(12 \times 30)^3}{12} + (12 \times 30 \times 43.3^2) \right] \\
 &= 0.4466 \times 10^7 \text{ mm}^4
 \end{aligned}$$

$$I_{xx} > I_{yy}$$

The effective length is taken as:

$$l_e = k_1 k_2 L$$

where  $L$  = the span of the beam  
= 4.137m

$k_1 = 0.85$  for a compression flange  
which is partially restrained  
against rotation in plan.

$$k_2 = 1.0$$

$$\begin{aligned}
 \therefore l_e &= 0.85 \times 1.0 \times 4.137 \\
 &= 3.52 \text{ m}
 \end{aligned}$$

### Slenderness

$$\text{Slenderness parameter, } \lambda_{LT} = \frac{l_e}{r_y} k_y n_v$$

where  $l_e$  = effective length  
= 3.52 m

$r_y$  = radius of gyration

$$\begin{aligned}
 r_y &= \left[ \frac{I_y}{A} \right]^{1/2} = \left( \frac{0.4466 \times 10^7}{4938.2} \right)^{1/2} \\
 &= 32.5 \text{ mm}
 \end{aligned}$$

$$k_y = 1.0$$

$$n_v = 1.0$$

BD 56/96

CL. 9.6.3

BD 56/96

CL. 9.7

CL. 9.7.2

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### References/Results

$v$  = dependent on the shape of the beam, and is obtained from table 9, using the parameters:

$$\lambda_F = \frac{l_e}{t_f} \left( \frac{t_f}{D} \right)$$

$$= \frac{3520}{32.5} \times \frac{12}{202} = 6.4$$

$$i = \frac{I_c}{I_c + I_t} = \frac{\frac{12 \times 92.7^3}{12}}{\frac{12 \times 92.7^3}{12} + \frac{12 \times 92.7^3}{12}}$$

$$= 0.5$$

From table 9,  $v = 0.758$

So, the slenderness parameter

$$\lambda_{LT} = \frac{3520}{32.5} \times 1.0 \times 1.0 \times 0.758 = 82$$

Limiting Compressive Stress,  $\sigma_{Li}$

BD 56/96  
CL 9.8.2

For a compact section:

$\sigma_{yc}$  = nominal yield stress of the compressive flange material  
= 230 N/mm<sup>2</sup>

$$\lambda_{LT} \sqrt{\frac{\sigma_{yc}}{355}} = 82 \sqrt{\frac{230}{355}} = 66$$

Therefore  $\frac{\sigma_{Li}}{\sigma_{yc}} = 0.79$

BD 56/96  
Fig. 10

$$\therefore \sigma_{Li} = 181.7 \text{ N/mm}^2$$

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### Bending Resistance

For a compact section:

BD 56/96

CL. 9.9.1.2

The bending resistance  $M_D$  of a beam should be taken as:

$$M_D = \frac{Z_{pe} \sigma_{lc}}{\gamma_m \gamma_{f3}}$$

where  $\sigma_{lc}$  = the limiting compressive stress  
 $= 181.7 \text{ N/mm}^2$ 

$$\gamma_m = 1.2$$

$$\gamma_{f3} = 1.1$$

BD 56/96

Tb. 2

CL. 4.3.3

 $Z_{pe}$  = the plastic modulus of the effective section

$$= (80 \times 12 \times 89.5) + (202 \times 12.7 \times 5.5) + (35.4 \times 12 \times 100.5) + (24 \times 12 \times 100.5)$$

$$= 171666.1 \text{ mm}^3$$

$$\therefore M_D = \frac{171666.1 \times 181.7 \times 10^{-6}}{1.2 \times 1.1} = 23.6 \text{ kNm}$$

$$M_D < M_{max}$$

 $\therefore$  Section fails in bending

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INTERNAL TROUGH  
SECTION

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### ASSESSMENT LOADS

#### Dead Load

Plate Girder

$$\text{Area} = (2 \times 305 \times 11) + (2 \times 4485.4)$$

$$= 15680.8 \text{ mm}^2$$

$$\text{Unit weight} = 7850 \text{ kg/m}^3$$

$$= 78.5 \text{ kN/m}^3$$

$$\text{Self-weight} = 0.0156808 \times 78.5$$

$$= 1.23 \text{ kN/m}$$

BD 21/01  
7b. 4.1

#### Superimposed Dead Load

Concrete Fill:

$$\text{Area} = 101202.4 \text{ mm}^2$$

$$\text{Unit weight} = 2300 \text{ kg/m}^3$$

$$= 23 \text{ kN/m}^3$$

$$\text{Self-weight} = 101202.4 \times 23 \times 10^{-6}$$

$$= 2.3 \text{ kN/m}$$

Surfacing:

$$\text{Area} = 120 \times 612.6$$

$$= 73512 \text{ mm}^2$$

$$\text{Unit weight} = 2300 \text{ kg/m}^3$$

$$= 23 \text{ kN/m}^3$$

$$\text{Self-weight} = 73512 \times 23 \times 10^{-6}$$

$$= 1.7 \text{ kN/m}$$

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Live Load

Length of beam = 4.002 m  
(distance between abutments)

Depth of section = 0.202 m

Span =  $4.002 + \left(\frac{2}{3} \times 0.202\right)$   
= 4.137 m

HA Loading

UDL

$$W = 336 \left(\frac{1}{L}\right)^{0.67}$$

where L is the loaded length

$$\therefore W = 336 \left(\frac{1}{4.137}\right)^{0.67} = 129.8 \text{ kN/m}$$

Assessment live loading values shall be determined by the application of Reduction Factors in accordance with BD21/01 CL 5.21

Hence, from fig. 5.7 for a low traffic good surface road and a loaded length of 4.137 m, Reduction Factor  $k = 0.76$ .

Adjustment Factor for UDL :

For  $0 < L \leq 20$

$$AF = \frac{a_L}{2.5}, \text{ where } a_L = 3.65 \text{ m}$$

$$\therefore AF = \frac{3.65}{2.5} = 1.46$$

$$\text{Adjusted UDL} = \frac{129.8}{1.46} = 88.9 \text{ kN/m}$$

Lane factor = 1.0

BD 21/01  
CL 5.18

BD 21/01  
CL 6.11

BD 21/01  
CL 5.23

BD 21/01  
CL 5.24

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### References/Results

UDL is applied over a 2.5m wide lane to occupy most onerous position.

BD 21/01  
CL. 6.10

UDL is taken as two longitudinal strip loads applied in the notional lane.

Each longitudinal strip load is applied over a transverse width of 0.3m with a 1.8m transverse spacing between the centre lines of the two strips.

BD 21/01  
CL. 6.11

Most onerous position at the edge of the carriageway, adjacent to the verge.

Distribution of loads:

BD 21/01  
CL. 6.14  
Fig. 6.9

See sketch on page 6.

Proportion of load taken by the section is:  $\frac{44.45}{2.720} = 16.4 \text{ kN/m}$

The distribution diagram for the two adjacent strip loads overlaps, therefore the amount of load taken by the trough located within the overlap area is obtained by adding the individual loads.

Divide by 2, as two sections exist in the overlap area.

Therefore:  $\frac{16.4 \times 2}{2} = 16.4 \text{ kN/m}$

### KEL

KEL is taken as two wheel loads applied in the 2.5m wide notional lane, by dividing KEL value of assessment live loading value, 120 kN, by 2.

BD 21/01  
CL. 6.10

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### References/Results

Reduction Factor  $k = 0.76$ 

see page 5

Adjustment Factor for KEL :  
 $AF = 1.46$ 

see page 5

Therefore, adjusted  $KEL = \frac{120}{1.46} = 82.2 \text{ kN}$ 

Lane factor = 1.0

BD 21/01  
CL. 5.24

The wheel loads are applied over a  
0.3m x 0.3m square contact area with  
a 1.8m transverse spacing between their  
centres.

BD 21/01  
CL. 6.11

Worst case is at the edge of the carriageway,  
adjacent to the verge.

Distribution of Loads:

See sketch on page 6

BD 21/01  
CL. 6.14

Proportion of KEL load taken by the  
trough deck is  $\frac{41.1}{2.720} = 15.1 \text{ kN/m}$ 

The distribution diagram for the two adjacent  
wheel loads overlaps, therefore the amount  
of load taken by the trough located  
within the overlap area is obtained by  
adding the individual loads.

BD 21/01  
CL. 6.14

Divide by 2, as two sections exist in the  
overlap area

Therefore:  $\frac{15.1 \times 2}{2} = 15.1 \text{ kN}$

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### References/Results

#### Single Axle Load

For low traffic good surface road  
Nominal Single Axle Load  $W = 165 \text{ kN}$ .

Axle load is applied over a 2.5m wide lane  
Worst case is considered to be adjacent to the parapet

BD 21/01  
CL S.31  
Tb S.3.1

#### Distribution of loads

See sketch on page 9

BD 21/01  
CL G.14  
Fig. G.2

The distribution diagram for the two adjacent wheel loads overlaps, therefore the amount of load taken by the trough located within the overlap area is obtained by adding the individual loads

BD 21/01  
CL G.14

$$\text{Hence } \left( \frac{82.5}{2.160} + \frac{82.5}{2.720} \right) = 68.5 \text{ kN/m}$$

Divide by 2, as two sections exist in the overlap area.

$$\text{Therefore: } \frac{68.5}{2} = 34.25 \text{ kN/m}$$

#### Single wheel load

For low traffic good surface road Nominal Single wheel load  $W = 82 \text{ kN}$

Wheel load is applied over a  $0.3\text{m} \times 0.3\text{m}$  square contact area.

Worst case is considered to be adjacent to the parapet.

BD 21/01  
CL S.32  
Tb S.3.2

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### References/Results

Distribution of loads

See Sketch on page 10.

BD 21/01  
CL. 6.14  
Fig. 6.2

the amount of load taken by the section is:  $\frac{82/2.160}{3} = 12.6 \text{ kN/m}$

Partial Factors for loads,  $\gamma_{FL}$

Steel plate,  $\gamma_{FL} = 1.05$   
Concrete fill,  $\gamma_{FL} = 1.20$   
Surfacing,  $\gamma_{FL} = 1.75$   
Live,  $\gamma_{FL} = 1.50$

BD 21/01  
Cb. 3.1

Reduction Factor for uDL and kEL,  $k = 0.76$

### Assessment Loads

Steel Plate Girder =  $1.23 \times 1.05 = 1.3 \text{ kN/m}$   
Concrete Fill =  $2.3 \times 1.20 = 2.8 \text{ kN/m}$   
Surfacing =  $1.7 \times 1.75 = 3.0 \text{ kN/m}$

Live:

(a) HA Loading

$$uDL = 16.4 \times 1.5 \times 0.76 = 18.7 \text{ kN/m}$$

$$kEL = 15.1 \times 1.5 \times 0.76 = 17.2 \text{ kN}$$

(b) Single Axle Load:

$$W = 34.25 \times 1.5 = 51.4 \text{ kN}$$

(c) Single wheel Load:

$$W = 12.6 \times 1.5 = 18.9 \text{ kN}$$

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### MOMENT and SHEAR

#### Dead Load

$$M = \frac{WL^2}{8} = \frac{1.3 \times 4.137^2}{8} = 2.8 \text{ kNm}$$

$$V = \frac{WL}{2} = \frac{1.3 \times 4.137}{2} = 2.7 \text{ kN}$$

#### Superimposed Dead Load

$$M = \frac{WL^2}{8} = \frac{(2.8 + 3.0) \times 4.137^2}{8} = 12.4 \text{ kNm}$$

$$V = \frac{WL}{2} = \frac{(2.8 + 3.0) \times 4.137}{2} = 12.0 \text{ kN}$$

#### Live Load

(a) HA Loading

$$M = \frac{WL^2}{8} + \frac{PL}{4} = \frac{18.7 \times 4.137^2}{8} + \frac{17.9 \times 4.137}{4} = 57.8 \text{ kNm}$$

$$V = \frac{WL}{2} + \frac{P}{2} = \frac{18.7 \times 4.137}{2} + \frac{17.9}{2} = 47.3 \text{ kN}$$

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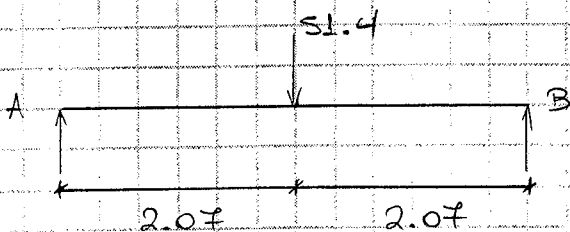
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(b) Single Axle Load:

 $M_{max}$  when 51.4 kN load at midspan


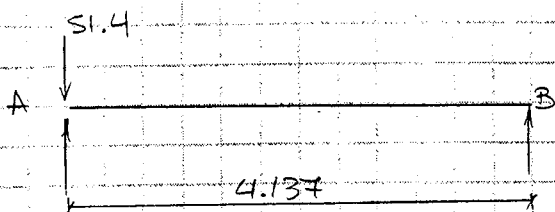
$$\sum M @ A: (51.4 \times 2.07) = R_B \times 4.137$$

$$R_B = 25.7 \text{ kN}$$

$$\therefore R_A = 25.7 \text{ kN}$$

$$M_{max} = 25.7 \times 2.07 = 53.2 \text{ kNm}$$

$$V = 25.7 \text{ kN}$$

 $V_{max}$  when 51.4 kN load at support:


$$V_{max} = 51.4 \text{ kN}$$

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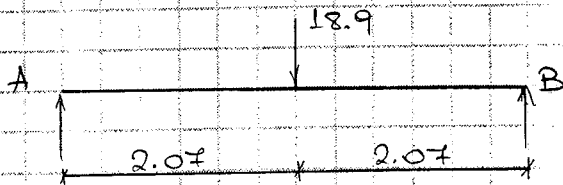
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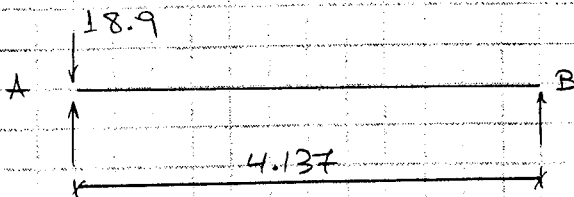
c) Single wheel load:

 $M_{max}$  when 18.9 kN load at midspan


$$M_{max} = \frac{PL}{4} = \frac{18.9 \times 4.137}{4}$$

$$= 19.5 \text{ kN.m}$$

$$V = 9.45 \text{ kN}$$

 $V_{max}$  when 18.9 kN load at support


$$V_{max} = 18.9 \text{ kN}$$

### LOAD COMBINATIONS

Maximum Moment with HA Loading

$$M_{max} = 2.8 + 12.4 + 57.8 = 73 \text{ kNm}$$

co-existent shear:

$$V = 2.7 + 12.0 + 47.3 = 62 \text{ kN}$$

Maximum Shear with Single Axle Load

$$V_{max} = 2.7 + 12.0 + 51.4 = 66.1 \text{ kN}$$

Co-existent Moment

$$M = 15.2 \text{ kNm}$$

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### BENDING RESISTANCE

#### Section Properties

| Part            | A       | $\gamma$ | $A\gamma^2$<br>( $\times 10^6$ ) | $I_{xx}$    |
|-----------------|---------|----------|----------------------------------|-------------|
| Top plate       | 3355    | 103.72   | 36.09                            | 33829.58    |
| Top Horiz. leg  | 2224.8  | 92.22    | 18.92                            | 26697.60    |
| Web             | 4521.2  | 2.78     | 0.035                            | 11937415.06 |
| Bot. Horiz. leg | 1730.4  | 97.78    | 16.54                            | 20764.8     |
| Bot. Plate      | 2901.8  | 109.28   | 34.65                            | 29259.82    |
| Total           | 14733.2 |          | 106.24                           | 12048026.86 |

$$I_{xx} = 12048026.86 + (106.24 \times 10^6)$$

$$= 11.8288 \times 10^7 \text{ mm}^4$$

$$\gamma = 114.78 \text{ mm (depth from the bottom to neutral axis)}$$

$$Z_t = \frac{11.8288 \times 10^7}{114.78} = 10.3056 \times 10^5 \text{ mm}^3$$

Project:

RAIL PROPERTY BOARD ASSESSMENTS

By: AC

Date: 09/09

Subject:

THE STUD BRIDGE no. 560

Check  
By:

Date:

### References/Results

### BENDING RESISTANCE

Section is compact

### Lateral Torsional Buckling

BD 56/96  
CL. 9.6.1

Depth to neutral axis from bottom of section

in  $x-x$ 

$$\bar{y} = 114.78 \text{ mm}$$

$$I_{xx} = 11.8288 \times 10^7 \text{ mm}^4$$

$$I_{yy} = 39.3757 \times 10^7 \text{ mm}^4$$

$$\therefore I_{yy} > I_{xx}$$

then effective length  $l_e = 0$

BD 56/96  
CL. 9.6

Limiting Compressive Stress;  $\sigma_{Li}$

Take  $\sigma_{Li}$  as the nominal yield stress

of the section material

$$\therefore \sigma_{Li} = 230 \text{ N/mm}^2$$

For a compact section:

The bending resistance  $M_D$  of a beam should be taken as:

BD 56/96  
CL. 9.9.1.2

$$M_D = \frac{Z_{pe} \sigma_{Li}}{\gamma_m \gamma_{f3}}$$

where  $\sigma_{Li}$  = the limiting compressive stress  
= 230 N/mm<sup>2</sup>

$$\gamma_m = 1.2$$

$$\gamma_{f3} = 1.1$$

$Z_{pe}$  = the plastic modulus of the effective section

BD 56/96  
TB. 2  
CL. 4.3.3

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References/Results

$$\begin{aligned}
 Z_{pe} &= (305 \times 12 \times 103.72) + (185.4 \times 12 \times 92.22) \\
 &+ (2 \times 12.7 \times 89 \times 41.72) \\
 &+ (2 \times 12.7 \times 89 \times 47.28) \\
 &+ (144.2 \times 12 \times 97.78) \\
 &+ (263.8 \times 11 \times 109.28) \\
 &= 1272287 \text{ mm}^3
 \end{aligned}$$

$$\begin{aligned}
 \therefore M_D &= \frac{1272287 \times 230 \times 10^{-6}}{1.2 \times 1.1} \\
 &= 221.7 \text{ kNm}
 \end{aligned}$$

$$M_D > M_{max}$$

Section adequate in bending

Project:

RAIL PROPERTY BOARD ASSESSMENTS

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References/Results

### SHEAR RESISTANCE

Shear resistance under pure shear:

$$V_D = \left[ \frac{t_w (d_w - h_n)}{\gamma_m \gamma_{f3}} \right] \tau_c$$

BD 56/96

CL 9.9.2.2

Where  $t_w$  = the thickness of the web  
= 25.4 mm

$d_w$  = the clear depth of the web  
between flanges  
= 178 mm

$h_n$  = the height of the largest hole  
or cut-out within the panel.  
= 0

$\gamma_m$  = 1.2

$\gamma_{f3}$  = 1.1

$\tau_c$  = the limiting shear strength  
of the web panel, determined  
from fig. 11 to 17, corresponding  
to the values of  $\tau_y$ ,  $\phi$ ,  $m_w$   
and the slenderness ratio  $\lambda$

Limiting shear strength  $\tau_c$ :  
Slenderness ratio,  $\lambda$ :

$$\lambda = \frac{d_{we}}{t_w} \sqrt{\frac{\sigma_{yw}}{355}}$$

$$= \frac{178}{25.4} \sqrt{\frac{230}{355}} = 5.64$$

$$\tau_y = \frac{\sigma_{yw}}{\sqrt{3}} = \frac{230}{\sqrt{3}} = 132.8 \text{ N/mm}^2$$

$$\phi = \text{aspect ratio of the panel}$$

$$= \frac{a}{d_{we}} = \frac{4.137}{0.178} = 23.3$$

Project:

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By: AC

Date: 09/08

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Check  
By:

Date:

References/Results

$$m_{fw} = \frac{\sigma_{yf} b_f e t_f^2}{2 \sigma_{yw} d w_e^2 t_w}$$

where  $b_f$  is the smallest of:

$$(a) \quad 10 t_f \sqrt{\frac{355}{\sigma_{yf}}} = 10 \times 23 \sqrt{\frac{355}{230}} = 285.7 \text{ mm}$$

(b) the distance from the mid-plane of the web to the nearer edge of the flange  
 $\therefore 306.3 \text{ mm}$

$$\therefore m_{fw} = \frac{230 \times 285.7 \times 23^2}{2 \times 230 \times 178^2 \times 25.4}$$

$$= 0.09$$

From Eq. 15 and 16:

$$\frac{\tau_e}{\tau_y} \approx 1.02$$

$$\text{Where } \tau_y = \frac{\sigma_{yw}}{\sqrt{3}} = \frac{230}{\sqrt{3}} = 132.8 \text{ N/mm}^2$$

$$\therefore \tau_e = 135.5 \text{ N/mm}^2$$

$$\text{Hence, } V_D = \left( \frac{25.4 \times 178}{1.2 \times 1.1} \right) \times 135.5 \times 10^{-3}$$

$$= 464.1 \text{ kN}$$

$$V_D > V_{max}$$

$\therefore$  Section adequate in shear

Project:

RAIL PROPERTY BOARD ASSESSMENTS

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THE STUD BRIDGE no. 560

Check

Date:

By:

References/Results

### STRENGTH OF FASTENERS

Shear Flow resisted by the rivets

$$\tau = \frac{V A \bar{y}}{I}$$

Where  $V$  = the shear force  
= 66.1 kN

$A$  = area of section above the shear plane  
= 3355 mm<sup>2</sup>

$\bar{y}$  = depth to neutral axis from the centroid of the section being considered.  
= 103.72 mm

$I$  = Moment of inertia of area  
= 11.8288 × 10<sup>7</sup> mm<sup>4</sup>

$$\therefore \tau = \frac{66.1 \times 3355 \times 103.72 \times 10^3}{11.8288 \times 10^7} = 194.45 \text{ kN/m}$$

Rivet Spacing at 100mm c/c

So 20 studs/m

$$\text{Shear on each rivet} = \frac{194.45}{20} = 9.72 \text{ kN}$$

$$\text{Area of rivet shaft} = \frac{\pi \times 20.6^2}{4} = 333.3 \text{ mm}^2$$

Nominal yield stress = 230 N/mm<sup>2</sup>

$$\text{Stress on rivets} = \frac{9.720}{333.3} = 29.2 \text{ N/mm}^2$$

29.2 N/mm<sup>2</sup> > 230 N/mm<sup>2</sup>  
∴ Rivets adequate in shear



# CALCULATION SHEET

No: 37

Rev:

Project:

RAIL PROPERTY BOARD ASSESSMENTS

By: AC

Date: 09/09

Subject:

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Check

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By:

## References/Results

EXTERNAL TROUGHSECTION

Project:

RAIL PROPERTY BOARD ASSESSMENTS

By: AC

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By:

Date:

### References/Results

### ASSESSMENT LOADS

#### Dead Load

Plate Girder:

$$\begin{aligned} \text{Area} &= (2 \times 305 \times 11) + (2 \times 4485.4) \\ &= 15680.8 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Unit weight} &= 7850 \text{ kg/m}^3 \\ &= 78.5 \text{ kN/m}^3 \end{aligned}$$

$$\begin{aligned} \text{Self-weight} &= 0.0156808 \times 78.5 \\ &= 1.23 \text{ kN/m} \end{aligned}$$

BD 21/01  
Cb. 4.1

#### Superimposed Dead Load

Parapet:

Assume dead load from parapet 0.5 kN/m

Surfacing:

$$\begin{aligned} \text{Area} &= 120 \times 612.6 \\ &= 73512 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Unit weight} &= 2300 \text{ kg/m}^3 \\ &= 23 \text{ kN/m}^3 \end{aligned}$$

$$\begin{aligned} \text{Self-weight} &= 73512 \times 23 \times 10^{-6} \\ &= 1.7 \text{ kN/m} \end{aligned}$$

Concrete Fill:

$$\text{Area} = 85887.4 \text{ mm}^2$$

$$\begin{aligned} \text{Unit Weight} &= 2300 \text{ kg/m}^3 \\ &= 23 \text{ kN/m}^3 \end{aligned}$$

$$\begin{aligned} \text{Self-weight} &= 85887.4 \times 23 \times 10^{-6} \\ &= 2.0 \text{ kN/m} \end{aligned}$$

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References/Results

Live Load

Span of beam = 4.137m

Single wheel load:

For low traffic good surface road

Nominal Single wheel load

 $W = 82 \text{ kN}$ 

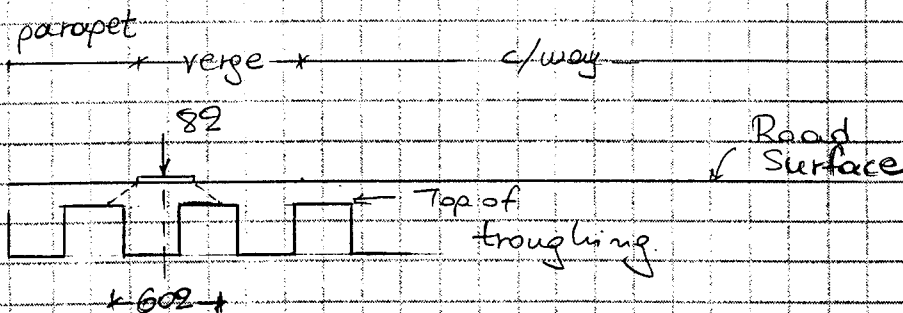
BD 21/01

CL. 5.32

Tb 5.3.2

Wheel load is applied over a  $0.3\text{m} \times 0.3\text{m}$  square contact area.

Distribution of loads:



BD 21/01

CL. 6.14

Fig 6.2



The amount of load taken by the section is:

$$\frac{82}{2000} = 13.7 \text{ kN/m}$$

Project:

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By: AC

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Subject:

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Check

By:

Date:

### References/Results

### Partial Factors for loads, $\phi_L$

|               |            |   |      |
|---------------|------------|---|------|
| Steel plate   | , $\phi_L$ | = | 1.05 |
| Concrete fill | , $\phi_L$ | = | 1.20 |
| Surfacing     | , $\phi_L$ | = | 1.75 |
| Parapet       | , $\phi_L$ | = | 1.20 |
| Live          | , $\phi_L$ | = | 1.50 |

BD 21/01

Tb. 3.1

### Assessment Loads

|                    |   |                    |   |          |
|--------------------|---|--------------------|---|----------|
| Steel Plate Girder | = | $1.23 \times 1.05$ | = | 1.3 kN/m |
| Concrete Fill      | = | $2.0 \times 1.20$  | = | 2.4 kN/m |
| Surfacing          | = | $1.7 \times 1.75$  | = | 3.0 kN/m |
| Parapet            | = | $0.5 \times 1.20$  | = | 0.6 kN/m |

Live:

$$\text{Single wheel load} = 13.7 \times 1.5 = 20.6 \text{ kN/m}$$

Project:

RAIL PROPERTY BOARD ASSESSMENTS

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Subject:

THE STUD BRIDGE no. 560

 Check  
By:
 

Date:

References/Results

### MOMENT and SHEAR

#### Dead Load

$$M = \frac{WL^2}{8} = \frac{1.3 \times 4.137^2}{8} = 2.8 \text{ kNm}$$

$$V = \frac{WL}{2} = \frac{1.3 \times 4.137}{2} = 2.7 \text{ kN}$$

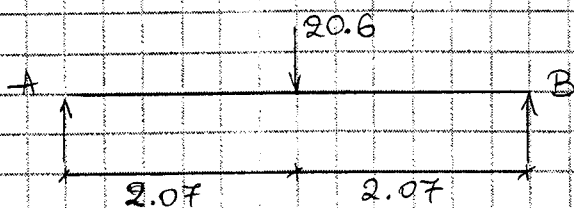
#### Superimposed Dead Load

$$M = \frac{WL^2}{8} = \frac{(2.4 + 3.0 + 0.6) \times 4.137^2}{8} = 12.8 \text{ kNm}$$

$$V = \frac{WL}{2} = \frac{(2.4 + 3.0 + 0.6) \times 4.137}{2} = 12.4 \text{ kN}$$

#### Live Load

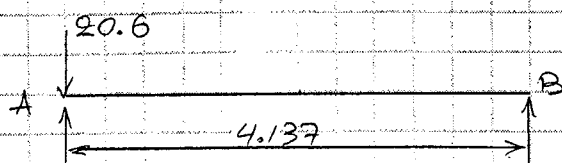
$M_{\max}$  when 20.6 kN load at midspan



$$M_{\max} = \frac{PL}{4} = \frac{20.6 \times 4.137}{4} = 21.3 \text{ kNm}$$

$$V = 10.3 \text{ kN}$$

$V_{\max}$  when 20.6 kN load at support



$$V_{\max} = 20.6 \text{ kN}$$

Project:

RAIL PROPERTY BOARD ASSESSMENTS

By: AC

Date: 09/09

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THE STUD BRIDGE no. 560

Check

By:

Date:

References/Results

Maximum Moment

$$M_{max} = 2.8 + 12.8 + 21.3 = 36.9 \text{ kNm}$$

Maximum Shear

$$V_{max} = 2.7 + 12.4 + 20.6 = 35.7 \text{ kN}$$

From page 33,

$$M_D = 221.7 \text{ kNm} > M_{max}$$

∴ Section adequate in bending

From page 35,

$$V_D = 464.1 \text{ kN} > V_{max}$$

∴ Section adequate in shear

Rivets adequate in shear (See page 36)

Project:

RAIL PROPERTY BOARD ASSESSMENTS

By: AC

Date:

Subject:

THE STUD BRIDGE no. 560

Check

By:

Date:

References/Results

### SUMMARY

The bridge has been checked for a carrying capacity of 40 tonnes vehicle, both at the internal and the external section.

For the internal section the worst applied moment and shear were found to be:

$$M_{max} = 73 \text{ kNm}$$

and

$$V_{max} = 66.1 \text{ kN}$$

The bending and shear resistance of the section were found to be  $M_D = 221.7 \text{ kNm}$  and  $V_D = 464.1 \text{ kN}$ .

The fasteners were found to be adequate in shear.

For the external section the worst applied moment and shear were found to be:

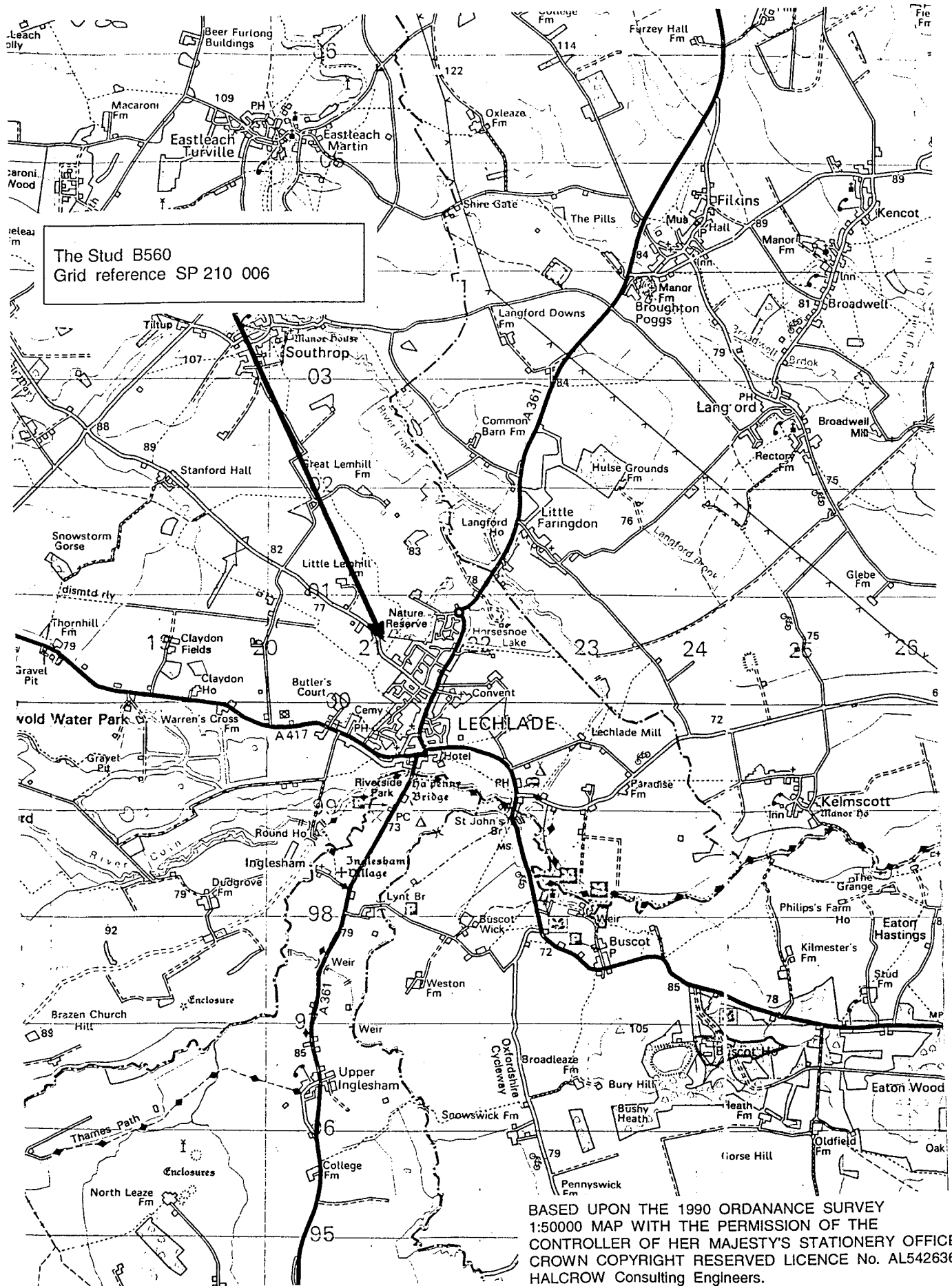
$$M_{max} = 36.9 \text{ kNm}$$

and

$$V_{max} = 35.7 \text{ kN}$$

The bridge was assessed for a 40 tonnes carrying capacity and was found adequate.

# **Appendix A – Location Plan – Drawing TB.2116.B560.SK02**



Halcrow Group Limited  
Lanthony Warehouse The Docks Gloucester GL1 2NS  
Tel +44 (0)1452 393908 Fax +44 (0)1452 393900  
www.halcrow.com

**Halcrow**

Project

RAIL PROPERTY  
BOARD BRIDGE  
ASSESSMENTS

Drawing

THE STUD  
LOCATION PLAN

Drawn by CJT  
Checked by  
Authorised by

Date: 03/02  
Date:  
Date:

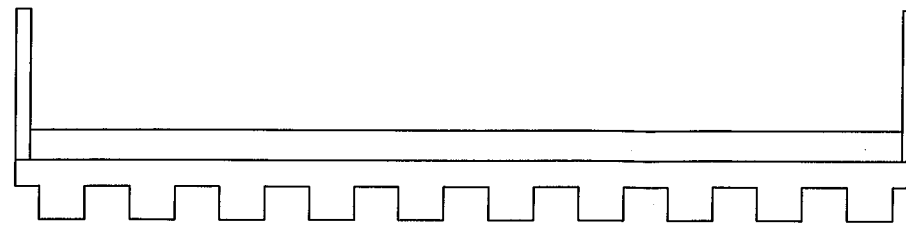
Drawing No. TB.2116.B560.SK01

Revision

Drawing Scale: AS SHOWN Plot Scale:

CAD Filename: NOT APPLICABLE

Status: INFORMATION



## TYPICAL SECTION A-A

NTS

Webs — generally good condition. Very isolated corroded patches.

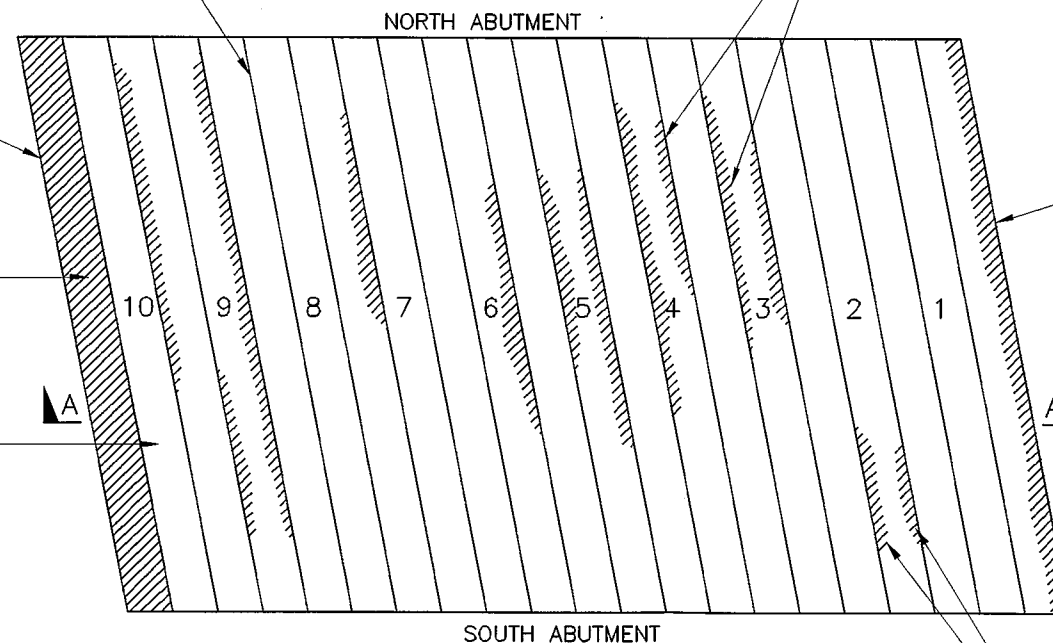
Generally surface corrosion on edges of top and bottom flanges. Most severe at joints with web where up to 3mm section loss has occurred

Edge plate — corroded severely throughout. Loss of section in places

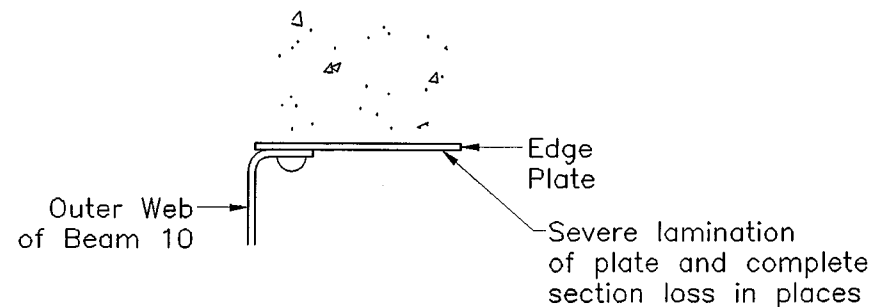
Corrosion around rivets on U/S of beam

Generally U/S of beam 10 is in reasonable condition — worst corrosion around rivets on U/S

Surface corrosion and delamination of edge plate. Some section loss along length upto 5mm



Surface corrosion



## EDGE BEAM 10

NTS

## PLAN ON SOFFIT

NTS

### NOTES

General condition of beams

Soffits in generally reasonable condition with isolated corrosion.

Beams have been painted — paint generally in reasonable condition.

Beams marked "Dorman & Co Ltd Middlesboro"

Rivets in satisfactory condition.

| Revision | By | Checked/Approved | Date | Description |
|----------|----|------------------|------|-------------|
|          |    |                  |      |             |

Client  
**GLOUCESTERSHIRE**  
COUNTY COUNCIL  
DIRECTOR OF ENVIRONMENT

Halcrow Group Limited  
Linsbury Workhouse The Docks Gloucester GL1 2NS  
Tel 01452 382808 Fax 01452 382800  
www.halcrow.com

**Halcrow**

Project  
**RAIL PROPERTY LTD  
BRIDGE ASSESSMENTS**

Drawing  
**THE STUD  
INSPECTION DETAILS**

|               |     |      |       |
|---------------|-----|------|-------|
| Drawn by      | CJT | Date | 12/02 |
| Checked by    | AW  | Date | 03/03 |
| Authorised by | AW  | Date | 03/03 |

Drawing No.  
**TB.2116.B560.SK02** | Revision  
-

Drawing Scale: A5 SHOWN

CAD Filename: KQ\_2116\_B560\_SK02.dwg Plot Scale: 1:1

Status:

## Appendix B – Form AA and Form AA/1

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

Appendix: 4

Issue: 1

ELR/ Bridge No: FFD 86m 20c

Revision: B (Nov 2000)

**APPROVAL IN PRINCIPLE FOR ASSESSMENT**

|   |   |
|---|---|
| <b>1. Bridge/Line Name</b>                      | The Stud Bridge<br>Disused railway  |
| <b>2. ELR/Bridge No.</b>                        | FFD 86m 20c<br>County bridge number 560   |
| <b>2.1 Location and grid reference</b>          | Unclassified County road over<br>disused rail bridge at OS grid<br>reference SP 210 006   |
| <b>3. Brief Description of Existing Bridge:</b> |   |
| <b>3.1 Span Arrangement:</b>                    | Single span steel trough deck (built<br>up) on masonry abutments.<br>4.00m (skew span)<br>Skew 12° (approx)   |
| <b>3.2 Superstructure Type:</b>                 | Steel trough deck (built up) on<br>masonry abutments.<br><br>Timber and corrugated metal parapet<br>on both sides of bridge<br>Square width between parapets:<br>6.130m<br><br>Carriageway width: 4.720m<br>Verge widths: 0.860m and 0.550m |
| <b>3.3 Substructure Type:</b>                   | Masonry abutments. Brick wing walls.<br>Foundations unknown   |
| <b>3.4 Details of any Special Features:</b>     | None  |
| <b>3.5 Statutory Undertakers Plant:</b>         | From the inspection and information<br>provided by statutory bodies there is<br>no reason to believe that any<br>apparatus will affect the assessment   |

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

Appendix: 4

Issue: 1

ELR/ Bridge No: FFD 86m 20c

Revision: B (Nov 2000)

**APPROVAL IN PRINCIPLE FOR ASSESSMENT****4. Assessment Criteria****4.1 Loadings and Speed:**

Speed not applicable to assessment of superstructure.

HA Live assessment loading as detailed in BD21/01.

Unit weights of superimposed dead loads shall be in accordance with BD21/01.

Footway live loading not applicable to assessment.

Calculation of abnormal load capacity shall not be undertaken.

**4.2 Codes to be used**

BD 21/01 The Assessment of Highway Bridges and Structures

BA 16/97 The Assessment of Highway Bridges and Structures

BD 56/96 The Assessment of Steel Highway Bridges and Structures

BA 56/96 The Assessment of Steel Highway Bridges and Structures

**4.3 Proposed Method of Structural Analysis**

There are no record drawings available for this structure

The superstructure shall be analysed in accordance with BD 56/96. Simple load distribution and dispersal techniques for trough decks shall be used in accordance with Chapter 6 of BD 21/01. A diagram of the idealised structure is shown on page (vi)

Initially a simple analysis shall be carried out based on the layout of structural elements recorded from the inspection.

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

ELR/ Bridge No: FFD 86m 20c

Appendix: 4

Issue: 1

Revision: B (Nov 2000)

**APPROVAL IN PRINCIPLE FOR ASSESSMENT****4.3 Proposed Method of Structural Analysis (continued)**

Calculation of section properties shall consider any loss of section due to corrosion.

Parameters to be used for assessment:

Characteristic yield stress of steel  
230N/mm<sup>2</sup> from Cl. 4.3, BD 21/01.

Characteristic strength of pre 1939 concrete assumed not to be greater than 15N/mm<sup>2</sup> from Cl. 4.7, BD 21/01.

A qualitative assessment shall be made of other parts of the structure.

The parapets will not be assessed.

**4.4 Details of any Special Requirements**

None

## FORM 'AA' (BRIDGES)

GC/TP0356

Appendix: 4

Issue: 1

ELR/ Bridge No: FFD 86m 20c

Revision: B (Nov 2000)

APPROVAL IN PRINCIPLE FOR ASSESSMENT

## 5. THE ABOVE IS SUBMITTED FOR ACCEPTANCE

Name



Title/Professional Qualification:

ENGINEER CENG MICE

Signed

Date: 20 JANUARY 2003

## 6. Senior Civil Engineer's Comments

None

Proposed Category for Independent Check ..... 1

Superstructure .....

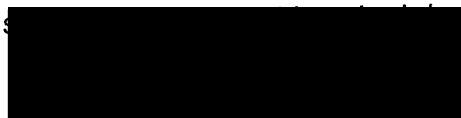
Substructure .....

Name Of Checker Suggested If Cat 2 Or 3 .....

## Category 1

The above assessment, with amendments

Signed



Title

Senior Civil Engineer

Date

28th January 2003

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

Appendix: 4

Issue: 1

ELR/ Bridge No: FFD 86m 20c

Revision: B (Nov 2000)

**APPROVAL IN PRINCIPLE FOR ASSESSMENT****Category 2 and 3**

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

Signed .....

Title .....

Date .....

Signed .....

Title .....

Date .....

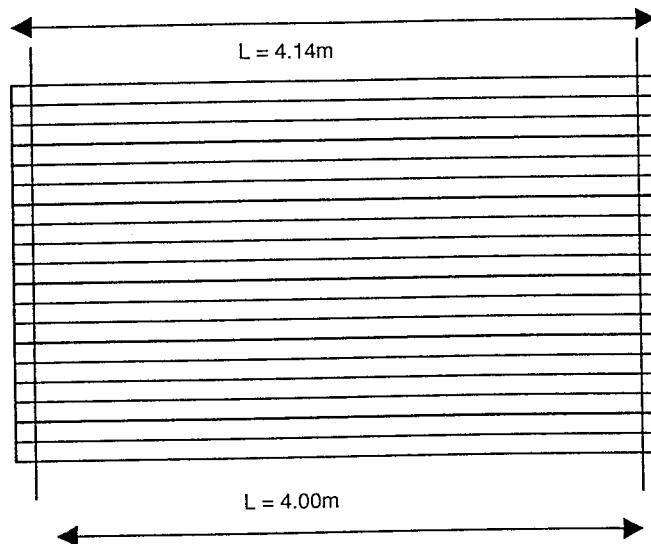
**FORM 'AA/1' (BRIDGES)****GC/TP0356**

Appendix: 4

Issue: 1

ELR/ Bridge No: FFD 86m 20c

Revision: B (Nov 2000)

**APPROVAL IN PRINCIPLE FOR ASSESSMENT****Diagram Showing the Idealised Structure****Parameters for Assessment:**

|                                       |                    |
|---------------------------------------|--------------------|
| Span between points of support (l):   | 4.14m              |
| Clear Span between abutments (L):     | 4.00m              |
| Characteristic yield stress of steel: | $230\text{N/mm}^2$ |
| Characteristic strength of concrete:  | $15\text{N/mm}^2$  |

**FORM 'AA/1' (BRIDGES)****GC/TP0356**

Appendix: 4

Issue: 1

ELR/ Bridge No: FFD 86m 20c

Revision: B (Nov 2000)

**APPROVAL IN PRINCIPLE FOR ASSESSMENT****Additional Information Required For BRB (Residuary) Limited Owned  
Public Road Overbridges Assessed As Part Of Bridgeguard III**

- |  |   |
|--|---|
| <b>1. Bridge/Line Name</b>                                   | The Stud Bridge<br>Disused railway line   |
| <b>2. ELR/Bridge No.</b>                                     | FFD 86m 20c<br>County bridge number 560   |
| <b>3. Scope Of Assessment</b>                                | Initially a simple analysis shall be carried out based on the layout of the structural elements recorded from the inspection.<br><br>A qualitative assessment of the spandrel walls, abutments and wingwall will be undertaken.<br><br>The parapets will not be assessed.   |
| <b>4. Assessment Criteria</b>                                |   |
| (a) Standards And Codes Of Practice To Be Used In Assessment | BD 21/01 The Assessment of Highway Bridges and Structures<br><br>BA 16/97 The Assessment of Highway Bridges and Structures<br><br>BD 56/96 The Assessment of Steel Highway Bridges and Structures<br><br>BA56/96 The Assessment of Steel Highway Bridges and Structures   |
| (b) Proposed Method Of Structural Analysis                   | There are no record drawings available for this structure.<br><br>The superstructure shall be analysed in accordance with BD 56/96. Simple load distribution and dispersal techniques for trough decks shall be used in accordance with Chapter 6 of BD 21/01. A diagram of the idealised structure is shown on page (vi) |

**FORM 'AA/1' (BRIDGES)****GC/TP0356**

Appendix: 4

Issue: 1

ELR/ Bridge No: FFD 86m 20c

Revision: B (Nov 2000)

**APPROVAL IN PRINCIPLE FOR ASSESSMENT**

(b) Proposed Method Of Structural  
Analysis (continued)

Calculation of section properties shall  
consider any loss of section due to  
corrosion.

Parameters to be used for  
assessment:

Characteristic yield stress of steel  
230N/mm<sup>2</sup> from Cl.4.3, BD 21/01.

Characteristic strength of concrete  
assumed to be not greater than  
15N/mm<sup>2</sup> from Cl.4.7, BD 21/01.

A qualitative assessment shall be  
made of all other parts of the  
structure.

The parapets will not be assessed.

(c) Planned Highway  
Works/Modifications At This Site

There are no known planned highway  
works/modifications at the site.

(d) Road Designation Class And  
Whether Classed As A Heavy Load  
Route

Unclassified County road

(e) Any Other Requirements

None

**FORM 'AA/1' (BRIDGES)****GC/TP0356**

Appendix: 4

Issue: 1

ELR/ Bridge No: FFD 86m 20c

Revision: B (Nov 2000)

**APPROVAL IN PRINCIPLE FOR ASSESSMENT**

The Above Is Agreed Subject To The Amendments And Comments Shown Below.

\*Signe

Title

Date

.....  
22/1/03

\*A Team Leader, Consultant Or Chief Officer Employed By An Agent

Authority May Sign "For And On Behalf

Of Gloucestershire County Council ..... Where Authorised To Do So.

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**GLOUCESTERSHIRE COUNTY COUNCIL  
RAIL PROPERTY LTD BRIDGE ASSESSMENTS  
THE STUD BRIDGE FFD 86m 20c      GCC No: B560**

**Sheet: 1 of 3**

**Structure: The Stud Bridge  
Grid Ref: FFD 86m 20c  
Date: March 2003**

---

**CERTIFICATE OF ASSESSMENT AND CHECKING**

---

**TECHNICAL APPROVAL FOR  
ASSESSMENT OF BRIDGES AND OTHER BRIDGES**

**1      Identification of Bridge**

|                             |                 |
|-----------------------------|-----------------|
| Name                        | The Stud Bridge |
| Location and grid reference | SP 210 006      |
| Engineers Line Reference    | FFD 86m 20c     |

**2      Certification of assessment and category I check**

We certify that reasonable professional skill and care have been used by a competent person in the assessment and checking of the above structure with a view to securing that:-

- (i) it has been assessed and checked in accordance with the Approval in Principle as recorded on Form AA signed by J Clarke dated 28<sup>th</sup> January 2003.
- (ii) the assessment and check comply with the following British Standards and Codes of Practice, with departures as shown:-

BD 21/01      The Assessment of Highway Bridges and Structures

BA 16/97      The Assessment of Highway Bridges and Structures

BD 56/96      The Assessment of Steel Highway Bridges and Structures

BA 56/96      The Assessment of Steel Highway Bridges and Structures

The unique numbers of the drawings used for the assessment are:

Inspection Details      TB.2116.B560.SK02

The assessed capacity of the structure is as follows:-

- (a)      Steel Trough

40 Tonnes Assessment Live Loading (ALL)

By observation the edge deck plate immediately adjacent to the west parapet would fail under accidental wheel loading.

Based on assumptions in the Assessment and Inspection Report (Document Ref. TB.2116.B560.Doc01)

**GLOUCESTERSHIRE COUNTY COUNCIL  
RAIL PROPERTY LTD BRIDGE ASSESSMENTS  
THE STUD BRIDGE FFD 86m 20c      GCC No: B560**

Sheet: 2 of 3

Structure: The Stud Bridge  
Grid Ref: FFD 86m 20c  
Date: March 2003

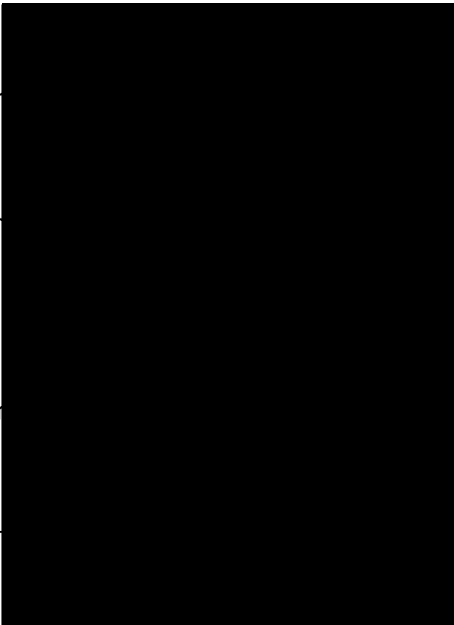
**CERTIFICATE OF ASSESSMENT AND CHECKING**

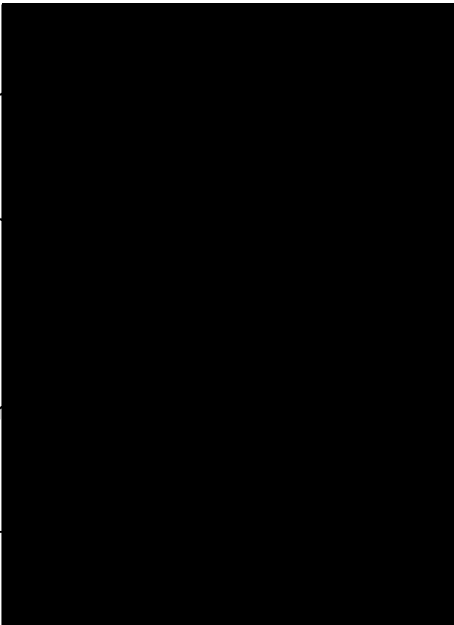
(b)      Wingwalls, abutments and foundations

All satisfactory based on a qualitative assessment.

The parapets were not assessed.

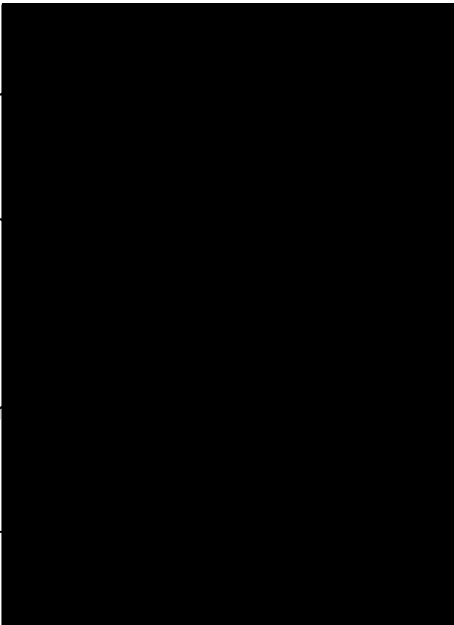
The HB capacity was not assessed.

Name:  Title/Professional Qualification: ASSISTANT ENGINEER

Signature:  Date: 24/04/03

(To be signed by the person or team leader carrying out the assessment)

Name:  Title/Professional Qualification: ASSISTANT ENGINEER

Signature:  Date: 24/04/03

(To be signed by the person or team leader carrying out the category I check)

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**GLOUCESTERSHIRE COUNTY COUNCIL  
RAIL PROPERTY LTD BRIDGE ASSESSMENTS  
THE STUD BRIDGE FFD 86m 20c      GCC No: B560**

Sheet: 3 of 3

Structure: The Stud Bridge  
Grid Ref: FFD 86m 20c  
Date: March 2003

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**CERTIFICATE OF ASSESSMENT AND CHECKING**

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**3      Certification of categories II and III checks**

(NB A category I check shall also be carried out in these cases)

We certify that reasonable professional skill and care have been used on the independent checking of the above structure with a view to securing that the criteria in Section 2 (i) and (ii) above have been met.

Name:.....

Title/Professional Qualification:.....

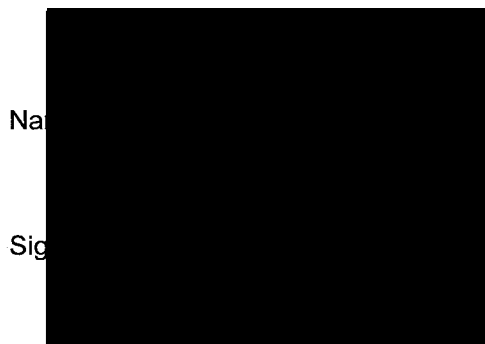
Signed: .....

Date:.....

(To be signed by the person or team leader carrying out the category II or III check)

**4      Acceptance by the Technical Approval Authority**

This certificate is accepted on behalf of Rail Property Ltd



Name

Title/Professional Qualification:.....

*C Eng MICE*

Signature

Date:.....

*30/4/2003*