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BRIDGE REFERENCE

CKP/87

REPORT 1

OTHER DOCUMENTS

DRAWINGS

CKP/87.

BRITISH RAIL PROPERTY BOARD

BRIDGE ASSESSMENT TO BD21/97

U3129 HILL COTTAGE RAILWAY BRIDGE NO 87

DESIGN SERVICES

CUMBRIA COUNTY COUNCIL - CONSTRUCTION SERVICES **BD 21/97 LOAD ASSESSMENT REPORT FOR BRITISH RAIL PROPERTY BOARD STRUCTURES** **FOR: U3129 HILL COTTAGE RAILWAY BRIDGE**	**PAGE No.** 1 **OF** 85 **PAGES** **REV No. 0** **DATE:. Oct 1999**

REPORT COVER SHEET AND INDEX

EX **PAGE No.**

LIENT: BRITISH RAIL PROPERTY BOARD

EME No.: As Quality Plan

SSESSMENT LIST APPENDIX No.: 28 **DATED:** 25/10/96

QUALITY PLAN REF: BG/97/98
(Note: Work is covered by Scheme Specific Instruction)

ORT TITLE: AS HEADER

TUS	DATE	AUTHOR	APPROVED
SUED FOR USE	OCTOBER 1999	[redacted]	[redacted]

CATEGORY B

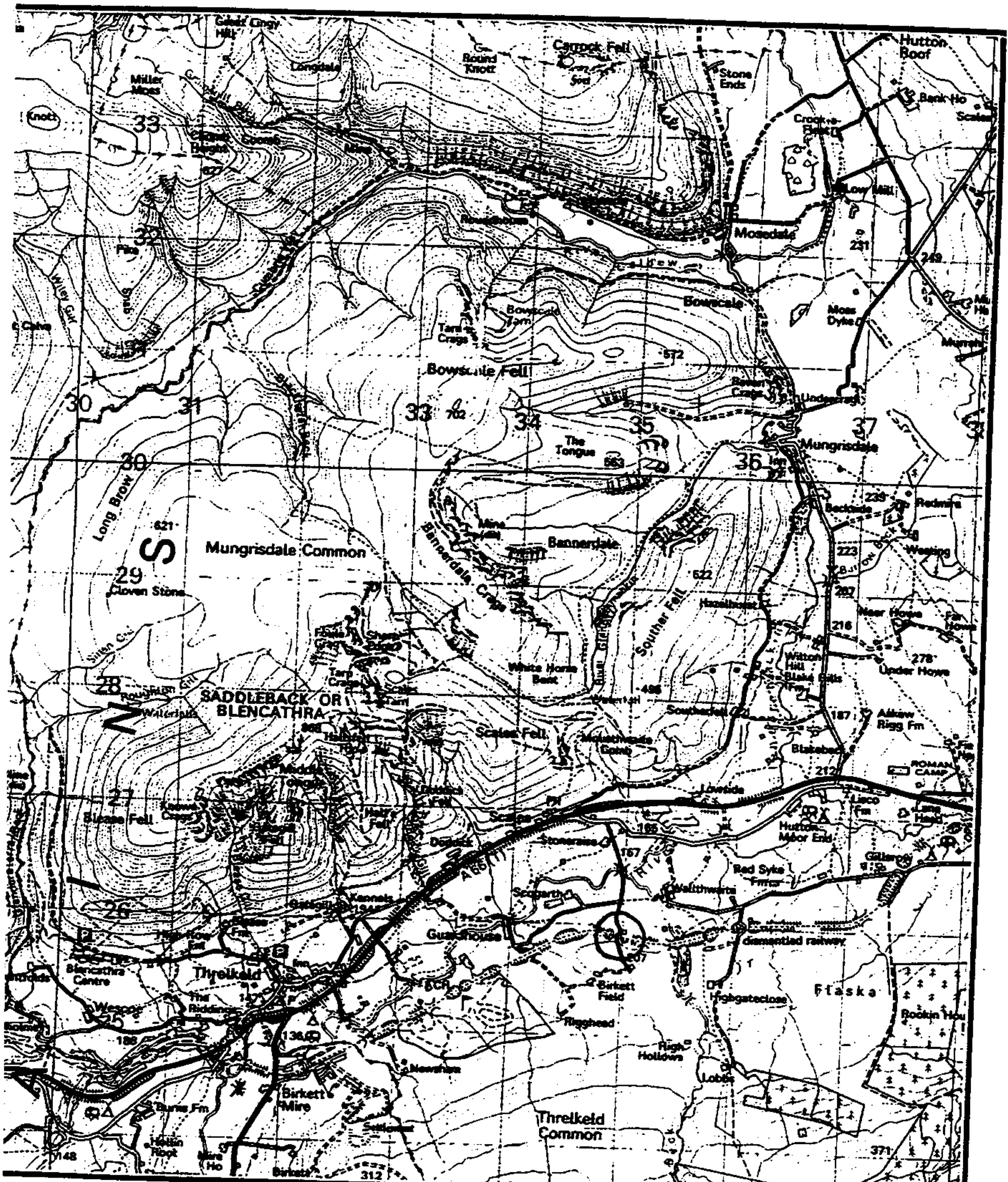
NED: ....[redacted]........ **Date:** 3 NOV 99
(Asses

ROVED:.......... **Date:** 3 NOV 99
(Team Leader)

E SUBMITTED TO CLIENT: 3.11.99

TRIBUTION LIST:
COPY ONLY PRODUCED FOR BRPB
NE COPY RETAINED IN E+E RECORD SYSTEM

LOCATION PLAN



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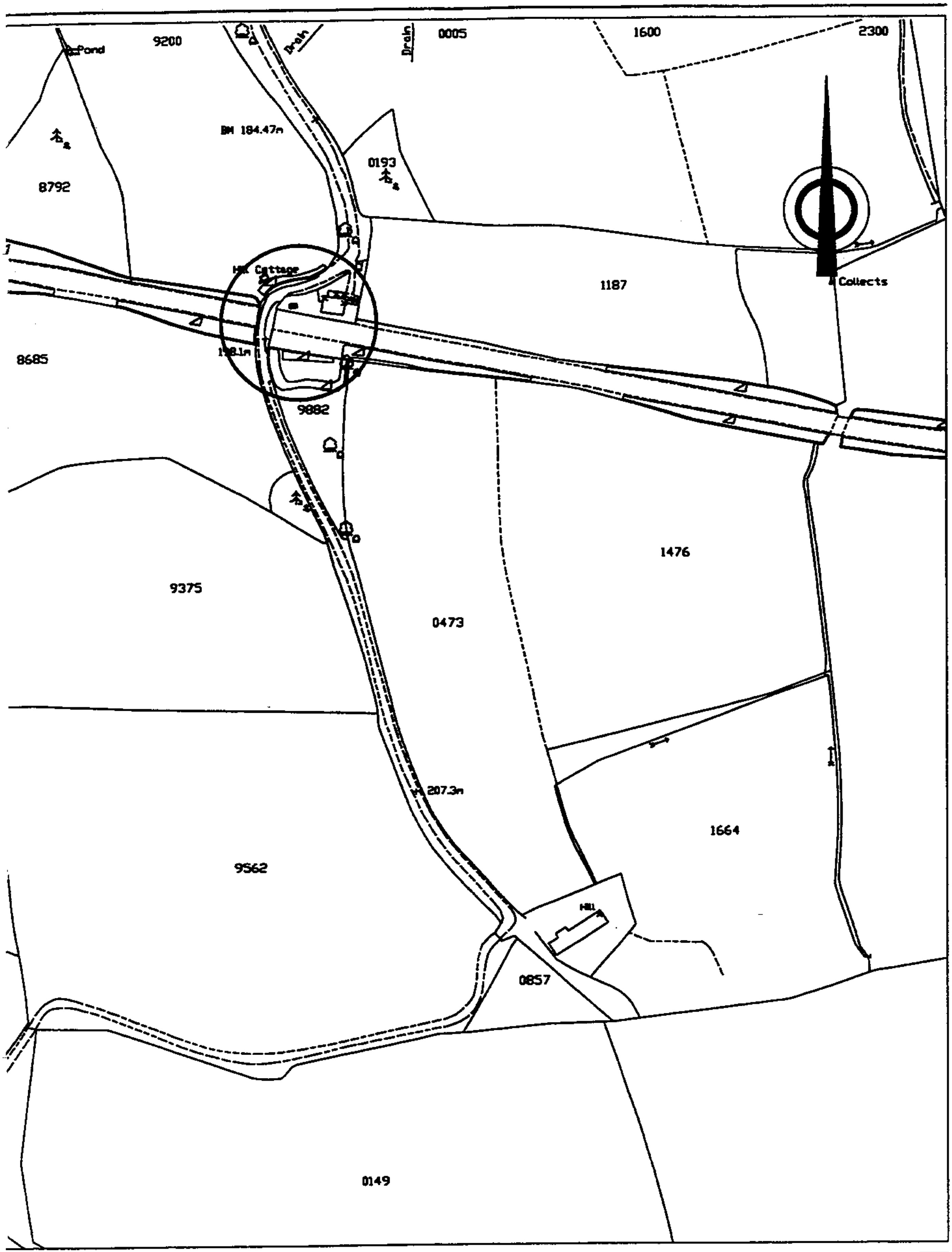
NSULTANCY & ESIGN

CUMBRIA COUNTY COUNCIL

Cumbria

CONSULTANCY & DESIGN
Viaduct Estate
CARLISLE
Cumbria
CA2 5BN

Railtrack Ref No	
ELR | **Mileage**	
O.S. Reference	NY 349 258
Bridge Name	HILL COTTAGE
Road No & Name	U3129
Scale	1: 50000
Drawing No	



CUMBRIA COUNTY COUNCIL

Cumbria

CONSULTANCY & DESIGN
Viaduct Estate
CARLISLE
Cumbria
CA2 5BN

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Drawn By	JCG	Date	18/8/99
O.S. Reference	NY 349 258		
Structure Name	HILL COTTAGE RAILWAY BRIDGE		
Road No. & Name	U3129		
Scale	1:2500		
Drawing No.			

xplanatory Notes on Completion of Inspection Report Form

everity:

- No significant defect.
- Minor defects of a non-urgent nature.
- Defects which should be included for attention within the next annual maintenance programme.
- Severe defects where urgent Client action is recommended for the protection of persons and property.

xtent:

- No significant defect.
- Slight, not more than 5% of length or area affected.
- Moderate, 5% - 20% affected.
- Extensive, more than 20% affected.

oxes for all applicable elements are to be completed, i.e. Extent A Severity 1 represents a 'nil' report.

oxes for non-applicable elements are to be dashed to indicate consideration.

typical form is shown overleaf.

he comments section is to be used to list remedial works and estimated costs. The rear of the form or an xtra sheet may be used for continuations.

3RIDGE INSPECTION REPORT

DEPARTMENT OF HIGHWAYS AND ENGINEERING.

IO U3129 BRIDGE NO 87 BRIDGE NAME HILL COTTAGE

F BRIDGE CAST IRON & BRICK JA SPANS SINGLE 7.48m SQUARE

F INSPECTION 23/7/97 INSPECTED BY [redacted]

O	ITEM DESCRIPTION	EXTENT	SEVERITY	COMMENTS/DESCRIPTION OF CONDITION
	FOUNDATIONS	A	1	NOT INSPECTED BUT NO SIGN OF ANY MOVEMENT
	INVERT OR APRONS	A	1	
	FENDERS	—	—	
	PIERS/COLUMNS	—	—	
	ABUTMENTS	B	3	POINT UP AND MONITOR CRACK IN NORTH ABUTMENT
	WING WALLS	C	2	REPOINT OPEN/CRACKED JOINTS MONITOR N-W & S.W WINGWALL FOR FURTHER MOVEMENTS
	RETAINING WALLS OR REVETMENTS	—	—	
	APPROACH EMBANKMENTS	—	—	
	BEARINGS			NOT INSPECTED
	MAIN BEAMS	D	2	GRIT BLAST AND REPAINT ALL VISIBLE C.I SURFACES
	TRANSVERSE BEAMS	—	—	
	DIAPHRAGMS OR BRACING	—	—	
	CONCRETE SLAB	—	—	
	METAL DECK PLATES	—	—	
	JACK ARCHES	B	3	REPOINT OPEN JOINTS TO CROWN OF JA No 4
	ARCH RING/ARMCO	—	—	
	SPANDRELS	—	—	
	TIE RODS	D	2	GRIT BLAST AND REPAINT TO PREVENT FURTHER SECTION LOSS
	DRAINAGE SYSTEM	—	—	
	WATERPROOFING	D	2	WATER PENETRATION EVIDENT THROUGH JACK ARCHES
	SURFACING	A	1	
	SERVICE DUCTS	—	—	
	EXPANSION JOINTS	—	—	
	PARAPETS	D	2	REPOINT OPEN JOINTS, MONITOR FOR FURTHER MOVEMENTS
	ACCESS GANTRIES OR WALKWAYS	—	—	
	MACHINERY	—	—	

DIAL WORK RECOMMENDED AT PREVIOUS INSPECTION SATISFACTORILY COMPLETED YES/NO

'S IF ANSWER IS NO..

....

CUMBRIA COUNTY COUNCIL – DESIGN SERVICES	**PAGE No. ....3.....**
BD 21/97 LOAD ASSESSMENT REPORT – RESULTS SUMMARY SHEET	**OF ....85...PAGES**
FOR: U3129 HILL COTTAGE RAILWAY BRIDGE	**REV No. 0**
	DATE: Oct 1999

The assessment was carried out in accordance with the standards stated in the Approval in Principle Form AA signed by the Client on 8 January 1998.

1. The results of the assessment are as follows:

Hill Cottage Railway Bridge has been assessed in accordance with BD 21/97 and BA16/97 using simple distribution methods for the cast iron beams and the modified MEXE method of assessment for the jack arches.

Element	**CASES**				**Remarks**
	1 Gross/enhanced	2 Gross	3 Nett/enhanced	4 Nett	
Inner beams	Group 1FE	7.5 tonnes	Group 1FE	7.5 tonnes	Stress in bottom flange critical.
Edge beams (Vertical Loading)	7.5tonnes Accidental Vehicle	7.5 tonnes Accidental Vehicle	3 tonnes Accidental Vehicle	3 tonnes Accidental Vehicle	Stress in bottom flange critical.

Edge beams	Assessment capacity	Remarks
Horizontal stability Governed by 3 No. 19mm dia wrought iron tie-rods.	3.0 tonnes Accidental Vehicle	Replacement of 3 No. 19mm dia tie-rods by 25mm dia of similar material would give assessment capacity of 7.5t Accidental Vehicle.

Jack arch — The capacity of the jack arches is 40 tonnes GVW – this is not a governing factor in the Bridge Assessment Capacity.

The weight restriction on the bridge is 3 tonnes gross vehicle weight.

The foundations, abutments, spandrel walls, wing walls, and parapets have all been assessed by visual inspection only, and have been found to be adequate for the current imposed loads.
The parapets do not comply to BD 52/93.

2. Recommendations to increase the assessed capacity are as follows:

(i) Further increase in capacity is possible by use of carbon fibre plate bonding to the bottom flange of all girders. Additional tie-rods would be required to provide adequate stability of the edge girders.

CERTIFICATE OF ASSESSMENT AND CHECKING
FORM BA & BAA

APPROVAL IN PRINCIPLE
FORM AA

British Railways Board Group Standard

FORM 'AA' (BRIDGES)

GC/TP0356
Appendix: 4
Issue: 1
Revision: A
Date: FEB 93

APPROVAL IN PRINCIPLE FOR ASSESSMENT

STRUCTURE/LINE NAME HILL COTTAGE RLY. Nº 87

ELR/STRUCTURE NO. CKP 87

BRIEF DESCRIPTION OF EXISTING BRIDGE:

(a) Span Arrangement
SINGLE SQUARE SPAN (APPROX SPAN 7450, APPROX WIDTH 74c

(b) Superstructure Type
6 No C.I MAIN BEAMS AT APPROX. 1470 crs WITH TRANSVERSE SPANNING BRICK JACK ARCHES AND TIE BARS.

(c) Substructure Type
MASS MASONRY ABUTMENTS.

(d) Details of any Special Features
INTERMEDIATE AND EDGE BEAMS ARE OF DIFFERENT SECTION.

ASSESSMENT CRITERIA

(a) Loadings and Speed
N/A

(b) Codes to be used
SEE LIST IN APPENDIX B

(c) Proposed Method of Structural Analysis
BEAMS BY BEAM STRIP & SIMPLE ANALYSIS JACK ARCHES BY MODIFIED MEXE METHOD (NOTE:- EXTRAPOLATION FOR SPAN)

(d) Details of any Special Requirements

STRUCTURAL ASSESSMENT ENGINEER'S COMMENTS

SEE APPENDIX A ATTACHED FOR MEXE ANALYSIS OF JACK ARCHES. ADEQUATE LATERAL RESTRAINT TO THE EDGE BEAM IS ASSUMED TO BE PROVIDED BY THE TIE RODS. WHERE THESE ARE FOUND TO HAVE A SECTION LOSS OF 10% OR GREATER OR ARE MISSING THEY SHALL BE REPLACED UNDER MAINTENANCE TO MAKE THIS ANALYSIS RELEVANT. SPECIAL CARE & NOTE TO BE TAKEN OF ANY HORIZONTAL DEFLECTION OR CRACKING IN THE EDGE BEAM.

British Railways Board | Group Standard

FORM 'AA' (BRIDGES)

GC/TP0356
Appendix: 4
Issue: 1
Revision: A
Date: FEB 93

APPROVAL IN PRINCIPLE FOR ASSESSMENT

CIVIL ENGINEER'S COMMENTS

BRB WORKS GROUP COMMENTS – IF APPLICABLE

PROPOSED CATEGORY FOR INDEPENDENT CHECK:

SUPERSTRUCTURE ....CAT 2....................

SUBSTRUCTURE ..VISUAL FOR CURRENT LOADING

NAME OF CHECKER SUGGESTED IF CAT 2 OR 3 ....

CATEGORY ~~1~~

THE ABOVE ASSESSMENT, WITH AMENDMENTS SHOWN, IS APPROVED IN PRINCIPLE:

SIGNED ....

TITLE ....

DATE ....

CATEGORY 2 AND 3

THE ABOVE ASSESSMENT, WITH AMENDMENTS SHOWN, IS APPROVED IN PRINCIPLE:

SIGNED [redacted]

TITLE ....

DATE ..16 January 1997..........

SIGNED ....

TITLE ....

DATE ....

FORM 'AA/1' (BRIDGES)

GC/TP0356
Appendix: 4
Issue: 1
Revision: A
Date: FEB 93

APPROVAL IN PRINCIPLE FOR ASSESSMENT

ADDITIONAL INFORMATION REQUIRED FOR BRB OWNED PUBLIC ROAD OVERBRIDGES ASSESSED AS PART OF BRIDGEGUARD III

STRUCTURE/LINE NAME HILL COTTAGE RLY No 87

ELR/STRUCTURE NO. CKP 87

SCOPE OF ASSESSMENT
DECK INSPECTION FOR CURRENT LOADING, SIMPLE STRIP ANALYSIS FOR BEAMS & MODIFIED MEXE FOR JACK ARCHES TO GIVE CALCULATED CAPACITY
REMAINDER OF STRUCTURE INSPECTION FOR CURRENT LOADING

ASSESSMENT CRITERIA

a) Standards and Codes of Practice to be used in assessment
SEE LIST IN APPENDIX B.

b) Proposed method of structural analysis
BEAMS BY BEAM STRIP & SIMPLE ANALYSIS JACK ARCHES BY MODIFIED MEXE METHOD (NOTE:- EXTRAPOLATION FOR SPAN)

c) Planned Highway works/modifications at this site
TRIAL HOLES WILL BE REQUIRED.

d) Road designation/class and whether classed as a heavy load route
U3129 NOT A HEAVY LOAD ROUTE.

e) Any other requirement

The above is agreed subject to the amendments and comments shown below.

*SIGNED [redacted]
TITLE BRIDGING MANAGER
DATE 8/1/98

*A team leader or chief officer employed by an Agent Authority may sign "for and on behalf of" DIRECTOR OF ECONOMY & ENVIRONMENT. where authorised to do so.

BRPB ASSESSMENTS

APPENDIX A

The use of modified MEXE method for assessment of single span masonry arch bridges with angle of skew 0° up to 20°.

1 FACTORS

BARREL FACTOR Fb as table 3/1 except that:-

Large coursed sandstone - Good quality workmanship 1.2

Uncoursed masonry (sandstone, limestone, slate) and non-engineering brickwork. 1.0

FILL FACTOR Ff as table 3/2. If no settlement or tracking of surfacing. 0.7

JOINT FACTOR Fj
Fw, Fmo, Fd as tables 3/3, 3/4, 3/5 respectively.

CONDITION FACTOR Fc

BASIC FACTOR TAKEN AS 0.9

deduct if verge less than approx 0.75m thus allowing wheel load near edge. -0.1

Further deductions where appropriate (eg flaking or exfoliating masonry, isolated area of open joints).

2 DIMENSIONS

SPAN. Use skew span for L.

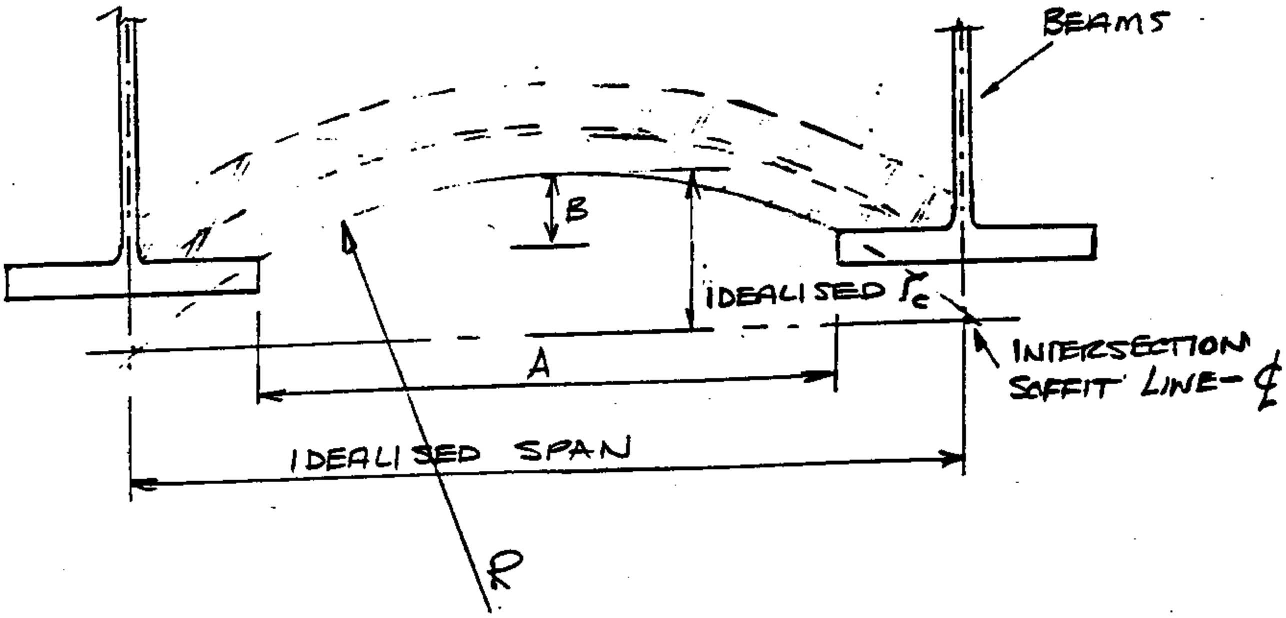
BARREL AND DEPTH OF COVER. In the absence of definite information from BR regarding 'd' the barrel thickness a figure of 2/3 of the depth of the edge voussoirs is taken, and the depth of fill limited to a maximum of the voussoir depth. If the structure passes the 40t assessment, no further investigation is deemed necessary. If fails (but would pass with d = voussoir thickness) then trial holes would be made over the crown of the arch to determine the actual barrel thickness.

3 CALCULATIONS

The the modified MEXE calculation is mounted on CASIO FX-730P personal computers which are monitored under the County Council's quality assurance scheme.

ANALYSIS OF JACK ARCHES

ANALYSIS BY MODIFIED MEXE METHOD



THE DIMENSIONS A & B TO BE TAKEN ON SITE AND USED TO CALCULATE R.
THE IDEALISED r_c AND r_q TO BE CALCULATED USING R AND THE IDEALISED SPAN.
THE JACK ARCH THICKNESS TO BE DETERMINED BY REFERENCE TO PREVIOUS ASSESSMENT TRIAL HOLES OR BY NEW TRIAL HOLES OR OTHER SUITABLE METHODS

APPENDIX D

CUMBRIA COUNTY COUNCIL-CONSTRUCTION SERVICES
LOAD ASSESSMENT PROGRAMME FOR STRUCTURES
DESIGN BASIS STATEMENT - APPENDIX DBSC 1

STANDARD CODE OF PRACTICE AND REFERENCE DOCUMENTS USED FOR ASSESSMENT

APP.DBSC 1
PAGE.......of.......
REV No. ....
DATE:................

(Note: Erase references not applicable)

A. MANDATORY DOCUMENTS

		Dated
BD 16/82	Design of Composite Bridges - Use of BS 5400 Pt 5:1979	Nov 1982
	Amendment No. 1	Dec 1987
BD 24/92	The Design of Concrete Bridges - Use of BS 5400 : Pt 4: 1990	Nov 1992
BD 37/88	Loads for Highway Bridges	Aug 1989
BD 2/89	Technical Approval of Highway Structures on Motorways and Other Trunk Roads. Part 1 - General Procedures	Oct 1989
BS 5400	Steel, Concrete and Composite Bridges	
	Part 3: 1982 - CP for Design of Steel Bridges (see BD 13/90)	1982
	Part 4: 1990 - CP for Design of Concrete Bridges (see BD 24/92)	1990
	Part 5: 1979 - CP for Design of Composite Bridges (see BD16/82)	1979
BD 13/90	The Design of Steel Bridges - Use of BS 5400: Part 3: 1982	Feb 1991
BD 34/90	Technical Requirements for the Assessment and Strengthening Programme for Highway Structures - Stage 1 - Older, Short Span Bridges and Retaining Structures	Sept 1990
BD 44/95	The Assessment of Concrete Highway Bridges and Structures	Jan 1995
BD 52/93	The Design of Highway Bridge Parapets	April 1993
BD 48/93	The Assessment and Strengthening of Highway Bridge Supports	June 1993
BD 21/97	The Assessment of Highways Bridges and Structures	Feb 1997
	Amendment No. 1	Aug 1987
BD 63/94	The Inspection of Highway Structures	Oct 1994
BD 31/87	Buried Concrete Box Type Structures	Jan 1988

B. ADVICE NOTES AND OTHER REFERENCE DOCUMENTS

(Note: Add references as appropriate)

BA 39/93	Assessment of Reinforced Concrete Half Joints	April 1993
BA 32/89	Technical Approval of Highway structures on Motorways and other Trunk Roads. Part 1 - General Procedures	Oct 1989
BA 16/97	The Assessment of Highway Bridges and Structures	May 1997
	Amendment No. 1	Nov 1997
BA 55/94	The Assessment of Bridge Substructures and Foundations, Retaining Walls and Buried Structures	1994
	Amendment No. 1	Nov 1997
NNMD 34/61/8	Assessment of Buried Concrete Box Structures - HA Letter	29 May 1997
BA 63/94	The Inspection of Highway Structures	Oct 1994
BA 44/96	The Use of BD 44/95 - The Assessment of Concrete Highway Bridges and Structures	Nov 1996
BS 8110	Structural Use of Concrete	
	Part 1: Code of Practice for Design and Construction	March 1997
Bridge Inspection Guide (HMSO ISBN 0 11 550638 1)		1984

C. LIST ANY DEPARTURES FROM STANDARDS

(Note: To be fully documented in the Report)

British Railways Board **Group Standard**

FORM 'BA' (BRIDGES)

GC/TP0356
Appendix: 5
Issue: 1
Revision: A
Date: FEB 93

CERTIFICATION FOR ASSESSMENT CHECK

STRUCTURE/LINE NAME ..HILL COTTAGE...... CATEGORY OF CHECK ......2.

ELR/STRUCTURE NO. ...C37/87................

I certify that reasonable professional skill and care have been used in the assessment of the above structure with a view to securing that:

(1) It has been assessed in accordance with the Approval in Principle (where appropriate) as recorded on Form AA approved on ..8/1/98...... (DATE).

(2) It has been checked for compliance with the following principal British Standards, Codes of Practice, BR Technical notes and Assessment standards.

List any departures from the above, and additional methods or criteria adopted, with reference and justification for their acceptance (commenting on the results if appropriate).

CATEGORY 1

NAME SIGNATURE

[redacted]

(ASSESSOR) 5/10/99 (DATE)

(ASSESSMENT CHECKER) 3/11/99 (DATE)

PARTNER OF THE FIRM OF CONSULTING ENGINEERS TO WHOM ASSESSOR/ CHECKER IS RESPONSIBLE 3/11/99 (DATE)

CATEGORY 2 AND 3 (NOTE: CATEGORY 1 CHECK MUST ALSO BE SIGNED)

(a) ASSESSMENT

NAME SIGNATURE

[redacted]

(ASSESSOR) 5/10/99 (DATE)

BRB SECTION ENGINEER OR THE PARTNER IN FIRM OF CONSULTING ENGINEERS TO WHOM ASSESSOR IS RESPONSIBLE (DATE) 3/11/99

(b) CHECK

NAME SIGNATURE

[redacted]

(ASSESSMENT CHECKER) 3/11/99 (DATE)

BRB SECTION ENGINEER OR THE PARTNER IN FIRM OF CONSULTING ENGINEERS TO WHOM CHECKER IS RESPONSIBLE 3/11/99 (DATE)

THE CERTIFICATE IS ACCEPTED BY ..[redacted]................

British Railways Board | Group Standard

FORM 'BAA' (BRIDGES)

GC/TP0356
Appendix: 6
Issue: 1
Revision: A
Date: FEB 93

CERTIFICATION FOR ASSESSMENT CHECK

NOTIFICATION OF ASSESSMENT CHECK

STRUCTURE NAME/ROAD NO. HILL COTTAGE / U3129

LINE NAME KESWICK - PENRITH

ELR CODE/STRUCTURE NO. C37/87

The above bridge has been assessed and checked in accordance with Standards which are listed on the appended Form BA. A summary of the results of the assessment in terms of capacity and restrictions is as follows:

STATEMENT OF CAPACITY

3 tonnes

Critical member/s: EDGE BEAMS + TIE RODS

RECOMMENDED LOADING RESTRICTIONS

3T GVW

DESCRIPTION OF STRUCTURAL DEFICIENCIES AND RECOMMENDED STRENGTHENING

Name: [redacted] Structural Assessment Engineer

Name: Civil Engineer

INSPECTION AND SURVEY INFORMATION (WRITTEN REPORT)

ACTION

ASSESSMENT TO BD 21/97
INSPECTION AND SURVEY INFORMATION

SPECTION AND SURVEY INFORMATION

ACTION

ENERAL

ill Cottage Railway Bridge comprises of a 7.48m single span, cast iron beam and brick jack ch deck supported on stone masonry abutments, carrying the U3129 over a disused railway e 2.75km east of the village of Threlkeld.

e structure can be located at Ordnance Survey Reference NY 349 258.

spection of the structure was carried out on 23 July 1997 using a 7.5m aluminium extension dder. The weather was warm and sunny on the day of the inspection.

OUNDATIONS (Item No 1)

spection of the bridge did not reveal any undue signs of movement or settlement that would dicate any inadequacies in the foundations. It can therefore be assumed that the foundations e sound and that they are adequate to support the present imposed loading.

VERT/TRACKBED (Item No 2)

e original railway line and ballast had been recovered and the trackbed returned to ricultural use.

BUTMENTS (Item No 5)

e abutments were constructed from random coursed rockfaced sandstone masonry. Both of hich followed a satisfactory alignment. 5% of the mortar joints to both abutments were open inted or cracked randomly over the abutment area, no significant deterioration of the ndstone elements was noted (See Photo Nos 3 and 4). A 3mm wide vertical crack was present nning the full height of the north abutment (See Photo No 5) mainly in the mortar joints.

Repoint open/ cracked joints
Repoint cracked joints monitor for further movement

NGITUDINAL CAST IRON BEAMS (Item No 10)

was only possible to inspect the outside face of the edge beams and the underside of the ernal beams due to the nature of this type of jack arch construction.

e paint protection to all the visible faces of the cast iron beams was at the end of its life, owing surface corrosion to develop which was particularly heavy to the bottom flanges of the ams, no significant section loss was noted (See Photo No 6). Water staining and leachate posits were evident at random to varying extents to the underside of all the beams (See Photo 7).

Grit blast
Repaint beams

No tie rods were present to each of the end bays, all of which were intact but heavily corroded th a minimum section of 19mmϕ (See Photo No 8).

Grit blast
Repaint ties

ICK JACK ARCHES (Item No 15)	
e 5 No common brick jack arches spanning between the main longitudinal beams were all the ne construction and followed a good uniform profile.	
avy leachate staining was evident to the two edge jack arches that were below the soft verge as of the bridge (See Photo No 6). Apart from the occasional random isolated open or cked joint the first, second, third and fifth jack arches from the west were satisfactorily inted. The crown joint on the fourth jack arch from the west was largely unpointed and heavy chate deposits were emitting from the joint (See Photo No 9).	Repoint open joints
INGWALLS (Item No 6)	
ndom coursed rockfaced sandstone masonry wingwalls were provided to each corner of the ucture.	
ndom cracked and open joints were present throughout the S.W. wingwall, in particular in the ne of influence of the edge beam (See Photo No 10). The coping bed and perp joints were en or cracked for the majority of the wingwall length. The south end of the wingwall over a length was being displaced by up to 50mm (See Photo No 11) probably due to a nbination of passive earth pressure and the trees present behind the wall.	Repoint open/ cracked joints. Rebuild displaced section of wingwall
e N.W. wingwall followed a good alignment and was satisfactorily pointed apart from the casional isolated open or cracked joint. The copings to this wingwall were being displaced by to 100mm outwards (See Photo No 12).	Repoint open/ cracked joints. Rebed displaced copings
e S.E. wingwall followed a good alignment and was satisfactorily pointed apart from the casional isolated open or cracked joint. A small tree was becoming established within the ngwall construction 1.5m from the abutment face, 1.8m above ground level (See Photo No).	Repoint open/ cracked joints Remove tree
e N.E. wingwall followed a good alignment and was satisfactorily pointed. The copings were coming dislodged and vegetation was starting to become established in the joints (See Photo 14). Cracking up to 4mm wide was evident to the two courses of masonry below the north d of the west edge beam and in the mortar joints for two courses below this level (See Photo 15).	Rebed copings Remove vegetation Repoint cracked masonry/joints Monitor for further movement

INSPECTION AND SURVEY INFORMATION

ACTION

PARAPETS (Item No 24)

Random coursed rockfaced sandstone parapets with flat topped copings were provided to both ides of the structure.

The east parapet was leaning outwards by up to 75mm at mid span. Random cracked mortar oints were present throughout the parapet length with the occasional isolated open joint (See Photo No 16). Slippage down the curved edge of the beam has resulted in the mortar joints becoming cracked up to 4mm wide at the north end of the parapet (See Photo No 17).

Repoint open/ cracked joints
Monitor for further movement

The west parapet was leaning outwards by up to 100mm at mid span (See Photo No 18). The parapet was generally well pointed apart from the occasional random cracked or open joint.

Repoint open/ cracked joints

CARRIAGEWAY (Item No 21)

The surface dressed carriageway was found to be in a satisfactory condition over the bridge.

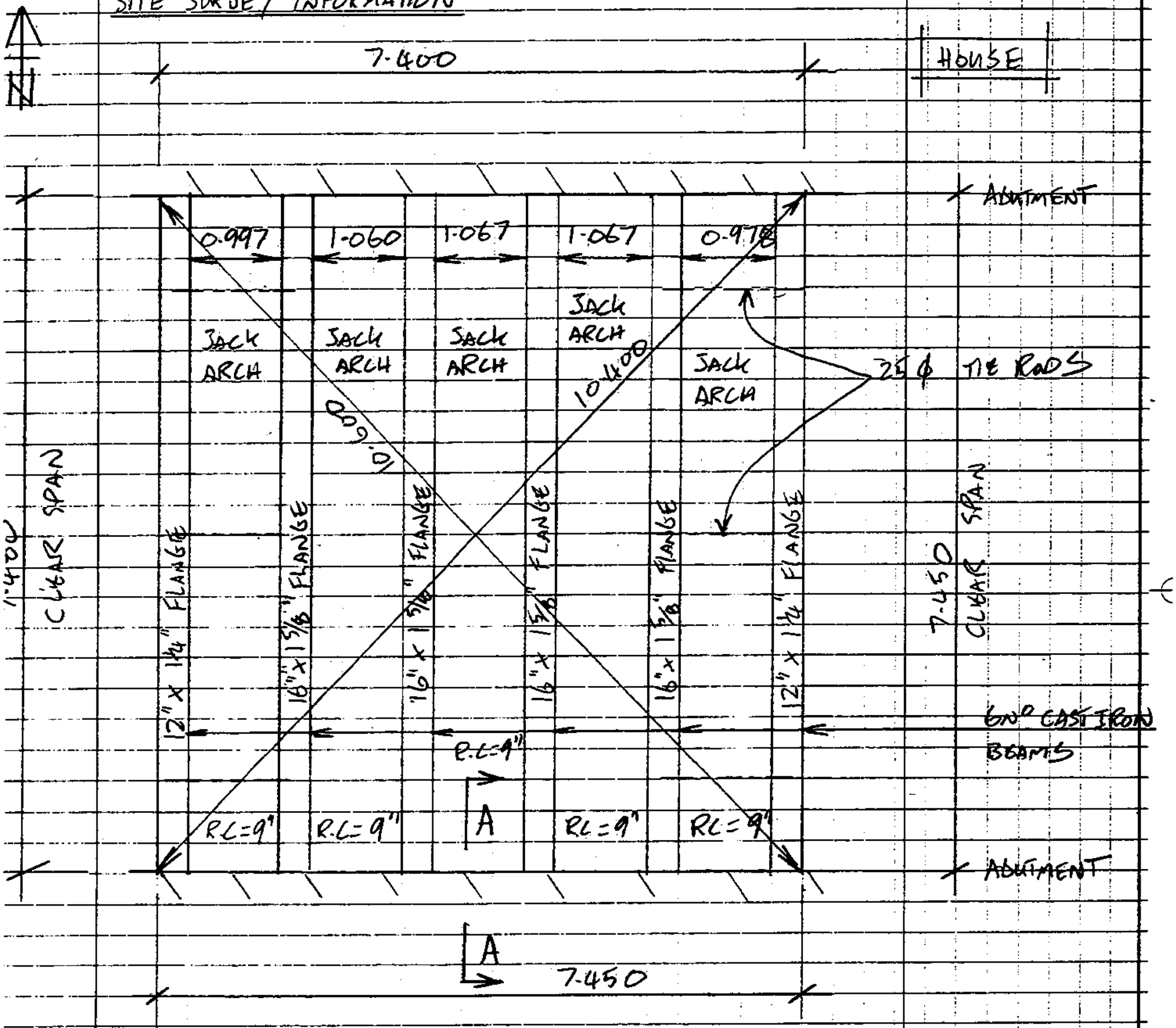
Cumbria County Council
CONSTRUCTION SERVICES
Consultancy & Design Work Sheet

Sheet No. 18
of 85 Sheets
Rev. No. 0

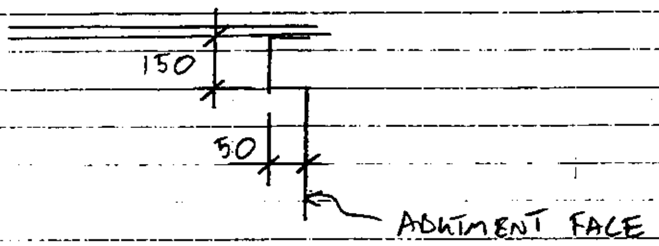
Scheme	Scheme Ref.	Date Prepared	Prepared by
BRITISH RAIL PROPERTY BOARD	C1461437	Aug 97	T.O
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
HILL COTTAGE RAILWAY BRIDGE	23342	Oct '99	[redacted]

CALCULATIONS / WORK | **Output / Remarks**

SITE SURVEY INFORMATION



DECK PLAN



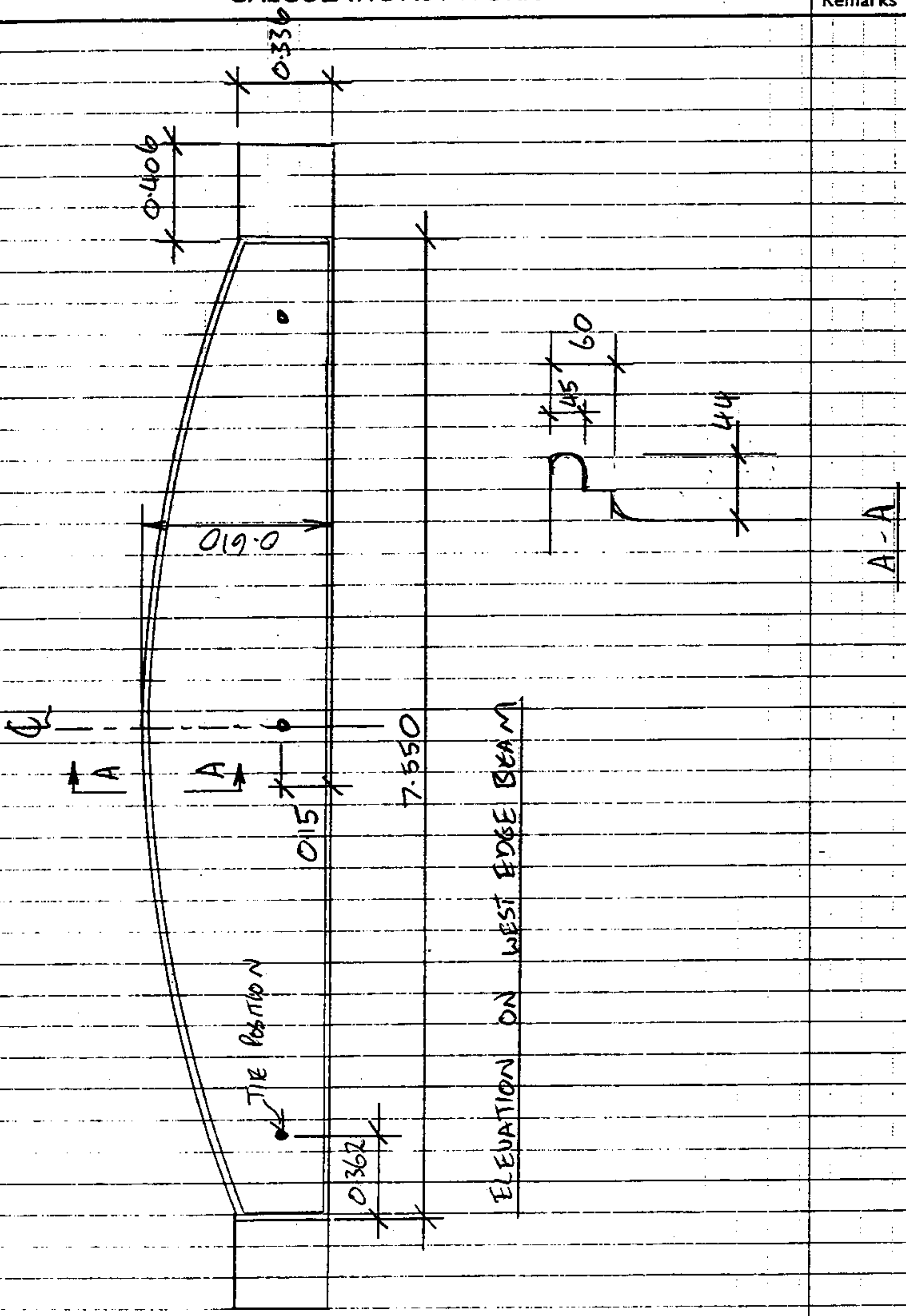
A - A

Cumbria County Council
CONSTRUCTION SERVICES
Consultancy & Design Work Sheet

Scheme BRITISH RAIL PROPERTY BOARD	Scheme Ref. C1461437	Date Prepared AUG 97	Sheet No. 19 of 85 Sheets Rev. No. 0
Element / Item HILL COTTAGE RAILWAY BRIDGE	Joblog No. 23342	Date Checked Oct '99	Prepared by T.O Checked by [redacted]

CALCULATIONS / WORK

Output / Remarks



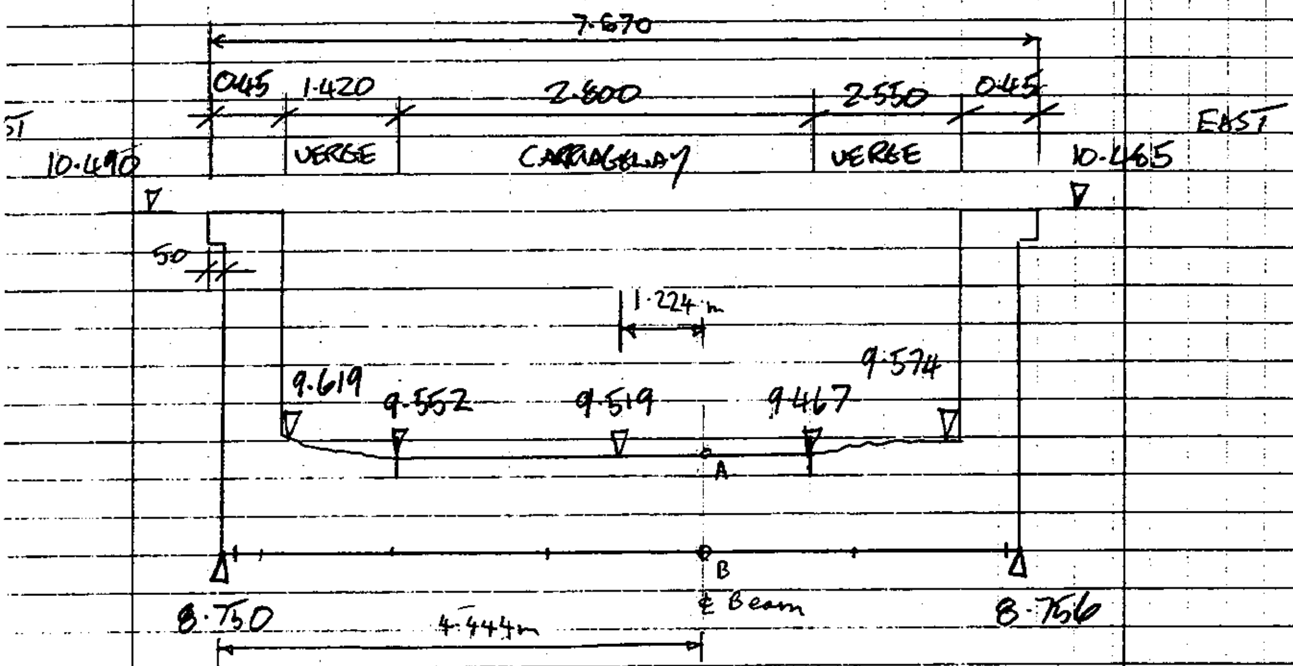
Cumbria County Council
CONSTRUCTION SERVICES
Consultancy & Design Work Sheet

Sheet No. 20
of 85 Sheets
Rev. No. 0

Scheme	Scheme Ref.	Date Prepared	Prepared by
BRITISH RAIL PROPERTY BOARD	C1461437	AUG 97	T.O
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
HILL COTTAGE RAILWAY BRIDGE	23342	Oct '99	[redacted]

CALCULATIONS / WORK

Output / Remarks



SQUARE CROSS-SECTION AT MID-SPAN

~~FOR INTERNAL GIRDERS, FIND MINIMUM OVERALL SECTION DEPTH~~

Level at A $= 9.519 - \frac{1.224}{1.400}(9.519 - 9.467)$

$= \underline{9.474 \text{ m}}$

Level at B $= 8.754$m

$\therefore H = 9.474 - 8.754$

$H = \underline{0.720\text{m}}$ (Overall Section Depth)

7.13
21/97

$D = H - 75\text{mm}$

$D = \underline{0.645\text{m}}$

d = depth of base girder at midspan

$= \underline{508 \text{ mm}}$

$\therefore$ Enhancement factor for internal beam $= \frac{D}{d} = 1.270$

No. C&D C/DES1 Rev A (5/96)

ASSESSMENT TO BD 21/97
CALCULATIONS

CONSULTANCY & DESIGN

CUMBRIA COUNTY COUNCIL - CONSTRUCTION SERVICES

ROUTE No: U3129 STR NAME: HILL COTTAGE RAILWAY BRIDGE

LOAD ASSESSMENT PROGRAMME FOR BRITISH RAIL PROPERTY BOARD STRUCTURES DESIGN BASIS STATEMENT AND CALCULATIONS FIRST SHEET

Sheet No: 22
of 65 sheets
Rev No: 0

Date Prepared: Oct '99
Prepared by: [redacted]

Date Checked: Oct '99
Checked by: P.H.

. **NAME OF ASSESSOR** [redacted]

. **NAME OF CHECKER**

. **CHECK CATEGORY** C2/I
(MS-04/03)

. **PURPOSE OF CALCULATIONS**
BD 21/97 ASSESSMENT FOR:- a) C & U VEHICULAR LOADING
b) PROPOSED EC 40T LOADING

ASSESSMENT OF TYPE HB LOADING CAPACITY FOR A SINGLE VEHICLE ON THE BRIDGE ONLY (WITH THE EXCEPTION OF MASONRY ARCH BRIDGES AND ALL U ROAD BRIDGES)

. **STANDARDS, CODES OF PRACTICE AND REFERENCE DOCUMENTS USED FOR ASSESSMENT** *(Erase as appropriate)*
SEE APPENDIX DBSC1 OVERLEAF
SEE APPROVAL IN PRINCIPLE FORM ~~TA1~~ AA

. **SOURCES OF INPUT DATA**
SITE SURVEY AND INSPECTION DATA
RECORD DRAWINGS - C37/87 & C37/94 IN APPENDIX.

. **DESCRIPTION OF METHODS OF ANALYSIS AND DETAILS OF COMPUTER PROGRAMS USED**
SCALE PROGRAM 650 (SECTIONAL PROPERTIES)
SIMPLE DISTRIBUTION METHODS TO BA 16/97.
"THE STRENGTH OF CAST IRON BRIDGES" - REF 6 BD21/97.

. **REVIEW AND VERIFICATION OF ASSESSMENT BY TEAM LEADER**
The assessment output meets above requirements

Signed [redacted] Date 3 Nov 99

Name

Comments ....

....

CUMBRIA COUNTY COUNCIL - CONSTRUCTION SERVICES
LOAD ASSESSMENT PROGRAMME FOR STRUCTURES
DESIGN BASIS STATEMENT - APPENDIX DBSC 1

APP.DBSC 1
PAGE 23 of 85
REV No. 0
DATE:Oct 99

STANDARD CODE OF PRACTICE AND REFERENCE DOCUMENTS USED FOR ASSESSMENT

(Note: Strike out references not applicable)

MANDATORY DOCUMENTS		**Dated**
~~BD 16/82~~	~~Design of Composite Bridges - Use of BS 5400 Pt 5:1979~~	~~Nov 1982~~
	~~Amendment No. 1~~	~~Dec 1987~~
~~BD 24/92~~	~~The Design of Concrete Bridges - Use of BS 5400 : Pt 4: 1990~~	~~Nov 1992~~
~~BD 37/88~~	~~Loads for Highway Bridges~~	~~Aug 1989~~
~~BD 2/89~~	~~Technical Approval of Highway Structures on Motorways and Other Trunk Roads. Part 1 - General Procedures~~	~~Oct 1989~~
~~BS 5400~~	~~Steel, Concrete and Composite Bridges~~	
	~~Part 3: 1982 - CP for Design of Steel Bridges (see BD 13/90)~~	~~1982~~
	~~Part 4: 1990 - CP for Design of Concrete Bridges (see BD 24/92)~~	~~1990~~
	~~Part 5: 1979 - CP for Design of Composite Bridges (see BD16/82)~~	~~1979~~
~~BD 13/90~~	~~The Design of Steel Bridges - Use of BS 5400: Part 3: 1982~~	~~Feb 1991~~
~~BD 34/90~~	~~Technical Requirements for the Assessment and Strengthening Programme for Highway Structures - Stage 1 - Older, Short Span Bridges and Retaining Structures~~	~~Sept 1990~~
~~BD 44/95~~	~~The Assessment of Concrete Highway Bridges and Structures~~	~~Jan 1995~~
~~BD 52/93~~	~~The Design of Highway Bridge Parapets~~	~~April 1993~~
~~BD 48/93~~	~~The Assessment and Strengthening of Highway Bridge Supports~~	~~June 1993~~
BD 21/97	The Assessment of Highways Bridges and Structures	Feb 1997
	Amendment No. 1	Aug 1997
BD 63/94	The Inspection of Highway Structures	Oct 1994
~~BD 31/87~~	~~Buried Concrete Box Type Structures~~	~~Jan 1988~~
ADVICE NOTES AND OTHER REFERENCE DOCUMENTS		
(Note: Add references as appropriate)		
~~BA 39/93~~	~~Assessment of Reinforced Concrete Half Joints~~	~~April 1993~~
~~BA 32/89~~	~~Technical Approval of Highway structures on Motorways and other Trunk Roads. Part 1 - General Procedures~~	~~Oct 1989~~
BA 16/97	The Assessment of Highway Bridges and Structures	May 1997
	Amendment No. 1	Nov 1997
~~BA 55/94~~	~~The Assessment of Bridge Substructures and Foundations, Retaining Walls and Buried Structures~~	~~1994~~
	~~Amendment No. 1~~	~~Nov 1997~~
~~NNMD 34/61/8~~	~~Assessment of Buried Concrete Box Structures - HA Letter~~	~~29 May 1997~~
BA 63/94	The Inspection of Highway Structures	Oct 1994
~~BA 44/96~~	~~The Use of BD 44/95 - The Assessment of Concrete Highway Bridges and Structures~~	~~Nov 1996~~
~~BS 8110~~	~~Structural Use of Concrete~~	
	~~Part 1: Code of Practice for Design and Construction~~	~~March 1997~~
Bridge Inspection Guide (HMSO ISBN 0 11 550638 1)		1984

LIST ANY DEPARTURES FROM STANDARDS

(Note: To be fully documented in the Report)

Cumbria County Council
Design & Business Services

Design Services Work Sheet

Sheet No. 24
of 85 Sheets
Rev. No. 0
Prepared by [redacted]
P.H

Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99
Element / Item Index	Joblog No. 23342	Date Checked Oct '99

CALCULATIONS / WORK

Output / Remarks

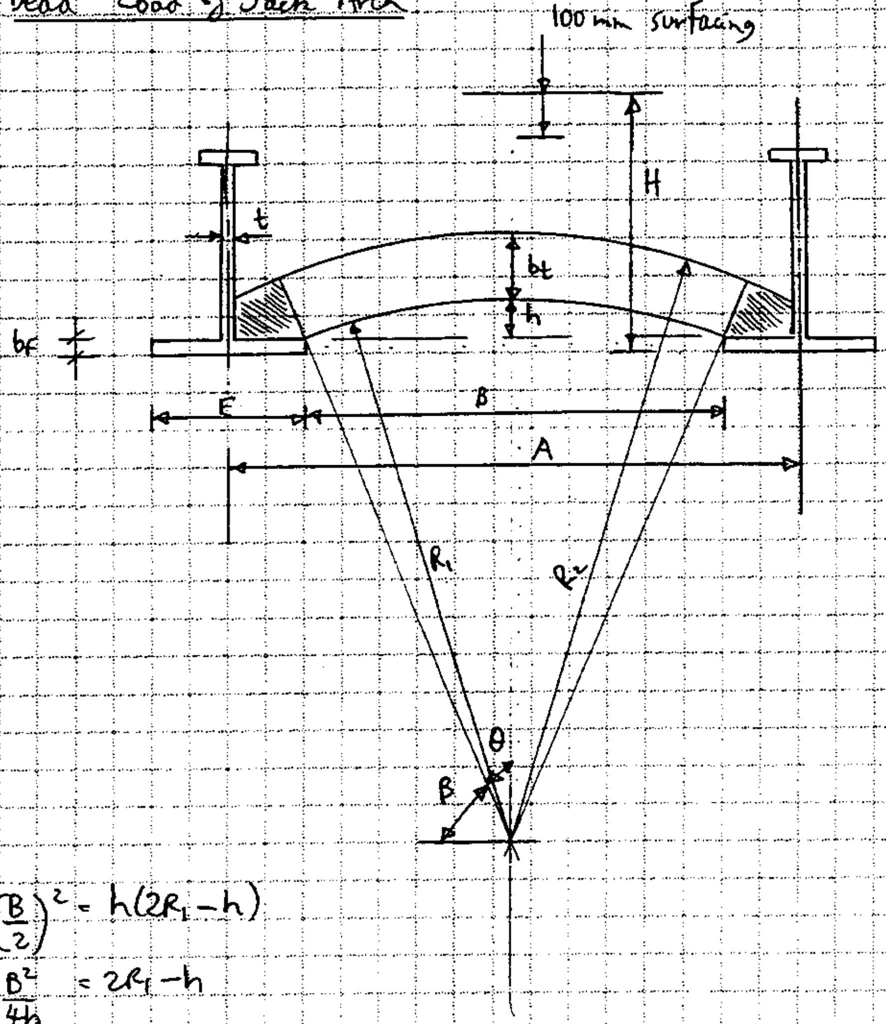
Index of calculations

Cumbria County Council		Design & Business Services		Sheet No. 25 of 85 Sheets Rev. No. 0
Design Services Work Sheet				
Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99		Prepared by [redacted]
Element / Item Dead Load of Jack Arch	Joblog No. 23342	Date Checked Oct '99		Checked by P.H

CALCULATIONS / WORK

Output / Remarks

Dead Load of Jack Arch



$$\left(\frac{B}{2}\right)^2 = h(2R_1 - h)$$

$$\frac{B^2}{4h} = 2R_1 - h$$

$$2R_1 = h + \frac{B^2}{4h}$$

$\frac{B}{2} = 531.8$ mm from spreadsheet

$h = 184.15$ mm

$$R_1 = \frac{h}{2} + \frac{B^2}{8h}$$

$$R_1 = \frac{184.15}{2} + \frac{(531.8 \times 2)^2}{8 \times 184.15}$$

$$= 92.07 + 767.88$$

$$= \underline{860.0 \text{ mm}}$$

$\therefore R_2 = 860 + 228.6 = \underline{1088.6 \text{ mm}}$

$$\tan\theta = \frac{(B/2)}{R_1 - h}$$

$$= \frac{531.8}{860 - 184.15}$$

$$= 0.78686$$

$$\underline{\theta = 38.198^\circ}$$

Area of Jack Arch (between radial lines)

$$= \pi\left(R_2^2 - R_1^2\right)\theta/180$$

$$= \pi\left(1088.6^2 - 860^2\right) 38.198/180$$

$$= \underline{296\,973 \text{ mm}^2}$$

Cumbria County Council | Design & Business Services

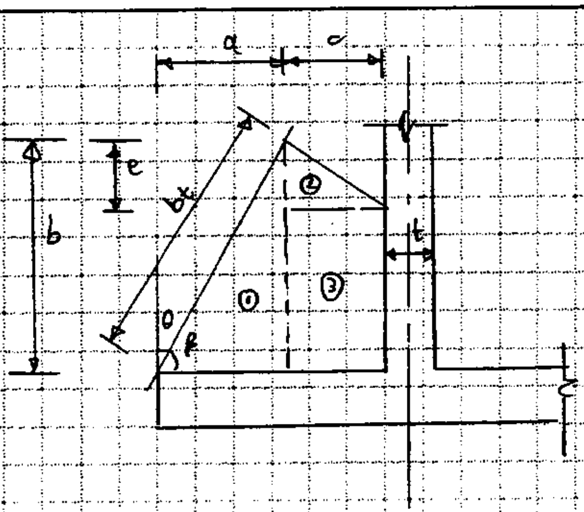
Design Services Work Sheet

Scheme: Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99	Prepared by [redacted]
Element / Item: Dead Load of Jack Arch	Joblog No. 23342	Date Checked Oct '99	Checked by P.H

Sheet No. 26 of 85 Sheets
Rev. No. 0

CALCULATIONS / WORK

Output / Remarks



$$c = \left(\frac{E-t}{2}\right) - a$$

$$= \left(\frac{E-t}{2}\right) - b_t \cos\beta$$

$$e = \frac{c}{\tan\beta}$$

$\frac{-a}{b_t}$

area ① $= \left(b_t \cos\beta \times b_t \sin\beta \times 0.5\right) = \underline{0.5\, b_t^2 \cos\beta \sin\beta}$

$\frac{b}{b_t}$

area ② $= ce/_2$

$$= \frac{c^2}{2\tan\beta}$$

area ② $= \left(\frac{E-t}{2} - b_t \cos\beta\right)^2 \cdot \frac{1}{2\tan\beta}$

area ③ $= (b-e)c = \left(b_t \sin\beta - \frac{c}{\tan\beta}\right)c$

$\beta = 90° - \theta_1$
$= 90° - 38.198°$
$= \underline{51.802}°$

Area ① $= 0.5 \times 228.6^2 \times 0.61838 \times 0.78588$

$= \underline{12698\ mm^2}$

$\cos\beta = 0.61838$
$\sin\beta = 0.78588$
$\tan\beta = 1.27086$

Area ② $= \left(\left(\frac{406.4 - 38.1}{2}\right) - 228.6 \times 0.61838\right)^2 \cdot \frac{1}{2 \times 1.27086}$

$= \frac{(184.15 - 141.36)^2}{2.54172}$

$= \underline{720.4\ mm^2}$

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. 27 of 85 Sheets
Rev. No. 0

Scheme: Hill Cottage Railway Bridge
Scheme Ref.: C461437
Date Prepared: Oct '99
P [redacted]
Element / Item: Dead Load of Jack Arch
Joblog No.: 23342
Date Checked: Oct '99
Checked by: PH

Output / Remarks

CALCULATIONS / WORK

$$c = \left(\frac{E-t}{2}\right) - b_t \cos\beta$$

$$= \left(\frac{406{\cdot}4 - 38{\cdot}1}{2}\right) - 229{\cdot}6 \times 0{\cdot}61838$$

$$= 184{\cdot}15 - 141{\cdot}36$$

$$= \underline{42{\cdot}79\ \text{mm}}$$

$$\text{Area ③} = \left(228{\cdot}6 \times 0{\cdot}78588 - \frac{42{\cdot}79}{1{\cdot}27086}\right) 42{\cdot}79$$

$$= (179{\cdot}65 - 33{\cdot}67)\ 42{\cdot}79$$

$$= \underline{6247\ \text{mm}^2}$$

∴ Area of jack arch over flange = 2(Areas ① + ② + ③)

$$= 2(12698 + 720 + 6247)$$

$$= \underline{39330\ \text{mm}^2}$$

∴ Total Area of Jack Arch = 296973 + 39330

$$= \underline{336303\ \text{mm}^2}$$

Cumbria County Council | Design & Business Services

Design Services Work Sheet

Sheet No. 28
of 85 Sheets
Rev. No. 0

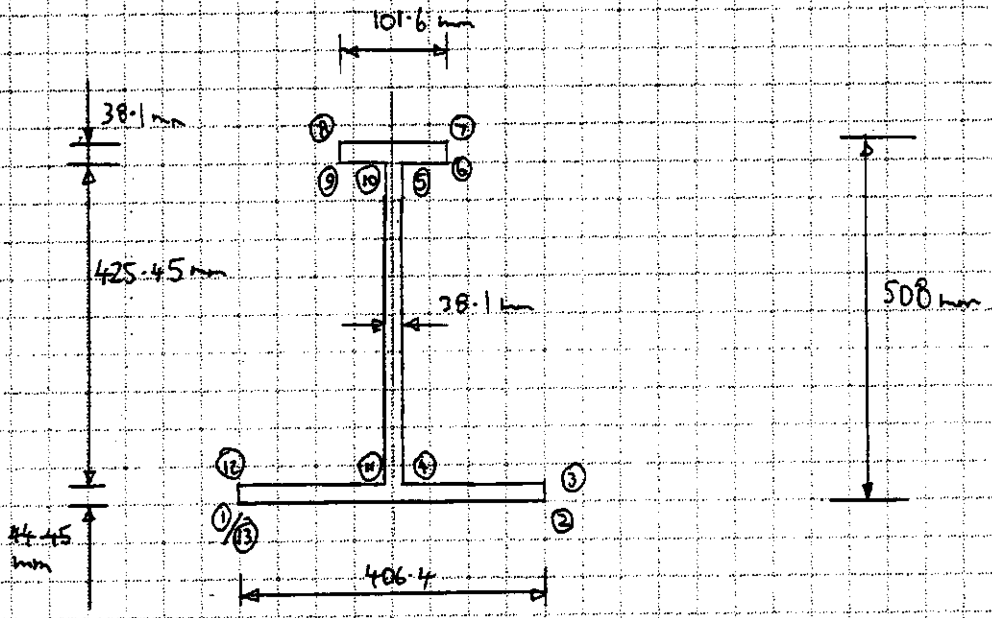
Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99	Prepared by [redacted]
Element / Item Section Properties of Beam.	Joblog No. 23342	Date Checked Oct '99	Checked by P.H

CALCULATIONS / WORK

Output / Remarks

Section Properties of Cast Iron Beam (Internal)

GROSS SECTION



(20")

Scale program 650 (Sectional Properties)

See output, Cast Iron Beam Area $A = 38145\ mm^2$

Neutral axis above base, $Y_b = 169.43$ mm

Second Moment of Area, $I_{xx} = 1.1594 \times 10^9\ mm^4$

Details of Beam - refer to Drg No C37/87 in the Appendix - then refers to Drg No C37/94 (also in the Appendix)

U3129 HILL COTTAGE RAILWAY BRIDGE No. 87
LONGITUDINAL BEAMS (CI) SECTION PROPERTIES
INTERNAL BEAM (GROSS-SECTION)

Page: 1
Made by: PH
Date: 01.10.99
Ref No:

Office: 5598

Location: INTERNAL BEAM @Midspan=508mm

Properties of any plane section

The section is defined by coordinates of corner points taken in anti-clockwise order round the section. The cross section is kept to the left of the edge running from a previous point to the next point. The section is closed when the original point is specified again.

Coordinates of points in order:

Point 1	: X-coordinate	x(1)=0 mm
	Y-coordinate	y(1)=0 mm
Point 2	: X-coordinate	x(2)=406.4 mm
	Y-coordinate	y(2)=0 mm
Point 3	: X-coordinate	x(3)=406.4 mm
	Y-coordinate	y(3)=44.45 mm
Point 4	: X-coordinate	x(4)=222.25 mm
	Y-coordinate	y(4)=44.45 mm
Point 5	: X-coordinate	x(5)=222.25 mm
	Y-coordinate	y(5)=469.9 mm
Point 6	: X-coordinate	x(6)=254 mm
	Y-coordinate	y(6)=469.9 mm
Point 7	: X-coordinate	x(7)=254 mm
	Y-coordinate	y(7)=508 mm
Point 8	: X-coordinate	x(8)=152.4 mm
	Y-coordinate	y(8)=508 mm
Point 9	: X-coordinate	x(9)=152.4 mm
	Y-coordinate	y(9)=469.9 mm
Point 10	: X-coordinate	x(10)=184.15 mm
	Y-coordinate	y(10)=469.9 mm
Point 11	: X-coordinate	x(11)=184.15 mm
	Y-coordinate	y(11)=44.45 mm
Point 12	: X-coordinate	x(12)=0 mm
	Y-coordinate	y(12)=44.45 mm
Point 13	: X-coordinate	x(13)=0 mm
	Y-coordinate	y(13)=0 mm

Sectional properties

Cross-sectional area	38145 mm^2

U3129 HILL COTTAGE RAILWAY BRIDGE No. 87
LONGITUDINAL BEAMS (CI) SECTION PROPERTIES
INTERNAL BEAM (GROSS - SECTION)

Page: 2
Made by: PH
Date: 01.10.99
Ref No:

Office: 5598

Second moments of area (inertias) $I_{xx}=1.1594E+9$ mm^4
$I_{yy}=253919597$ mm^4

Product of inertia $\int dA.xy$ $I_{xy}=0.71526E-6$ mm^4

Distance of centroid from origin X=203.2 mm
Y=169.43 mm

X and Y are principal axes.

No650

$$Z_t = \frac{I_{xx}}{169.43}$$

$$= \frac{1.1594 \times 10^9}{169.43}$$

$$= \underline{6842944 \text{ mm}^3}$$

$$Z_c = \frac{I_{xx}}{(508-169.43)}$$

$$= \frac{1.1594 \times 10^9}{338.57}$$

$$= \underline{3424403 \text{ mm}^3}$$

Cumbria County Council		Design & Business Services	Sheet No. 31 of 85 Sheets Rev. No. 0
Design Services Work Sheet			
Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99	Prepared by [redacted]
Element / Item Section Properties of Beam	Joblog No. 23342	Date Checked Oct '99	Checked by P.H.

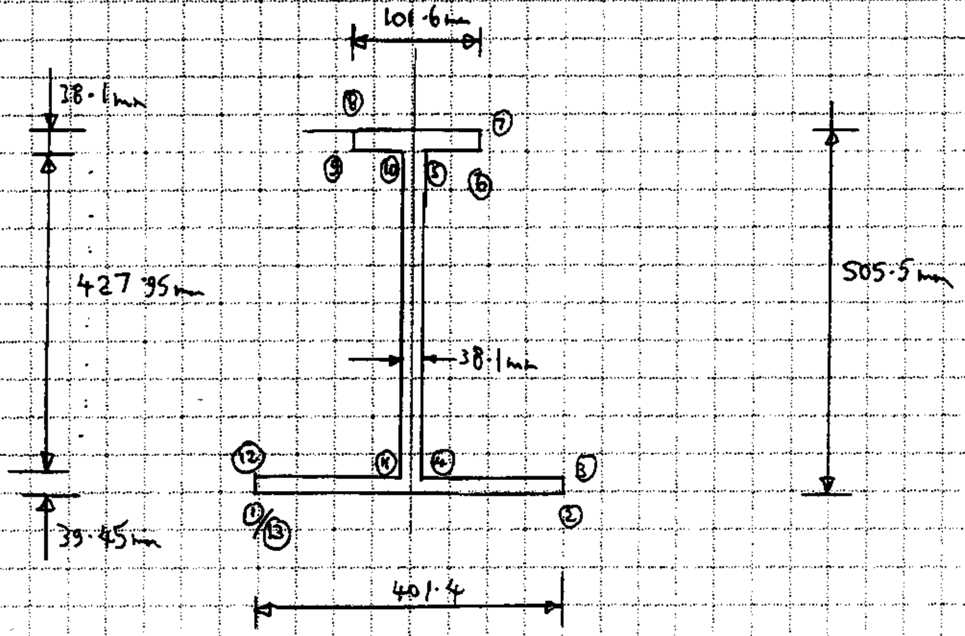
CALCULATIONS / WORK | Output / Remarks

Section Properties of Cast Iron Beam (Internal)

NETT - SECTION

Agreed with Client that Nett Section (Corroded)

- take off 2.5mm around perimeter of bottom flange from Gross Section.



Scale Program 650 (Sectional Properties)

See output, Cast Iron Beam Area = 36011 mm^2

Neutral axis above base, Y_b = 175.71 mm

Second Moment of Area, I_{xx} = 1.1089×10^9 mm^4

No. C&D C/DES1 REV C (6/99)

U3129 HILL COTTAGE RAILWAY BRIDGE No. 87
LONGITUDINAL BEAMS (CI) SECTION PROPERTIES
INTERNAL BEAM (NETT SECTION)

Page: 1
Made by: PH
Date: 01.10.99
Ref No:

Office: 5598

Location: INTERNAL BEAM @ Midspan=505.5mm

Properties of any plane section

The section is defined by coordinates of corner points taken in anti-clockwise order round the section. The cross section is kept to the left of the edge running from a previous point to the next point. The section is closed when the original point is specified again.

Coordinates of points in order:

Point 1	: X-coordinate	x(1)=0 mm
	Y-coordinate	y(1)=0 mm
Point 2	: X-coordinate	x(2)=401.4 mm
	Y-coordinate	y(2)=0 mm
Point 3	: X-coordinate	x(3)=401.4 mm
	Y-coordinate	y(3)=39.45 mm
Point 4	: X-coordinate	x(4)=219.75 mm
	Y-coordinate	y(4)=39.45 mm
Point 5	: X-coordinate	x(5)=219.75 mm
	Y-coordinate	y(5)=467.4 mm
Point 6	: X-coordinate	x(6)=251.5 mm
	Y-coordinate	y(6)=467.4 mm
Point 7	: X-coordinate	x(7)=251.5 mm
	Y-coordinate	y(7)=505.5 mm
Point 8	: X-coordinate	x(8)=149.9 mm
	Y-coordinate	y(8)=505.5 mm
Point 9	: X-coordinate	x(9)=149.9 mm
	Y-coordinate	y(9)=467.4 mm
Point 10	: X-coordinate	x(10)=181.65 mm
	Y-coordinate	y(10)=467.4 mm
Point 11	: X-coordinate	x(11)=181.65 mm
	Y-coordinate	y(11)=39.45 mm
Point 12	: X-coordinate	x(12)=0 mm
	Y-coordinate	y(12)=39.45 mm
Point 13	: X-coordinate	x(13)=0 mm
	Y-coordinate	y(13)=0 mm

Sectional properties

Cross-sectional area 36011 mm^2

U3129 HILL COTTAGE RAILWAY BRIDGE No. 87
LONGITUDINAL BEAMS (CI) SECTION PROPERTIES
INTERNAL BEAM (NETT SECTION)

Page: 2
Made by: PH
Date: 01.10.99
Ref No:

Office: 5598

Second moments of area (inertias) $Ixx=1.1089E+9$ mm^4
$Iyy=217919155$ mm^4

Product of inertia $\int dA.xy$ $Ixy=-0.47684E-6$ mm^4

Distance of centroid from origin $X=200.7$ mm
$Y=175.71$ mm

X and Y are principal axes.

No650

$$Z_t = I_{xx}/175{\cdot}71$$

$$= \frac{1{\cdot}1089 \times 10^9}{175{\cdot}71}$$

$$= \underline{6310967 \text{ mm}^3}$$

$$Z_c = I_{xx}/(505{\cdot}5 - 175{\cdot}71)$$

$$= \frac{1{\cdot}1089 \times 10^9}{329{\cdot}79}$$

$$= \underline{3362443 \text{ mm}^3}$$

Cumbria County Council
Design & Business Services

Design Services Work Sheet

Sheet No. 34
of 85 Sheets
Rev. No. 0

Scheme U3129 Hill Cottage
Scheme Ref. C1461437
Date Prepared Oct '99
Prepared by [redacted]

Element / Item Live Loading
Joblog No. 23342
Date Checked Oct '99
Checked by P.H

CALCULATIONS / WORK

Output / Remarks

Clear span = 7.480m

BD 44/95 Clause 5.3.1.1 Effective span

(c) the distance between the centroids of the bearing pressure diagrams

— depth of beam (internal) at mid-span is 508mm

∴ effective span = $\frac{2\times508}{3} + 7480$

= $\underline{7.82\text{m}}$

Carriageway width = 2.80m

No. of notional lanes = 1 No.

Nom HA udl W = $336\left(\frac{1}{7.82}\right)^{0.67}$

= $\underline{84.70 \text{ kN/m}}$

Nom KEL / lane = 120kN

Adjustment factor for loaded length < 20m = 1.46

Adjusted UDL = $\frac{84.70}{1.46}$ = 58.01 kN/m per lane (of 2.5m width)

" KEL = $\frac{120}{1.46}$ = 82.19 kN / lane —"—

$$M_u = \frac{wl^2}{8} + \frac{Wl}{4}$$

$$= \frac{58.01 \times 7.82^2}{8} + \frac{82.19 \times 7.82}{4}$$

$$= 443.43 + 160.68$$

= $\underline{604.11 \text{ kN m} / 2.5\text{m lane}}$

ESIGN
ERVICES

Cumbria County Council
Design & Business Services

Design Services Work Sheet

Sheet No. 35
of 85 Sheets
Rev. No. 0

Scheme: U3129 Hill Cottage
Scheme Ref.: C1461437
Date Prepared: Oct '99.
Prepared by: [redacted]

Element / Item: Simple Distribution Methods to BA 16/97
Joblog No.: 23342
Date Checked: Oct '99
Checked by: P.H

de

CALCULATIONS / WORK

Output / Remarks

ause 2.8
A 16/97

$S_U = \frac{wl}{2} = \frac{58.01 \times 7.82}{2} = 226.82$ kN / 2.5m lane

$S_K = 82.19$ kN / 2.5m lane

7 16/97
l 2.6.

Simple Distribution Methods

Girder spacing = 1.47m (see sheet 18 = 1067 mm + 16 inches = 1473 m)

Effective span = 7.82m

Graph a) Single lane loading

$K_L = 0.32$

$M_{LL} = 604.11$ kNm

$M_{LL}' = 604.11 \times 0.32 = \underline{193.32 \text{ kNm}}$ (Moment due to full HA loading)

193.32 kNm input into spreadsheet

l 2.8

Nominal shear on longitudinal member ≥ 2m

$S_L = K_L S_U + 0.5 S_K$

where S_L = shear on longitudinal members (kN)

K_L = appropriate proportion factor from Fig 2/2.

S_U = gross shear of one 2.5m notional lane of UDL (kN)

S_K = Value of KEL for one 2.5m notional lane (kN)

$$S_L = \left(\frac{Wl}{2}\right)K_L + 0.5 \times 82.19$$

$$= \left(\frac{58.01 \times 7.82}{2}\right) \times 0.32 + 41.10$$

$$= \underline{113.68 \text{ kN}}$$

113.68 kN input into spreadsheet

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PROJECT : BRITISH RAIL PROPERTY BOARD ASSESSMENTS 99/00
BRIDGE : HILL COTTAGE RAILWAY **Bridge No : 87**
Assessor :PH **Ref : 23342**

Internal Beam

Structure File	Clear Span	[redacted]	m
P. 1	Effective span	7.82	m
	Overall Section Depth H	720.00	mm
	Depth less 100 surfacing	620.00	mm
	Section Depth D	[redacted]	mm
	Girder Spacing	[redacted]	mm
	Top Flange Width	[redacted]	mm
	Top Flange Thickness	[redacted]	mm
	Bottom Flange Width	[redacted]	mm
	Web thickness	[redacted]	mm
	Web Depth	[redacted]	mm
	Beam Depth	[redacted]	mm
	B/2	531.80	mm
	Soffit lower flange to crown	[redacted]	mm
	Bottom Flange thickness b_f	[redacted]	mm
	h	184.15	mm
	R_1	859.96	mm
	$C = R_1 - h$	675.81	mm
	Barrel thickness b_t	[redacted]	mm
	R_2	1088.56	mm
	Tan Q_1	0.786910109	
	Q_1	[redacted]	°
	Area of Internal Beam	0.038145	m^2
	Pi	[redacted]	
Area of Jack arch	(between radial lines)	296972.27	mm^2
	Area of Jack arch over flange	39330.00	mm^2
	Total area of Jack arch	0.336302	m^2
	Area of Segment	0.133654	m^2
	Area of filling (concrete)	0.356021	m^2
	Area of surfacing	0.147000	m^2
BD 21/97	**UNIT WEIGHTS**		
Table 4.2	Cast Iron	[redacted]	kg/m^3
	Concrete	[redacted]	kg/m^3
	Surfacing	[redacted]	kg/m^3
	Engineering Brick	[redacted]	kg/m^3
	Conversion Factor	0.009807	

PROJECT : BRITISH RAIL PROPERTY BOARD ASSESSMENTS 99/00
BRIDGE : HILL COTTAGE RAILWAY **Bridge No : 87**
Assessor :PH **Ref : 23342**

ASSESSMENT PERMANENT LOAD EFFECTS

	Assessment Loads	Area	Density (KN/m$^{3)}$	UDL (KN/m)
BD 21/97	* Surfacing	0.147000	23.54	5.19
	S/W Beam	0.038145	70.61	2.69
	Jack Arch	0.336302	23.54	7.92
	Fill (Concrete)	0.356021	23.54	8.38
			W =	**24.18**

* For surfacing, mutiply udl by 1.5

Maximum BM	DL+SDL =	**184.77**	KN.m
Maximum SF	DL+ SDL=	**94.53**	KN

GROSS CROSS SECTION PROPERTIES

	Cast Iron Beam Area	A	[redacted]	mm^2
	Overall Beam Depth		[redacted]	mm
Scale Output	Neutral axis above base	Y_b	[redacted]	mm
		Y_t	338.57	
Scale Output	Second Moment of Area	I_{xx}	[redacted]	mm^4
	Section Modulus Top	Z_c	3424402.63	mm^3
	Section Modulus Bottom	Z_t	6842943.99	mm^3
BD 21/97 Cl 7.13	Enhancement Factor (D/d)		1.27	
	Section Modulus Top	Z'_c	4347912.794	mm^3
	Section Modulus Bottom	Z'_t	8688383.608	mm^3

STRESSES DUE TO PERMANENT LOADS

Tensile	f_d	27.00	N/mm^2
Compressive	f_d	53.96	N/mm^2
Shear	q_d	5.83	N/mm^2

STRESSES AVAILABLE FOR LIVE LOADING

		Permissible Working Stresses		
BD21/97	Tensile	[redacted]	19.00	N/mm^2
	Compressive	[redacted]	100.04	N/mm^2
	Shear	[redacted]	40.17	N/mm^2

However, these available stresses are subject to Clauses 4.10 and 4.11 as shown below

PERMISSIBLE LIVE LOAD STRESSES

BD21/97 Cl. 4.10	$24.6 - 0.44f_d$	Tensile	f_l	**12.72**	N/mm^2
	$19.6 - 0.76f_d$			-0.92	N/mm^2
Cl 4.10	$0.79f_d - 43.9$	Compressive	f_l	**-86.53**	N/mm^2
	$3.15f_d - 81.3$			-251.26	N/mm^2
Cl. 4.11	$24.6 - 0.44q_d$	Shear	q_l	**22.03**	N/mm^2

LIVE LOAD BM & SHEAR FORCE (HA $_{kel + udl}$)

BA16/97	Bending Moment	[redacted]	KN.m
Sheet 31	Shear Force	[redacted]	KN

STRESSES DUE TO LIVE LOAD

			Gross Cross Section CASE 1 With Enhancement	CASE 2 No Enhancement	
BD21/97	Tensile	f_l'	22.25	28.25	N/mm^2
Fig 5/4	k factor		0.57	0.45	
	Assessment Rating		[redacted]	[redacted]	
	Compressive	f_l'	44.46	56.45	N/mm^2
	k factor		1.95	1.53	
	Assessment Rating		[redacted]	[redacted]	
	Shear	$q_l' =$	7.01	7.01	N/mm^2
	Assessment Rating		[redacted]	[redacted]	

NETT (CORRODED) CROSS SECTION PROPETIES

Scale	Nett Cross Section Area	A	[redacted]	mm^2
Scale	Overall Beam Depth		[redacted]	mm
Scale	Neutral axis above base	Y_b	[redacted]	mm
		Y_t	329.79	mm
	Second Moment of Area	I_{xx}	[redacted]	mm^4
	Section Modulus Top	Z_c	3362442.77	mm^3
	Section Modulus Bottom	Z_t	6310966.93	mm^3
BD 21/97	Enhancement Factor (D/d)		1.27	
Cl 7.13	Section Modulus Top	Z'_c	4269243.277	mm^3
	Section Modulus Bottom	Z'_t	8012940.3	mm^3

STRESSES DUE TO PERMANENT LOADS

Tensile	f_d	29.28 N/mm^2
Compressive	f_d	54.95 N/mm^2
Shear	q_d	5.83 N/mm^2

STRESSES AVAILABLE FOR LIVE LOADING

BD 21/97

	Permissible Working Stresses	
Tensile	[redacted]	16.72 N/mm^2
Compressive		99.05 N/mm^2
Shear		40.17 N/mm^2

However, these available stresses are subject to Clauses 4.10 and 4.11 as shown below

PERMISSIBLE LIVE LOAD STRESSES

BD 21/97 Cl 4.10	Tensile	f_l'	$24.6 - 0.44*f_d$	**11.72** N/mm^2
			$19.6 - 0.76*f_d$	6.72 N/mm^2
Cl 4.10	Compressive	f_l'	$0.79f_d - 43.9$	**-87.31** N/mm^2
			$3.15*f_d - 81.3$	-254.39 N/mm^2
Cl 4.11	Shear	q_l'	$24.6 - 0.44*q_d$	**22.03** N/mm^2

PROJECT : BRITISH RAIL PROPERTY BOARD ASSESSMENTS 99/00
BRIDGE : HILL COTTAGE RAILWAY BRIDGE **Bridge No : 87**
Assessor :PH **Ref : 23342**

STRESSES DUE TO LIVE LOAD (HA $_{kel\ +udl}$)

		Nett Cross Section		
		Case 3 With Enhancement	Case 4 No Enhancement	
Tensile	$f'l$	24.13	30.63	N/mm^2
K factor		0.49	0.38	
Assessment Rating		[redacted]	[redacted]	
Compressive	$f'l$	45.28	57.49	N/mm^2
k factor		1.93	1.52	
Assessment Rating		[redacted]	[redacted]	
Shear	$q'l$	7.01	7.01	N/mm^2
Assessment Rating		[redacted]	[redacted]	

DESIGN SERVICES

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. 42
of 85 Sheets
Rev. No. 0

Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99	Prepared by [redacted]
Element / Item Single wheel / axle loads	Joblog No. 23342	Date Checked Oct '99	Checked by P. H

CALCULATIONS / WORK

Output / Remarks

inal
ams

Consider single axle / wheel loads

distance between wheels on single axle = 1·8m > girder spacing

∴ consider single wheel load only.

Table 5/3/2 BD 21/97 40t Lp category

Nominal single wheel load = 90 kN

Proportion factor KL = 0·32

$$M_{LL} = \frac{90 \times 7{\cdot}82}{4} = 175{\cdot}95 \text{ kNm}$$

$$M_{LL}' = 175{\cdot}95 \times 0{\cdot}32$$
$$= \underline{56{\cdot}3 \text{ kNm}} \quad \text{(at mid-span)}$$

Consider Case 3 Nett cross-section with enhancement

Tensile

$$f_d = 29{\cdot}28 \text{ N/mm}^2 \text{ (sheet 40)}$$

$$f_{t\,LL}' = \frac{56{\cdot}30 \times 10^6}{8012940{\cdot}3} = \underline{7{\cdot}03 \text{ N/mm}^2}$$

$$f_L = 24{\cdot}6 - 0{\cdot}44 f_d$$

$$= 24{\cdot}6 - (0{\cdot}44 \times 29{\cdot}28)$$

$$\text{Allowable } f_L = \underline{11{\cdot}72 \text{ N/mm}^2} > \underline{7{\cdot}03 \text{ N/mm}^2}$$

∴ OK for 40 tonnes (Lp) single wheel load

Compressive stress not critical

Cumbria County Council **Design Services Work Sheet**		Design & Business Services	Sheet No. 43 of 85 Sheets Rev. No. 0
Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99.	Prepared by [redacted]
Element / Item Survey details for edge beam	Joblog No. 23342	Date Checked Oct '99.	Checked by P.H

CALCULATIONS / WORK

Output / Remarks

FOR EDGE GIRDERS, FIND MINIMUM OVERALL SECTION DEPTH

By inspection, see sheet 20

$H = 9.574 - 8.756$

$= \underline{0.818\,m}$ (Overall section depth)

$D = H - 75\,mm$ (for carriageway surfacing)

So say $D = H - 150\,mm$ in this case for verge (soft material)

$D = \underline{668\,mm}$

See sheet 19,

depth of edge girder at mid-span = 610 mm.

∴ Enhancement factor $= \frac{D}{d}$

$= \frac{668}{610}$

$= \underline{1.10}$

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. 44
of 85 Sheets
Rev. No. 0

Scheme: Hill Cottage Railway Bridge
Scheme Ref.: C1461437
Date Prepared: Oct '99
Prepared by: [redacted]

Element / Item: Section Properties of Beam
Joblog No.: 23342
Date Checked: Oct '99.
Checked by: P.H

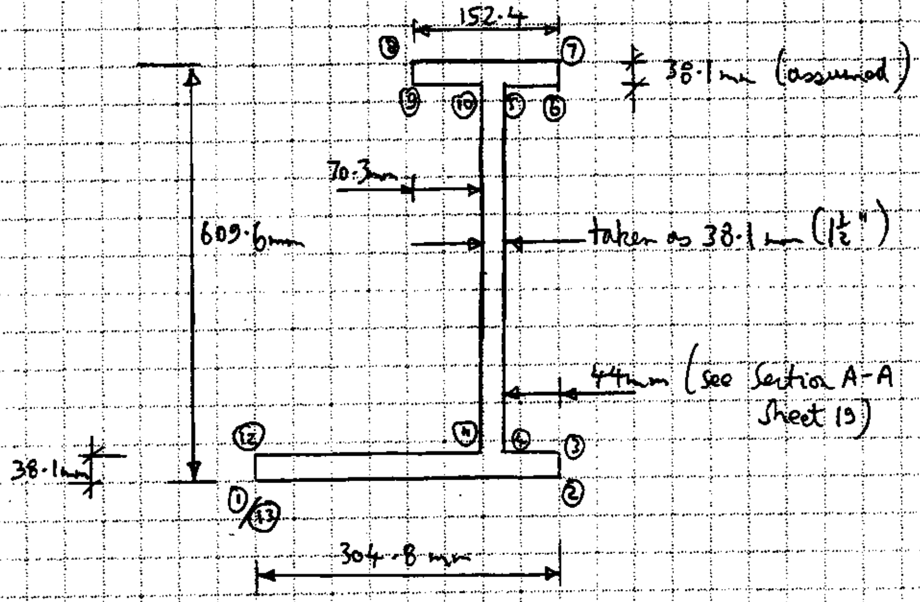
CALCULATIONS / WORK

Output / Remarks

Section Properties of Cast Iron Beam (Edge)

GROSS SECTION

Details of Beam - refer to Drg No C37/94 in the Appendix



web thickness not shown on drg - assumed

Scale Program 650 (Sectional Properties)

see ~~output~~, Cast Iron Beam Area, $A = 37742 \text{ mm}^2$

Neutral axis above base, $Y_b = 260.84 \text{ mm}$

Second Moment of Area, $I_{xx} = 1.8333 \times 10^9 \text{ mm}^4$

45 OF 85

U3129 HILL COTTAGE RAILWAY BRIDGE No. 87
LONGITUDINAL BEAMS (CI) SECTION PROPERTIES
EDGE BEAM (GROSS SECTION)

Page: 1
Made by: PSH
Date: 05.10.99
Ref No:

Office: 5598

Location: Edge Beam @ Midspan =610mm

Properties of any plane section

The section is defined by coordinates of corner points taken in anti-clockwise order round the section. The cross section is kept to the left of the edge running from a previous point to the next point. The section is closed when the original point is specified again.

Coordinates of points in order:

Point 1	: X-coordinate	x(1)=0 mm
	Y-coordinate	y(1)=0 mm
Point 2	: X-coordinate	x(2)=304.8 mm
	Y-coordinate	y(2)=0 mm
Point 3	: X-coordinate	x(3)=304.8 mm
	Y-coordinate	y(3)=38.1 mm
Point 4	: X-coordinate	x(4)=260.8 mm
	Y-coordinate	y(4)=38.1 mm
Point 5	: X-coordinate	x(5)=260.8 mm
	Y-coordinate	y(5)=571.5 mm
Point 6	: X-coordinate	x(6)=304.8 mm
	Y-coordinate	y(6)=571.5 mm
Point 7	: X-coordinate	x(7)=304.8 mm
	Y-coordinate	y(7)=609.6 mm
Point 8	: X-coordinate	x(8)=152.4 mm
	Y-coordinate	y(8)=609.6 mm
Point 9	: X-coordinate	x(9)=152.4 mm
	Y-coordinate	y(9)=571.5 mm
Point 10	: X-coordinate	x(10)=222.7 mm
	Y-coordinate	y(10)=571.5 mm
Point 11	: X-coordinate	x(11)=222.7 mm
	Y-coordinate	y(11)=38.1 mm
Point 12	: X-coordinate	x(12)=0 mm
	Y-coordinate	y(12)=38.1 mm
Point 13	: X-coordinate	x(13)=0 mm
	Y-coordinate	y(13)=0 mm

Sectional properties

Cross-sectional area	37742 mm^2
Second moments of area (inertias)	Ixx=1.8333E+9 mm^4 Iyy=164438074 mm^4
Product of inertia $\int dA.xy$	Ixy=225707305 mm^4
Distance of centroid from origin	X=212.23 mm Y=260.84 mm
Principal second moments of area	Iu=1.8633E+9 mm^4 Iv=134451661 mm^4

Angle of principal U
counter-clockwise from XX-axis -7.5677 degrees

$$Z_t = \frac{I_{xx}}{260.84}$$

$$= \frac{1.8333 \times 10^9}{260.84}$$

$$= \underline{\underline{7028447 \text{ mm}^3}} \quad (\text{Case } 2)$$

$$Z_c = \frac{I_{xx}}{(609.6 - 260.84)}$$

$$= \frac{1.8333 \times 10^9}{348.76}$$

$$= \underline{\underline{5256624 \text{ mm}^3}} \quad (\text{Case } 2)$$

Case 1 (with enhancement)

Factor - 1.1

$$\therefore Z_t = 7028447 \times 1.1$$

$$= \underline{7731291.7 \text{ mm}^3}$$

$$Z_c = 5256624 \times 1.1$$

$$= \underline{5782286 \text{ mm}^3}$$

Cumbria County Council
Design & Business Services
Design Services Work Sheet

Sheet No. 47
of 85 Sheets
Rev. No. 0

Scheme	Scheme Ref.	Date Prepared	Prepared by
Hill Cottage Railway Bridge	C1461437	Oct '99	[redacted]
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Section Properties of Beam	23342	Oct '99	P.H

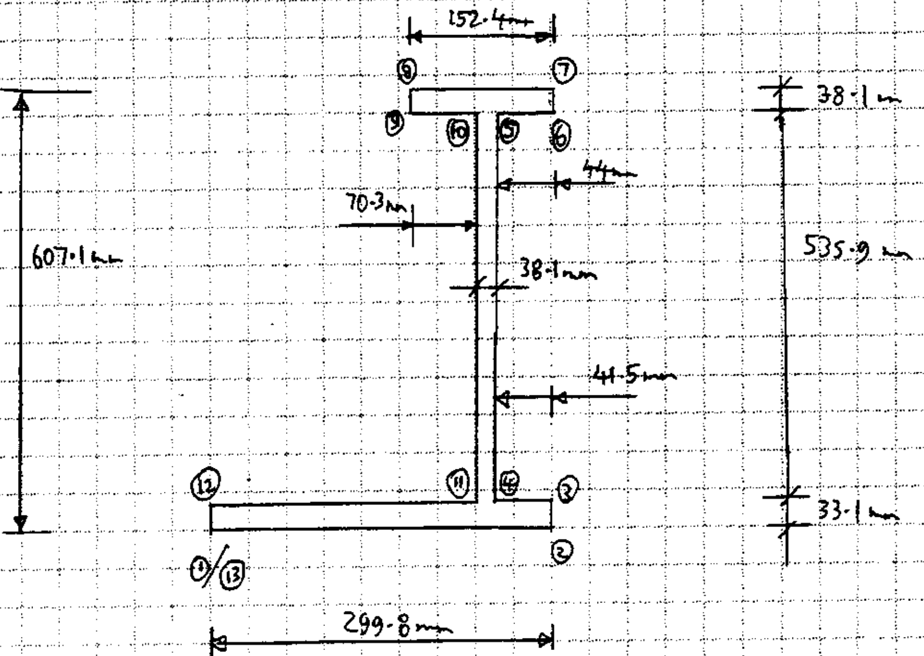
CALCULATIONS / WORK

Output / Remarks

NETT - SECTION

Section Properties of Cast Iron Beam (Edge)

Agreed with Client that Nett Section (corroded) take off 2.5mm around perimeter of bottom flange from Gross Section.



Scale Program 650 (Sectional Properties)

See output, Cast Iron Beam Area, $A = 36148\ mm^2$

Neutral axis above base, Y_b - 269.05mm

Second Moment of Area, $I_{xx} = 1.7347 \times 10^9\ mm^4$

U3129 HILL COTTAGE RAILWAY BRIDGE No. 87
LONGITUDINAL BEAMS (CI) SECTION PROPERTIES
EDGE BEAM (NETT SECTION)

Page: 1
Made by: PH
Date: 05.10.99
Ref No:

Office: 5598

Location: Edge Beam @ Midspan =610mm

Properties of any plane section

The section is defined by coordinates of corner points taken in anti-clockwise order round the section. The cross section is kept to the left of the edge running from a previous point to the next point. The section is closed when the original point is specified again.

Coordinates of points in order:

Point 1 :	X-coordinate	x(1)=0 mm
	Y-coordinate	y(1)=0 mm
Point 2 :	X-coordinate	x(2)=299.8 mm
	Y-coordinate	y(2)=0 mm
Point 3 :	X-coordinate	x(3)=299.8 mm
	Y-coordinate	y(3)=33.1 mm
Point 4 :	X-coordinate	x(4)=258.3 mm
	Y-coordinate	y(4)=33.1 mm
Point 5 :	X-coordinate	x(5)=258.3 mm
	Y-coordinate	y(5)=569 mm
Point 6 :	X-coordinate	x(6)=302.3 mm
	Y-coordinate	y(6)=569 mm
Point 7 :	X-coordinate	x(7)=302.3 mm
	Y-coordinate	y(7)=607.1 mm
Point 8 :	X-coordinate	x(8)=149.9 mm
	Y-coordinate	y(8)=607.1 mm
Point 9 :	X-coordinate	x(9)=149.9 mm
	Y-coordinate	y(9)=569 mm
Point 10 :	X-coordinate	x(10)=220.2 mm
	Y-coordinate	y(10)=569 mm
Point 11 :	X-coordinate	x(11)=220.2 mm
	Y-coordinate	y(11)=33.1 mm
Point 12 :	X-coordinate	x(12)=0 mm
	Y-coordinate	y(12)=33.1 mm
Point 13 :	X-coordinate	x(13)=0 mm
	Y-coordinate	y(13)=0 mm

Sectional properties

Cross-sectional area 36148 mm^2

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U3129 HILL COTTAGE RAILWAY BRIDGE No. 87
LONGITUDINAL BEAMS (CI) SECTION PROPERTIES
EDGE BEAM (NETT SECTION)

Page: 2
Made by: PH
Date: 05.10.99
Ref No:

Office: 5598

Second moments of area (inertias)	$I_{xx}=1.7347E+9$ mm^4 $I_{yy}=142605366$ mm^4
Product of inertia $\int dA.xy$	$I_{xy}=199522197$ mm^4
Distance of centroid from origin	X=212.61 mm Y=269.05 mm
Principal second moments of area	$I_u=1.7593E+9$ mm^4 $I_v=117982102$ mm^4
Angle of principal U counter-clockwise from XX-axis	-7.0354 degrees

No650

$$Z_t = \frac{I_{xx}}{269 \cdot 05}$$

$$= \frac{1 \cdot 7347 \times 10^9}{269 \cdot 05}$$

$$Z_t = \underline{6447501 \text{ mm}^3} \quad (\text{Case } 4)$$

$$Z_c = \frac{I_{xx}}{(607 \cdot 1 - 269 \cdot 05)}$$

$$= \frac{1 \cdot 7347 \times 10^9}{338 \cdot 05}$$

$$= \underline{5131490 \text{ mm}^3} \quad (\text{case } 4)$$

Case 3 (with enhancement)

Factor = 1·1

$$Z_t = 6447501 \times 1 \cdot 1$$
$$= \underline{7092251 \text{ mm}^3}$$

$$Z_c = 5131490 \times 1 \cdot 1$$
$$= \underline{5644639 \text{ mm}^3}$$

Cumbria County Council Design & Business Services **Design Services Work Sheet**			Sheet No. 50 of 85 Sheets Rev. No. 0
Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99-	Prepared by [redacted]
Element / Item Accidental Loading – edge beam	Joblog No. 23342	Date Checked Oct '99	Checked by P.H

CALCULATIONS / WORK

Output / Remarks

See survey details, bridge has negligible skew

∴ is a right span.

Cl 2.7 BA 16/97, check whether there is a beam between nearside wheels and edge member.

See sheet 20,

penultimate beam at east side, distance from east side of parapet to ℄ beam = 60 + 305 + 978 + 203

= 1546 mm

edge of carriageway = 2.550 + 0.40 from parapet east face

= 2.950m ✓ OK

penultimate beam at west side, distance from west side of parapet to ℄ beam = 60 + 305 + 997 + 203

= 1565 mm

edge of carriageway = 0.4 + 1.420

= 1.820m ✓ OK

There is a beam between nearside wheels and edge member

∴ The edge beams do not need to be examined for live load on the carriageway

Cl 5.35 BD 21/97. This bridge has non-cantilevered members ∴ select single accidental vehicle from Appendix D.

– As the critical case (CASE 2) = 7.5t

Case 2 = Gross Section
– No enhancement

Cumbria County Council | Design & Business Services

Design Services Work Sheet

Sheet No. 51
of 85 Sheets
Rev. No. 0

Scheme: Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared: Oct '99	Prepared by: [redacted]
Element / Item: Accidental Loading - Edge Beam	Joblog No. 23342	Date Checked: Oct '99	Checked by: P.H

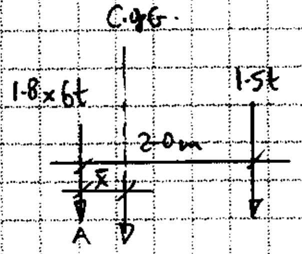
CALCULATIONS / WORK

Output / Remarks

D4
21/97

vehicle
y. RF
1.5t)

choose 7.5t accidental loading



single vehicle - apply impact factor of 1.8 to most critical axle (as shown)

Find centre of gravity of bogie

$1.8 \times 6t = 1.8 \times 6000 \times 9.81\ N$

$= \underline{105.95\ kN}$

$1.5t = 1.5 \times 1000 \times 9.81\ N$

$= \underline{14.715\ kN}$

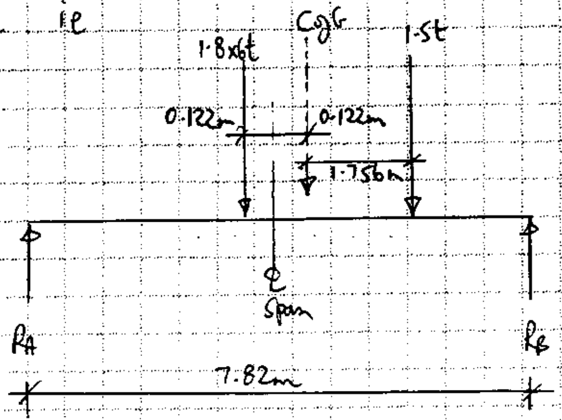
M(A)

$(105.95 + 14.715)\bar{x} = 14.715 \times 2.0$

$\bar{x} = \frac{29.43}{120.665}$

$\underline{\bar{x} = 0.244\ m}$

Max Bm occurs where ℄ span bisects C of G of bogie & 1st axle ie



Live loading

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99	Prepared by [redacted]
Element / Item Accidental Loading – Edge Beam	Joblog No. 23342	Date Checked Oct '99	Checked by P.H

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of 85 Sheets
Rev. No. 0

CALCULATIONS / WORK

Output / Remarks

Max BM under leading axle 1·8 x 6t

M(B)/

$$7{\cdot}82 R_A = 105{\cdot}95\,(0{\cdot}122 + 3{\cdot}91) + 14{\cdot}715 \times (3{\cdot}91 - 0{\cdot}122 - 1{\cdot}756)$$

$$= 427{\cdot}19 + 29{\cdot}9$$

$$\underline{R_A = 58{\cdot}45\ \text{kN}}$$

$$\therefore BM\,(Max) = 58{\cdot}45 \times (3{\cdot}91 - 0{\cdot}122)$$

$$= \underline{221{\cdot}41\ \text{kNm}}$$

Use the appropriate factor from Fig 2/3 BA 16/97 graph a), girder spacing = 1·45m (at edge)

span = 7·82m

$$\therefore \underline{K_L = 0{\cdot}41}$$

& Max live loading BM due to 7.5 accidental loading

$$= 0{\cdot}41 \times 221{\cdot}41$$

$$= \underline{90{\cdot}78\ \text{kNm}}$$

Cumbria County Council | Construction Services

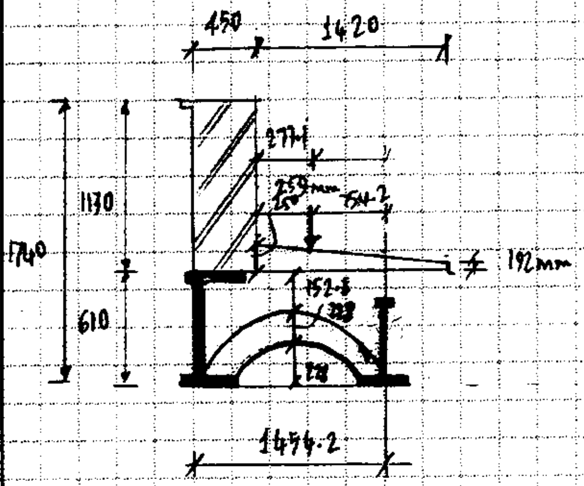
Consultancy & Design Work Sheet

Scheme BRITISH RAIL PROPERTY BOARD	Scheme Ref. C1461437	Date Prepared JUNE 1999	Sheet No. 53 of 85 Sheets Rev. No. 0
Element / Item HILL COTTAGE RAILWAY BRIDGE	Joblog No. 23342	Date Checked Oct '99	Prepared by Chec [redacted]

de

CALCULATIONS / WORK | Output / Remarks

EDGE BEAM (DL + SDL)



Levels [West]
10.490 − 8.750 = 1.74

Parapet ht = 1.74 − 0.610
= 1.13 m

East girder
10.465 − 8.756 = 1.729
Parapet ht = 1.729 − 0.610
= 1.12 m

$$L/2 = \left(1454.2 - \left[\frac{406.4 + 304.8}{2}\right]\right)/2 = 549.3\,\text{mm}$$

$$\sqrt{(L/2)^2 + H^2}$$

$$= (549.3^2 + 183.6^2)^{1/2} = 579.17\,\text{mm}$$

$$\tan\theta = 183.6/549.3 = 0.3342 = 18.48°$$

$$OA = \frac{579.17/2}{\tan\theta} = \frac{289.59}{0.3342} = 866.5\,\text{mm}$$

$$r = (866.5^2 + 289.59^2)^{1/2} = 913.61\,\text{mm} \checkmark$$

$$R = 913.61 + 228.6 = 1142.11\,\text{mm}$$

Area of Brick Jack Arch [as Carried by Edge Beam]

$$\pi(R^2 - r^2) \times \frac{4\theta}{360} = \pi(1142.11^2 - 913.61^2) \times \frac{73.92}{360} = 303011.768\,\text{mm}^2$$

0.3030 m²

$$= \underline{\underline{0.1545\,\text{m}^2}}$$

Area of segment

$$= \pi r^2 \times \frac{4\theta}{360} - \frac{549.3 \times 730.04 \times 2}{2}$$

$$= \pi \times 913.61^2 \times \frac{73.92}{360} - 400994.493$$

$$= 0.538432 - 0.400994 = \underline{\underline{0.137438\,\text{m}^2}}$$

ONSULTANCY
ESIGN

Cumbria County Council
Construction Services

Consultancy & Design Work Sheet

Sheet No. 54
of 85 Sheets
Rev. No. 0

Scheme BRITISH RAIL PROPERTY BOARD	Scheme Ref. C1461437	Date Prepared JUNE 1999	Prepared by [redacted]
Element / Item HILL COTTAGE RAILWAY BRIDGE	Joblog No. 23342	Date Checked Oct '99	C [redacted]

de

CALCULATIONS / WORK

Output / Remarks

$$\text{Area of Filling} = (1.4542 \times 0.610) - \overset{\text{Arch}}{0.3030} - \overset{\text{Segment}}{0.33744} - \overset{\text{Beam}}{\underbrace{[0.04376+0.01844]}_{0.06219}}$$

$$- \underbrace{0.044 \times 1.0986}_{0.0483}$$

$$= 0.336142$$

load area per Edge girder. = $0.16841\ m^2$

LOADING.

Jack Arch = 0.1515 x 23.5 = 3.56 KN/m

Fill = 0.1681 x 21.6 = 3.63 KN/m

Fill (Footway) = $\frac{(0.259+0.192)}{2} \times 0.277 \times 23.5$ = 1.467 KN/m

S/w Cast Iron Beam = 70.56 x 0.043768 = 3.09 KN/m

Parapet = 1.130 x 0.450 x 23.8 = 12.10 KN/m

23.85 KN/m

SDL + DL
w = 23.85 KN/m

BM Due to Permanent Loads

$$BM_{DL+SDL} = \frac{Wl^2}{8} = \frac{23.85 \times 7.82^2}{8}$$

$$= 182.82\ KN.m$$

$$SF = \frac{Wl}{2} = \frac{23.85 \times 7.82}{2}$$

$$= 93.25\ KN$$

Tensile Stresses due to dead loads

$$\frac{M}{Z_t} = \frac{182.82 \times 10^6}{7028447} = 26.01\ N/mm^2$$

$f_d = 26.01\ N/mm^2$

055 / No
hancement
value

n No. C&D C/DES1 REV B (3/98)

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99	Sheet No. 55 of 85 Sheets Rev. No. 0
Element / Item check stresses	Joblog No. 23742	Date Checked Oct '99	Prepared by C [redacted]

CALCULATIONS / WORK

Output / Remarks

e 1
ɔss/With
ancement

Case 1 (check 7.5t in bending)

$f_{t\,u}' = \dfrac{90.78 \times 10^6}{7731291.7}$ See sheet 48

$= \underline{11.74\ N/mm^2}$

$f_d = 26.01\ N/mm^2$ (sheet 50)

) 4.10

$f_L = 24.6 - 0.44 f_d$

$= 24.6 - (0.44 \times 26.01) = \underline{13.16\ N/mm^2}$

or

$f_L - 19.6 - 0.76 f_d$

$= 19.6 - (0.76 \times 26.01) - -0.\underline{47\ N/mm^2}$

Tensile stress due to LL

$\underline{= 11.74\ N/mm^2 < 13.16\ N/mm^2}$

$\therefore$ OK for 7.5t accidental vehicle

$f_{c\,u}' = \dfrac{90.78 \times 10^6}{5782286} = \underline{15.70\ N/mm^2}$

$f_d = \dfrac{M}{Z_c} = \dfrac{182.82 \times 10^6}{5256624} = \underline{34.78\ N/mm^2}$ (compressive)

heet 48
- Zc (no
hancement
r load)

$f_L = -43.9 + 0.79 f_d$

$= -43.9 + (0.79 \times 34.78) = \underline{-71.38\ N/mm^2}$

or $f_L = -81.3 + (3.15 \times -34.78) = \underline{-190.86\ N/mm^2}$

Compressive stress due to LL $= \underline{15.70\ N/mm^2 < 71.38\ N/mm^2}$

$34.78 + 71.38 \ \underline{-106.16\ N/mm^2} < 154\ N/mm^2$ (limiting stress)

<u>O.K for 7.5t accidental vehicle</u>

Cumbria County Council
Design & Business Services

Design Services Work Sheet

Sheet No. 56
of 85 Sheets
Rev. No. 0

Scheme: Hull Cottage Railway Bridge
Scheme Ref.: C1461437
Date Prepared: Oct '99
Prepared by: [redacted]

Element / Item: deck stresses
Joblog No.: 23342
Date Checked: Oct '95
Checked by:

CALCULATIONS / WORK

Output / Remarks

Case 2 (check 7.5t for bending)

$f_{t_{LL}}' = \frac{90.78 \times 10^6}{7028447} = 12.92 \, N/mm^2$

$f_{t_{DL+SDL}} = 26.01 \, N/mm^2$

$f_L = 24.6 - 0.44 f_d$

$= 24.6 - (0.44 \times 26.01) = 13.16 N/mm^2$

Tensile stress due to LL

$= 12.92 \, N/mm^2 < \underline{13.16 \, N/mm^2}$

∴ OK for 7.5t accidental vehicle

$f_{c_{LL}}' = \frac{90.78 \times 10^6}{5256624} = 17.27 \, N/mm^2$

$f_{c_{DL+SDL}} = 34.78 \, N/mm^2$

$f_L = -71.38 \, N/mm^2$

Compressive stress due to LL

$= \underline{17.27 \, N/mm^2 < 71.38 \, N/mm^2}$

∴ OK for 7.5t accidental vehicle

check limiting stress $< 154 \, N/mm^2$

$34.78 + 71.38 = \underline{106.16 \, N/mm^2}$

ESIGN
RVICES

Cumbria County Council | Design & Business Services

Design Services Work Sheet

Sheet No. 57
of 85 Sheets
Rev. No. 0

Scheme: Hill Cottage Railway Bridge
Scheme Ref.: C1461437
Date Prepared: Oct '95
Prepared by: [redacted]

Element / Item: check stresses
Jobiog No.: 23342
Date Checked: Oct '95
Checked by: P.H

CALCULATIONS / WORK | Output / Remarks

Case 3 (Check 7.5t for bending)

$$f_{t_{LL}} = \frac{90.78 \times 10^6}{7092251}$$

$$= \underline{12.80\ N/mm^2} \checkmark$$

$$f_{t_{DL+SDL}} = \frac{182.82 \times 10^6}{6447501}$$

$$= \underline{28.36\ N/mm^2}$$

$$f_L = 24.6 - 0.44 f_d$$

$$= 24.6 - (0.44 \times 28.36) = \underline{12.12\ N/mm^2} \checkmark$$

Tensile stress due to LL - $\underline{12.80}\ N/mm^2 > \underline{12.12}\ N/mm^2$ — NOT OK for 7.5t acc. vehicle

∴ OK for 3t accidental vehicle

$$f_c' = \frac{90.78 \times 10^6}{5644639} = 16.08\ N/mm^2$$

eet 45

$$f_{c_{DL+SDL}} = \frac{M}{Z_c} = \frac{182.82 \times 10^6}{5131490}$$

$$= \underline{35.63\ N/mm^2} = f_d$$

$$f_L = -43.9 + 0.79 f_d$$

$$= -43.9 + (0.79 \times -35.63)$$

$$= \underline{-72.05}\ N/mm^2$$

Compressive stress due to LL

$$= 16.08\ N/mm^2 < 72.05\ N/mm^2$$

∴ OK for 7.5t accidental vehicle in Compression

Check limiting Stress < 154 N/mm² 35.63 + 72.05 = $\underline{107.68}\ N/mm^2$

Cumbria County Council | Design & Business Services

Design Services Work Sheet

Sheet No. 58
of 85 Sheets
Rev. No. 0

Scheme	Scheme Ref.	Date Prepared	Prepared by
Hill Cottage Railway Bridge	C1461437	Oct '99	[redacted]
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
check stresses	23342	Oct '99	P.H

CALCULATIONS / WORK

Output / Remarks

Case 4. (check 7.5t for bending)

$$f_{t_{LL}} = \frac{90.78 \times 10^6}{6447501} = 14.08 \, N/mm^2$$

$$f_{t_{DL+SDL}} = 28.36 \, N/mm^2$$

$$f_L = 24.6 - 0.44 f_d$$

$$= 24.6 - (0.44 \times 28.36) = 12.12 \, N/mm^2$$

Tensile stress due to LL $= 14.08 \, N/mm^2 > 12.12 \, N/mm^2$

∴ OK for 3t Accidental vehicle only

NOT OK for 7.5t Acc veh

$$f_c' = \frac{90.78 \times 10^6}{5131490} = 17.69 \, N/mm^2$$

$$f_{c_{DL+SDL}} = 35.63 \, N/mm^2 = f_d$$

$$f_L = -72.05 \, N/mm^2$$

Compressive stress due to LL

$= 17.69 \, N/mm^2 < 72.05 \, N/mm^2$

∴ OK for 7.5tonne accidental vehicle

check limiting stress $< 154 \, N/mm^2$ $\quad 35.63 + 72.05 = 107.68 \, N/mm^2$

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99	Prepared by [redacted]
Element / Item Shear Stress (7.5t Accidental)	Joblog No. 23342	Date Checked Oct '99	Checked by PH

Sheet No. 59
of 85 Sheets
Rev. No. 0

CALCULATIONS / WORK

Output / Remarks

Shear stress check at support for 7.5 tonnes accidental loading:

Dead load w on edge beam = 23.85 kN/m

& Shear force at support = 93.25 kN (sheet 54)

$$q_d = \frac{V}{d_w t} = \frac{93.25 \times 10^3}{535.9 \times 38.1}$$

= 535.9 mm

$$= \underline{4.57\ N/mm^2}$$

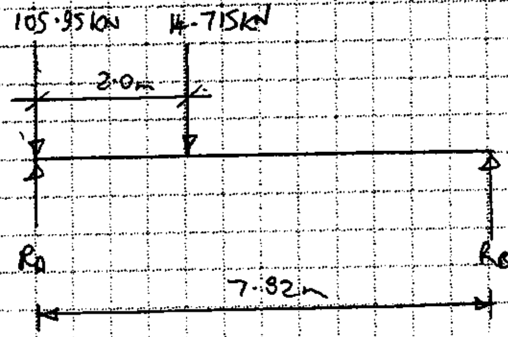
section

et 47)

7.5t accidental loading positioned as follows for max. shear :-

e

et 51



$M(B)/\quad 7.82 R_A = 105.95 \times 7.82 + 14.715(5.82)$

$= 828.5 + 85.6$

$\therefore \underline{R_A = 116.9\ kN}$

& Shear force $S_L = K_L \times 116.9$

=0.41

et 52

$= 0.41 \times 116.9$

$= \underline{47.93\ kN}$

$$\therefore \text{live shear stress} = \frac{47.93 \times 10^3}{535.9 \times 38.1} = \underline{2.35}\ N/mm^2$$

Total shear stress = $\underline{6.92\ N/mm^2}$

Cumbria County Council Design Services Work Sheet	Design & Business Services			Sheet No. 60 of 85 Sheets Rev. No. 0
Scheme Hill Cottage Railway Bridge .		**Scheme Ref.** C1461437	**Date Prepared** Oct '99	**Prepared by** [redacted]
Element / Item Shear Stress (7.5t Accidental)		**Joblog No.** 233x2	**Date Checked** Oct '99 .	**Checked by** P.H

CALCULATIONS / WORK

Output / Remarks

24.11 $q_L \le 24.6 - 0.44 q_d$ where $q_d = 4.57\ N/mm^2$

$q_L \le 22.59\ N/mm^2$

✓ ok $q_L = 2.35\ N/mm^2$

& also total shear stress of $6.92\ N/mm^2 < 46\ N/mm^2$

∴ ok for 7.5t Accidental vehicle in Shear

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. 61
of 85 Sheets
Rev. No. 0

Scheme U3129 Hill Cottage Railway Bridge

Scheme Ref. C1461437

Date Prepared Oct '99

Prepared by [redacted]

Element / Item Mexe details

Joblog No. 23542

Date Checked Oct '99

Checked by P.H

CALCULATIONS / WORK

Output / Remarks

Jack arch assessment to BA 16/97

Span L = 1·470m, is outside the lower boundary limit of 1·5m for MEXE

L = girder spacing (sheet 36)

beam soffit to crown of arch = 9" for each bay

for Internal beams, flange (lower) thickness = $1\frac{5}{8}''$

Barrel thickness = 9" (Ref C37/87)

$\therefore r_c = (9-1\frac{5}{8})'' = \underline{0{\cdot}187\,m}$

r_q not measured, taken as $\frac{3}{4} r_c$ ~ reasonable as arch appears to be parabolic rather than circular.

Joint width

In range 6–12.5 mm $\therefore F_w = 0{\cdot}9$

Hard mortar, $F_{mo} = 1{\cdot}0$

$F_d = 0{\cdot}9$ – all bays well pointed except for fourth jack arch from the west at crown joint

Condition Factor, F_{cm}

Old structure, $F_{cm} = 0{\cdot}9$

– 0·1 open joint at fourth jack arch crown

$F_{cm} = 0{\cdot}8$

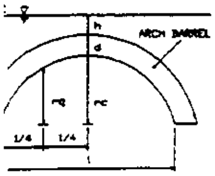
Axle lift off – negligible curvature to vertical alignment $\therefore$ not applicable

CUMBRIA COUNTY COUNCIL - CONSULTANCY & DESIGN
ARCH ASSESSMENT DESIGN SHEET - MODIFIED MEXE METHOD FOR BRPB

Page No. 62
of 85 Pages
Rev No: 0

: No: 87	Bridge Name: U3129 HILL COTTAGE RAILWAY BRIDGE		
) ASSESSMENT OF ARCHES IN ACCORDANCE WITH ASSESSMENT OF HIGHWAY BRIDGES AND STRUCTURES" RTMENTAL STANDARD BD 21/97 ADVICE NOTE BA 16/97 RENCES ARE TO BA 16/97 UNLESS NOTED OTHERWISE)	DATE PREPARED: Oct '99 DATE CHECKED: Oct '99	PREPARED BY: [redacted] CHECKED BY: PH	

CTURAL DIMENSIONS



SPAN (square/skew)		L=	1·470		(m)
RISE OF ARCH BARREL AT CROWN	9" – 1 5/8"	rc=	0·187		(m)
RISE OF ARCH BARREL AT 1/4 POINT	say 3/4 rc	rq=	0·140		(m)
EFFECTIVE THICKNESS OF ARCH BARREL	2 bricks	d=	0·220		(m)
EFFECTIVE DEPTH OF FILL AT CROWN		h=	0·500 →	0·220	(m)
	(≈0·72m)	d + h=	0·720	0·440	(m)

ISIONAL ASSESSMENT (Cl 3.10)
= 740 $(d + h)^2/L^{1.3}$ but ≯ 70T

AN	(L) =	1·473			h modified to d	
TAL CROWN THICKNESS	(d + h) =	0·440		PAL =		
	PAL =	70		(70T max)	70	(T)

/RISE FACTOR (Fsr) (Cl 3.11)

	l / rc	= 7·877	Fsr=	0·622
.3)		=		

ILE FACTOR (Fp) (Cl 3.12)

2.3 $[(rc - rq)/rc]^{0.6}$	rq / rc	= 0·749	Fp=	1·00
		=		

RIAL FACTOR (Fm) (Cl 3.13)
RREL FACTOR (Fb) (TABLE 3/1) Fb = 1·0
L FACTOR (Ff) (TABLE 3/2) Ff = 0·7
MATERIAL FACTOR (Fm) = $\frac{(Fb \times d) + (Ff \times h)}{d + h}$ Fm = 0·85

T FACTOR (Fj) (Cl 3.16)
DTH FACTOR (Fw) (TABLE 3/3) Fw = 0·9
RTAR FACTOR (Fm) (TABLE 3/4) Fmo = 1·0
PTH FACTOR (Fd) (TABLE 3/5) Fd = 0·9
JOINT FACTOR (Fj) = Fw x Fmo x Fd Fj = 0·81

DITION FACTOR (Fc_M) (Cl 3.17 To 3.23 Inclusive) Fc = 0·80

I SPAN FACTOR

gle Span or Massive Piers	Msf = 1.0	1·0
d span normally	Msf = 0.9	
erMediate span normally	Msf = 0.8	

IFIED AXLE LOAD (MAL) (Cl 3.24)
L = Msf x Fsr x Fp x Fm x Fj x Fc_M x PAL MAL = 23·990

RIFUGAL EFFECT (Fa) (Cl 3.29)
Centrifugal Effect considered applicable? ~~YES~~/NO
Radius (r) = ______ Fa = 1·0

WABLE AXLE LOAD (AAL) (Cl 3.25)
Axle Lift-Off applicable?

	~~YES~~	NO			
	(Fig 3/5b)	(Fig 3/5a)			
LE FACTORS (Af) SINGLE AXLE =		1·0	AAL =	24	(T)
2 AXLE BOGIE =		1·0	AAL =	24	
3 AXLE BOGIE =		1·0	AAL =	24	

OSS VEHICLE WEIGHT RESTRICTION (Table 3/6) NA – 40/44t GVW (T)

ESIGN
ERVICES

Cumbria County Council
Design & Business Services

Design Services Work Sheet

Sheet No. 63
of 85 Sheets
Rev. No. 0

Scheme U3129 HILL COTTAGE RAILWAY BRIDGE
Scheme Ref. C1461737
Date Prepared Oct '99
Prepared by [redacted]

Element / Item Check tie-rods
Joblog No. 23342
Date Checked Oct '99
Checked by PH

de

CALCULATIONS / WORK

Output / Remarks

E-RODS
) END BAY
ACK ARCHES

Horizontal Force (H) due to permanent loads

$$H = \frac{wl^2}{8f}$$

where l - span of arch = 1.470 m

w = udl due to dead loads (at edge girder)

see sheet 54 take off parapet & s/w beam and double = 17.32 kN/m

f = rise of arch (= rc) = 0.301 m (to mid depth of arch)

See Roark

$$\therefore H = \frac{14.11 \times 1.470^2}{8 \times 0.301}$$

$$w = \frac{17.32}{1.470} \times \underset{(\gamma_{fL})}{1.2} = 14.11 \text{ kN/m}$$

$$\underline{H = 12.71 \text{ kN/m}}$$

7.5t accidental wheel loading on edge bay (wrought iron ties in these bays only)

- consists of 6t × 1.8 impact
+ 1.5t nominal

$$\text{At ULS,} \quad P = \frac{6000 \times 9.81 \times 1.8}{1000} \text{ kN} \times \underset{(\gamma_{fL})}{1.5}$$

$$\underline{P = 158.9 \text{ kN}}$$

see Roark

Horizontal reaction (H) due to point load

$$H' = \frac{25PL}{128f}$$

$$H' = \frac{25 \times 158.9 \times 1.470}{128 \times 0.301}$$

$$\underline{H' = 151.8 \text{ kN}}$$

(& for 1.5t axle), $P = 1.5 \times 9.81 \times 1.5 = \underline{22.1 \text{ kN}}$

$$\therefore H' = \frac{25 \times 22.1 \times 1.470}{128 \times 0.301} = \underline{21.1 \text{ kN}}$$

m No. C&D C/DES1 REV C (6/99)

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. 64 of 85 Sheets

Rev. No. 0

Scheme U3129 Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99	Prepared by [redacted]
Element / Item Check tie-rods	Joblog No. 23342	Date Checked Oct '95	Checked by P.H

CALCULATIONS / WORK

Output / Remarks

Total force due to 7.5t accidental and dead load (over span of bridge) = $151 \cdot 8 + 21 \cdot 1 + 12 \cdot 71 \times 7 \cdot 32$

$= \underline{272 \cdot 3 \text{ kN}}$

<u>Capacity of existing tie rods</u>

– see structure file, ϕ now 19mm (corroded from 25mm)

For wrought iron, $\sigma_y = 220 \text{ N/mm}^2$

Allowable stress $= \dfrac{\sigma_y}{\gamma_m \times \gamma_{f3}}$

$= \dfrac{220}{1 \cdot 2 \times 1 \cdot 1}$

$= \underline{166 \cdot 7 \text{ N/mm}^2}$

& Force per rod $= \dfrac{\pi (19)^2}{4} \times 166 \cdot 7 \times 10^{-3} \text{ kN}$

$= \underline{47 \cdot 3 \text{ kN}}$

Only 3 tie rods per end bay, total capacity = $3 \times 47 \cdot 3$

$= \underline{141 \cdot 9 \text{kN}}$ $< 272 \cdot 3 \text{kN}$

<u>∴ 3 No 19mm ϕ tie-rods are inadequate for</u>

<u>the 7.5t Accidental vehicle</u>

Cumbria County Council
Design & Business Services
Design Services Work Sheet

Sheet No. 65
of 85 Sheets
Rev. No. 0

Scheme Hill Cottage Railway Bridge
Scheme Ref. C1461 437
Date Prepared Oct '99
Prepared by [redacted]
Element / Item tie - rods
Joblog No. 23342
Date Checked Oct '99
Checked by PH

CALCULATIONS / WORK | Output / Remarks

Check 7.5t Accidental vehicle if 3 No 19mm ø tie-rods are replaced with 3 No 25mm ø tie rods

tie-rods are wrought iron

Total horizontal thrust on edge beam = 272.3 KN.

sheet 64

Force per rod $= \frac{\pi(25)^2}{4} \times 166.7 \times 10^{-3}$ KN

$= \underline{81.8 \text{ kN}}$

3 No rods = 245.5 kN

∴ Frictional force at end support required for lateral stability = (272.3 − 245.5)0.5

$= \underline{13.4 \text{kN}}$

Calculate the frictional resistance at end support due to dead loading.

eet 54
v=23.85
kN/m

$W = 23.85 \underset{\gamma_{fL}}{\times 1.2} = \underline{28.62} \text{ kN/m}$

Support reaction $= \frac{wl}{2} = \underline{111.9 \text{ kN}}$

Frictional Resistance
assuming $\mu\left(=F/_R\right) = 0.35$ $= 111.9 \times 0.35$

$= \underline{39.2\text{kN}} > \underline{13.4 \text{ kN}}$

OK

∴ 3 No. 25 mm ø replacement tie - rods would be adequate for 7.5t Accidental loading

No. C&D C/DES1 REV C (6/99)

Cumbria County Council **Design Services Work Sheet**		Design & Business Services	Sheet No: 66 of 85 Sheets Rev. No. 0
Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99	Prepared by [redacted]
Element / Item tie - rods	Joblog No. 23342	Date Checked Oct '99	Checked by PH
CALCULATIONS / WORK			Output / Remarks

Check existing 19mm ϕ tie - rods for 3t Accidental vehicle

W_1 (impacted) $= 1{\cdot}8 \times 2{\cdot}1 \times 9{\cdot}81 = 37{\cdot}1$ kN

$W_2 = 0{\cdot}9 \times 9{\cdot}81 = 8{\cdot}83$ kN

ULS Assessment loads

Live load at ULS $= (37{\cdot}1 \times 1{\cdot}5) + (8{\cdot}83 \times 1{\cdot}5)$

$= \underline{68{\cdot}9 \text{ kN}}$

Total horizontal thrust produced $H = \frac{25PL}{128f}$

$= \frac{25 \times 68{\cdot}9 \times 1{\cdot}470}{128 \times 0{\cdot}307}$

$= \underline{65{\cdot}9 \text{ kN}}$

$H = 12{\cdot}71$ kN/m (Sheet 63)

for DL & SDL

∴ Total horizontal thrust on edge beam $= (12{\cdot}71 \times 7{\cdot}82) + 65{\cdot}9$

$= \underline{165{\cdot}3 \text{ kN}}$

& 3No 19mm (existing) ϕ tie-rods capacity = 141·9 kN

+ Frictional resistance due to DL & SDL = 39·2 kN

181·1 kN > 165·3 kN

∴ OK for 3t Accidental Vehicle for existing 3No 19mm ϕ tie - rods.

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. 67
of 85 Sheets
Rev. No. 0

Scheme Hill Cottage Railway Bridge	Scheme Ref. C1461437	Date Prepared Oct '99	Prepared by [redacted]
Element / Item Results Summary Sheet	Joblog No. 23342	Date Checked Oct '99.	Checked by P.H

CALCULATIONS / WORK

Output / Remarks

CASES

	1 Gross/enhanced	2 Gross	3 Nett/enhanced	4 Nett
Inner Beam	Group 1FE	7.5 Tonnes	Group 1FE	7.5 Tonnes
Edge Beam	7.5t accidental	7.5t accidental	3t accidental	3t accidental

∴ Weight restriction on bridge is 3tonnes

(as bridge is in nett (corroded) condition)

PHOTOGRAPHS

U3129 - HILL COTTAGE RAILWAY BRIDGE

PHOTO NO. 1 - EAST ELEVATION

PHOTO NO. 2 - WEST ELEVATION

U3129 - HILL COTTAGE RAILWAY BRIDGE

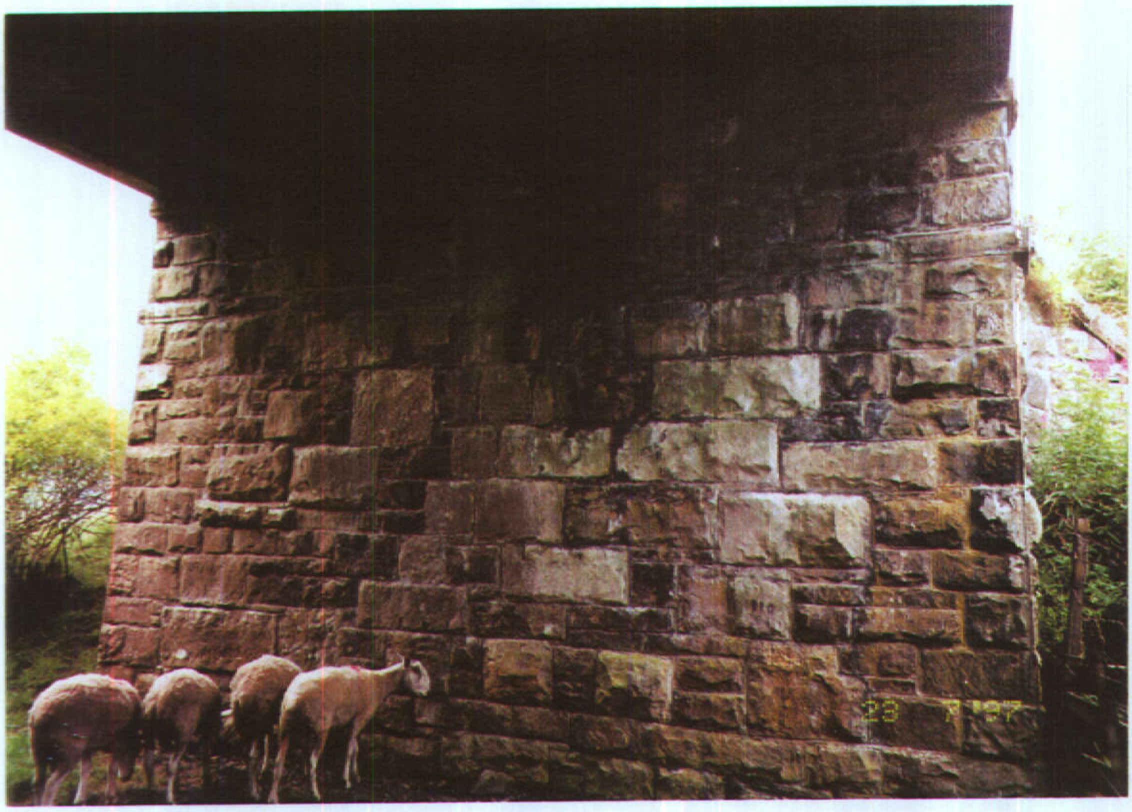


PHOTO NO. 3 - NORTH ABUTMENT

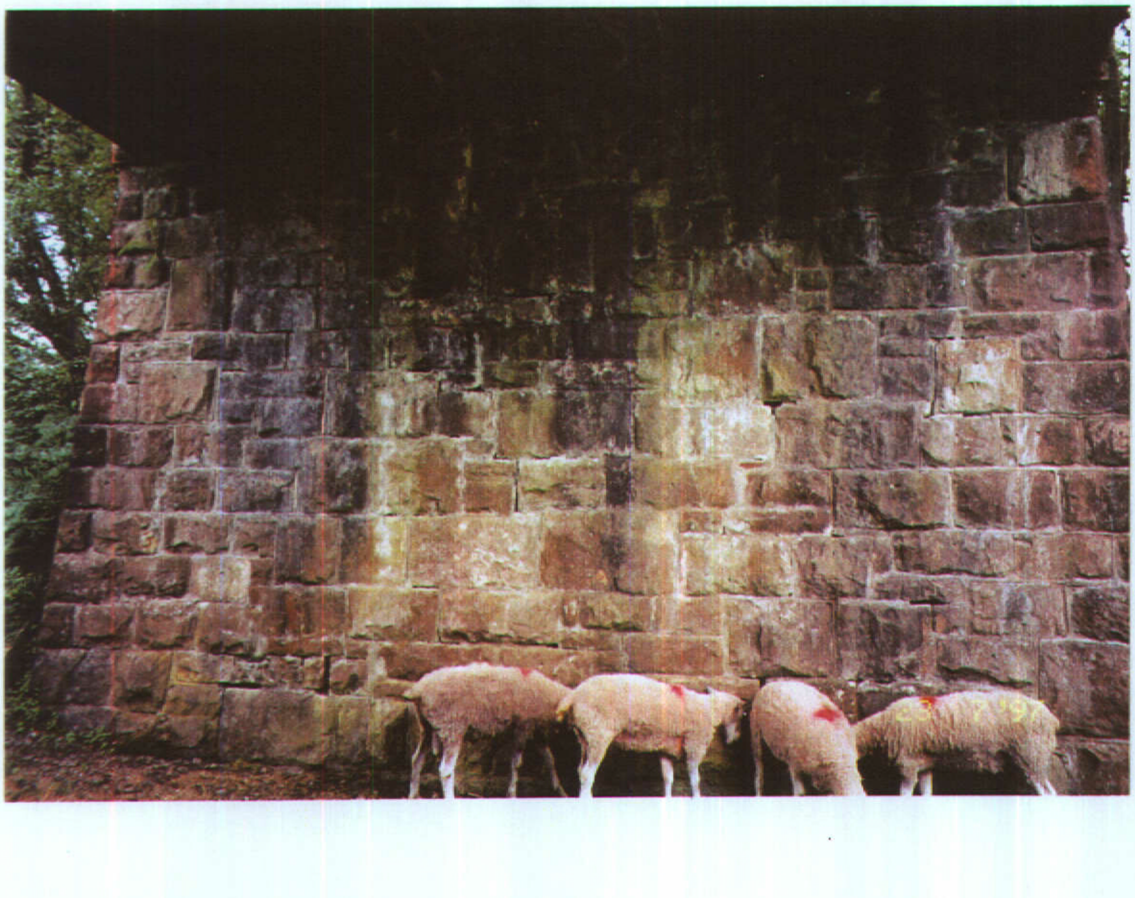


PHOTO NO. 4 - SOUTH ABUTMENT

U3129 - HILL COTTAGE RAILWAY BRIDGE

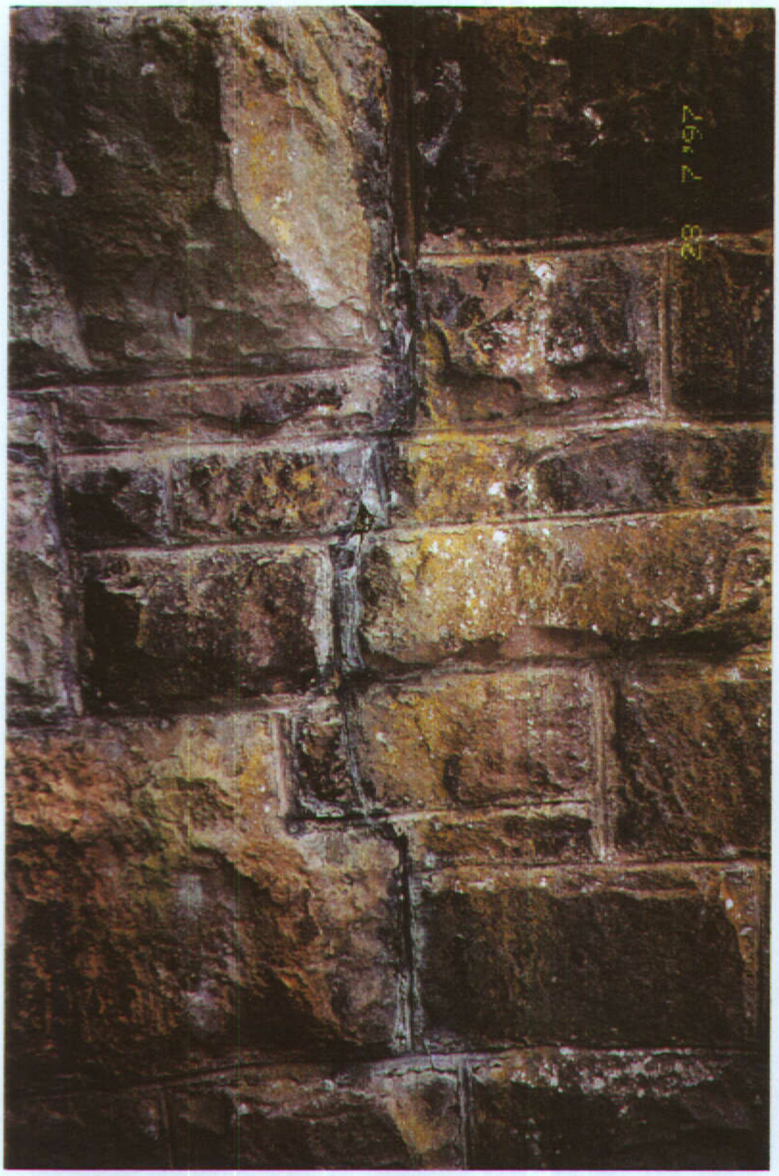


PHOTO NO. 5 - VERTICAL CRACK TO NORTH ABUTMENT

U3129 - HILL COTTAGE RAILWAY BRIDGE

23 7 '97

PHOTO NO. 6 - GENERAL DECK SOFFIT

23 7 '97

PHOTO NO. 7 - SURFACE CORROSION TO UNDERSIDE OF CAST IRON BEAM

U3129 - HILL COTTAGE RAILWAY BRIDGE

PHOTO NO. 8 - HEAVY CORROSION TO TRANSVERSE TIE ROD

U3129 - HILL COTTAGE RAILWAY BRIDGE

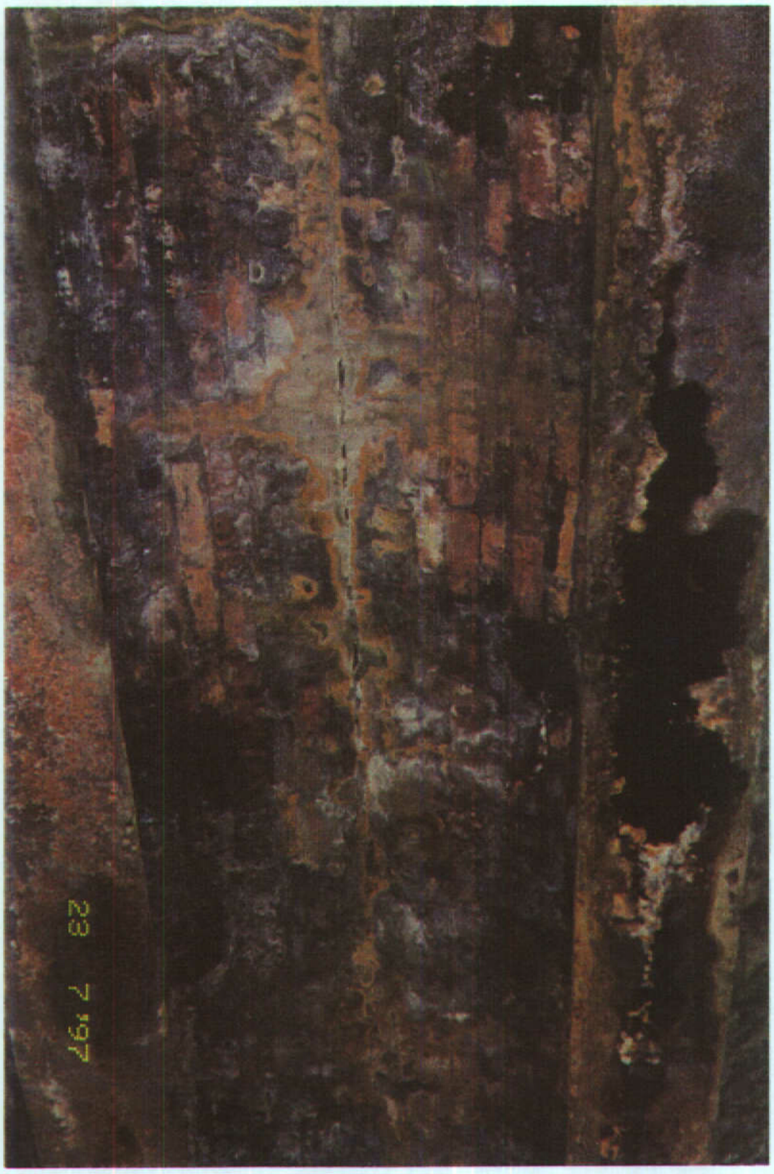


PHOTO NO. 9 - OPEN JOINT AT JACK ARCH CROWN WITH LEACHATE EMITTING FROM JOINT

U3129 - HILL COTTAGE RAILWAY BRIDGE

PHOTO NO. 10 - RANDOM CRACKED JOINTS BELOW EDGE BEAM ON S.W. WINGWALL

U3129 - HILL COTTAGE RAILWAY BRIDGE

PHOTO NO. 11 - DISPLACEMENT OF SOUTH END OF S.W. WINGWALL

PHOTO NO. 12 - DISPLACED COPINGS TO N.W. WINGWALL

U3129 - HILL COTTAGE RAILWAY BRIDGE

PHOTO NO. 13 - SMALL TREE BECOMING ESTABLISHED IN S.E. WINGWALL

PHOTO NO. 14 - DISPLACED COPINGS AND VEGETATION BECOMING ESTABLISHED TO N.E. WINGWALL COPINGS

U3129 - HILL COTTAGE RAILWAY BRIDGE

PHOTO NO. 15 - CRACKED SANDSTONE MASONRY BELOW WEST EDGE BEAM ON N.E. WINGWALL

PHOTO NO. 16 - OUTSIDE FACE OF EAST PARAPET

U3129 - HILL COTTAGE RAILWAY BRIDGE

PHOTO NO. 17 - MOVEMENT TO NORTH END OF EAST PARAPET

U3129 - HILL COTTAGE RAILWAY BRIDGE

[redacted]

PHOTO NO. 18 - WEST PARAPET LEANING OUTWARDS BY 100MM AT MID SPAN

U3129 - HILL COTTAGE RAILWAY BRIDGE


[redacted]

PHOTO NO. 19 - VIEW OVER LOOKING NORTH

U3129 - HILL COTTAGE RAILWAY BRIDGE

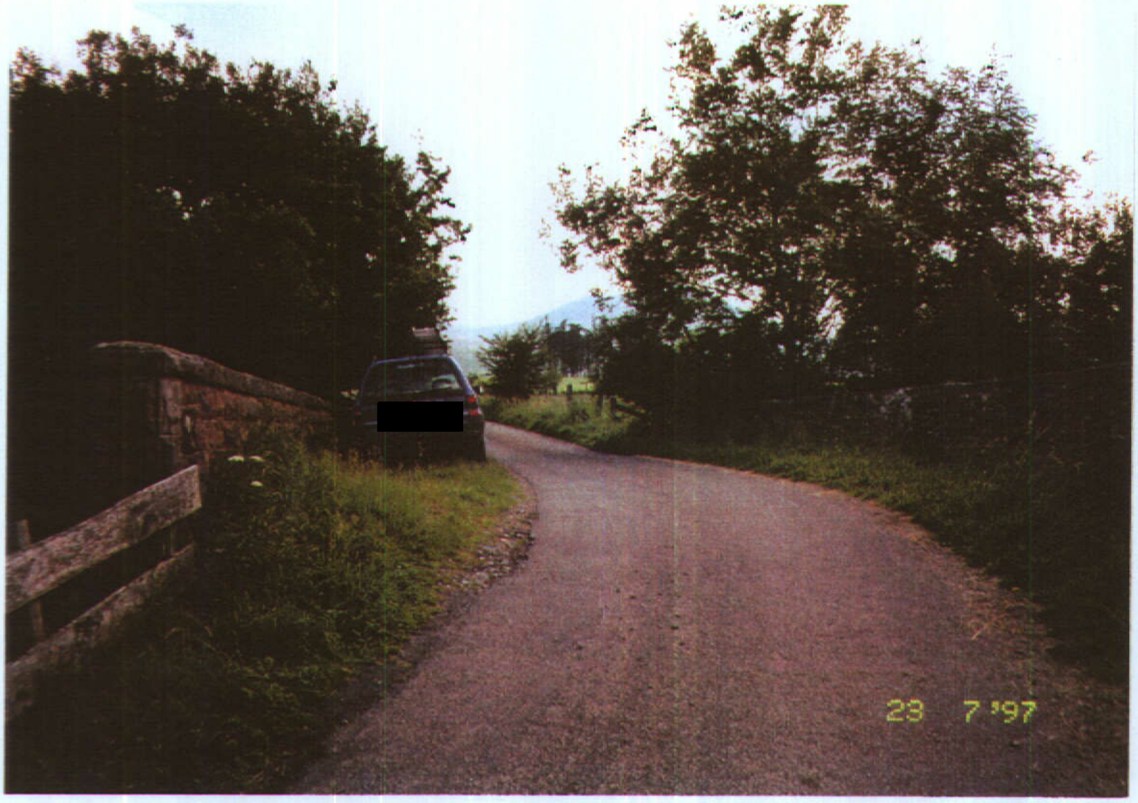

[redacted]

PHOTO NO. 20 - VIEW OVER LOOKING SOUTH

APPENDIX

INDEPENDENT CHECK CALCULATIONS

Cumbria County Council | Design & Business Services

Design Services Work Sheet

Sheet No. I/1
of Sheets
Rev. No.

Scheme: British Rail Property Board
Scheme Ref.: C1461437
Date Prepared: 28/9/99
Prepared by: [redacted]

Element / Item: Hill Cottage Railway Bridge
Joblog No.: 23342
Date Checked: 4/10/99
Checked by: DK

CALCULATIONS / WORK

Output / Remarks

Index to Calculations

Design Services Work Sheet

Sheet No. I/2
of Sheets
Rev. No.

Scheme: British Rail Property Board
Scheme Ref.: C1461437
Date Prepared: 28/9/99
Prepared by:
Element / Item: Hill Cottage Railway Bridge
Joblog No.: 23342
Date Checked: 4/10/99
Checked by:

CALCULATIONS / WORK

Output / Remarks

Index to Calculations (cont'd)

Section	Description	Sheet Nos
	Internal Beam	
B	Assessment Capacities for cases 1-4 inc wrt tensile stress in bottom flange (ie. critical mode of failure for Load Assessment) Results plotted on Fig 5/4 of BD21/97 K factors for Low Traffic Poor Surface (L_p)	B/5/1
	Compressive stress in bending check at mid-span.	B/6
	Single Axle and Single Wheel Loads	B/7&8
	Jack arches – not critical to this Assessment. (Assessor's results agreed)	None.

Cumbria County Council Design Services Work Sheet	Design & Business Services		Sheet No. I/3 of Sheets Rev. No.
Scheme BRPB	Scheme Ref. C1461437	Date Prepared 28/9/99	Prepared by SK
Element / Item Hill Cottage Railway Bridge	Joblog No. 23342	Date Checked 4/10/99	Checked by SK

CALCULATIONS / WORK

Output / Remarks

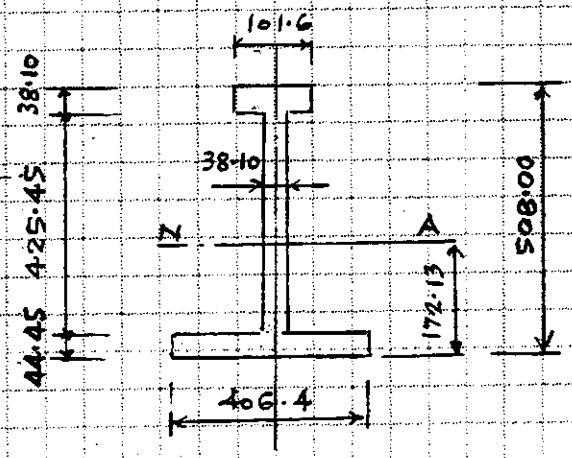
Index to Calculations (cont'd)

Section	Description	
	Edge Beam	
C	Cases considered	C1/1
	DL + SDL (nom)	C1/1/1
	" " moment at mid-span	
	" " shear at support	
	Gross cross-section	C/2
	" " section properties	C/2/1 & 2
	" " DL & SDL stresses	C/4
	Nett cross-section	C/3
	" " section properties	C/3/1 & 2
	DL & SDL stresses	C/5
	Accidental Vehicle Loading	C/6
	Max. BM due to 7.5 Tonnes AWL	C/7
	Fig 2/3 (a) Proportion Factor for Single Lane Loading	C/7/1
	Max SF due to 7.5 Tonnes AWL	C/8
	Max BM due to 17.0 Tonnes AWL	C/9
	Max SF due to 17.0 Tonnes AWL	C/10
	Case 1 Check 7.5 Tonnes AWL wrt bending	C/11
	Case 2 "	C/12
	Case 3 "	C/13
	Case 4 "	C/14
	Case 1 Check 17.0 Tonnes AWL wrt bending	C/15
	Case 3 "	C/16
	Shear stress check at support for 7.5 Tonnes AWL	C/17
D	Stability of Edge Beams	D/1-6 inc
	Jack arches - not critical to this assessment (Assessor's results agreed)	None.

Cumbria County Council	Design & Business Services **Design Services Work Sheet**		Sheet No. A/1 of Sheets Rev. No.
Scheme British Rail Property Board	Scheme Ref. C1461437	Date Prepared 9/8/99	Prepared by JK.
Element / Item Hill Cottage Railway Bridge.	Joblog No. 23342	Date Checked 16/8/99	Checked by JK
CALCULATIONS / WORK			Output / Remarks

Longitudinal Load from Internal Beam.

1) gross cross-section.



Clear span 7·48 m. } diff

Effective span 7·82 m } 0·34 m

Carriageway 2·80 m

Verges 1·42 m & 2·55 m.

Consider the following cases: Z values.

1) gross cross-section with enhancement	Z_c	4485967 mm^3
	Z_t	8964257 "
2) gross cross-section without enhancement	Z_c	3424402 "
	Z_t	6842944 "
3) nett cross-section with enhancement	Z_c	4404800 "
	Z_t	8267367 "
4) nett cross-section without enhancement.	Z_c	3362443 "
	Z_t	6310967 "

For "enhancement" see BD 21/97 cl. 7·13.

NB Ref. Drg C37/87
states that girder details are
as for C37/94
ie Gills Railway Bridge.

CONSULTANCY & DESIGN

Cumbria County Council
CONSTRUCTION SERVICES
Consultancy & Design Work Sheet

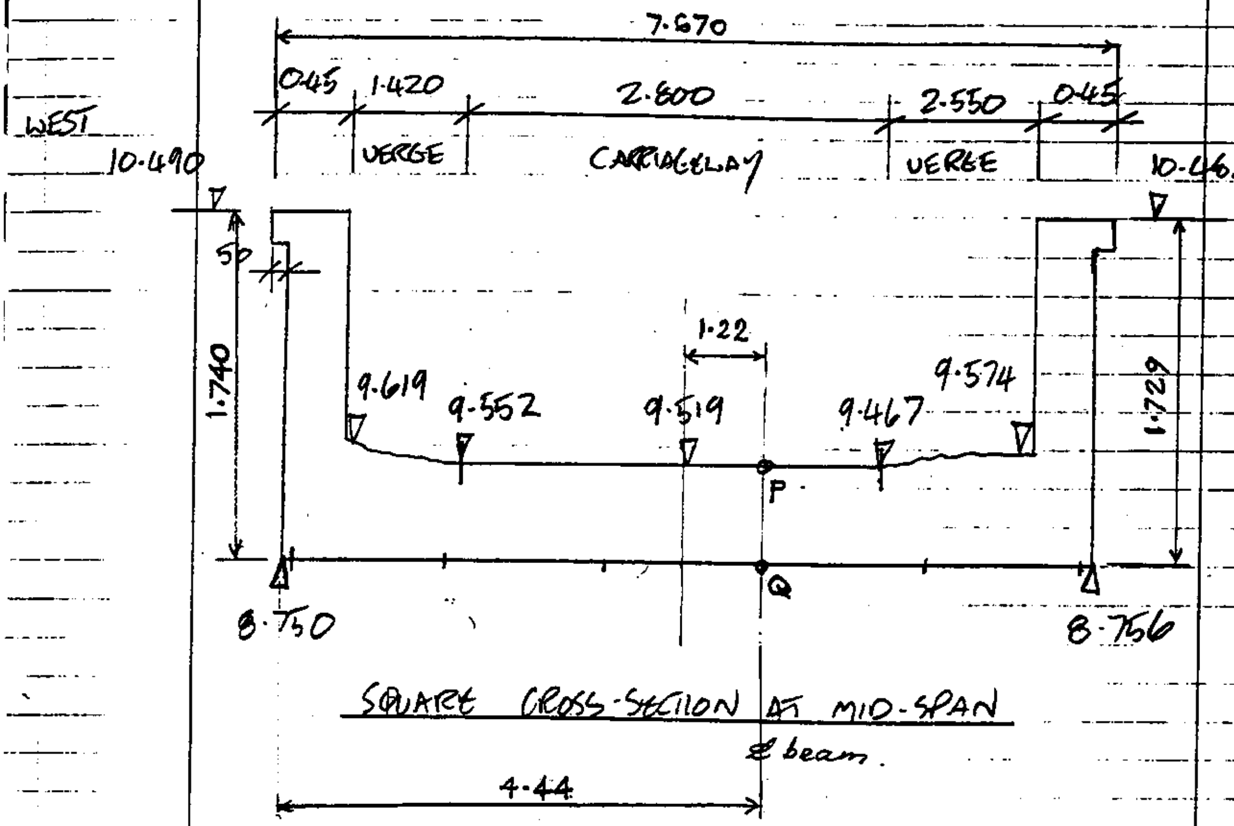
Sheet No. A/1/1 of Sh
Rev. No.

Scheme: BRITISH RAIL PROPERTY BOARD
Scheme Ref.: C1461437
Date Prepared: AUG 97
Prepared by: T.O
Element / Item: HILL COTTAGE RAILWAY BRIDGE
Joblog No.: 23342
Date Checked: 21/10/99
Checked by

Code Ref.

CALCULATIONS / WORK

Output / Remarks



SQUARE CROSS-SECTION AT MID-SPAN

$$\text{Level at } P = 9.519 - \frac{1.22}{1.400} \times (9.519 - 9.467)$$
$$= 9.474$$

Level at Q = 8.754

$\therefore H = 9.474 - 8.754 = 0.720$

$D = 0.720 - 0.075 = 0.645$

$d = 0.508$

$\therefore$ Enhancement factor for Internal Beam $\frac{D}{d} = 1.27$

For Edge Beam:

$H = 9.574 - 8.756 = 0.818$

$D = 0.818 - 0.075 = 0.743$ say 0.668.

$d = 0.610$
(at ℄ span)

subtract additional 0.075 (grass verge)

$\therefore$ Enhancement factor $\frac{D}{d} = 1.10$

Cumbria County Council

Design & Business Services

Design Services Work Sheet

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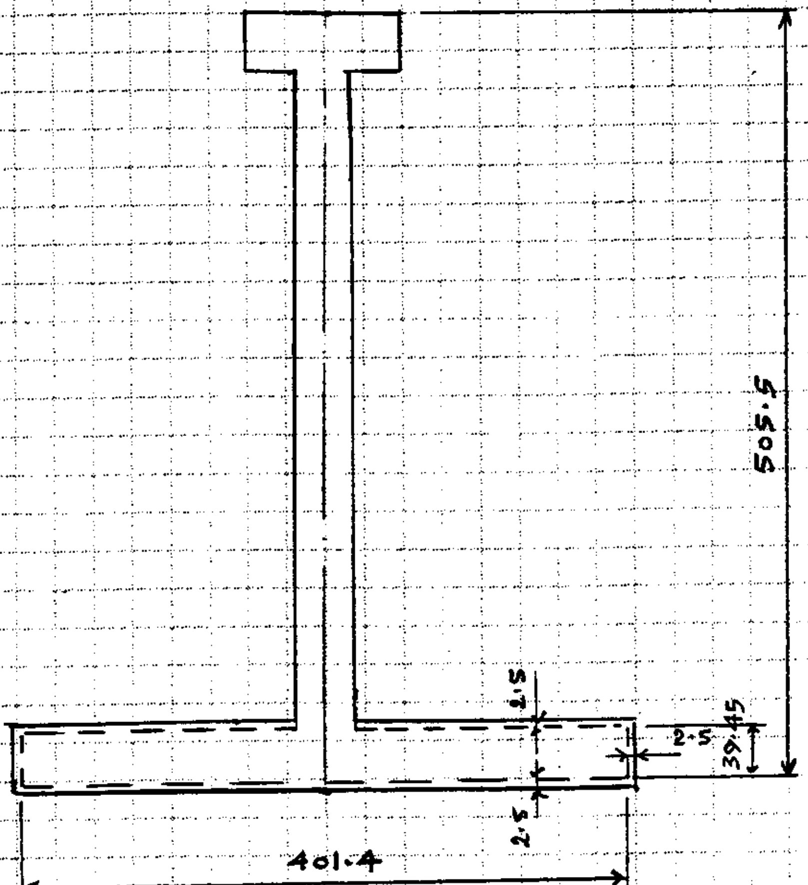
Rev. No.

Scheme	Scheme Ref.	Date Prepared	Prepared by
BRPB	C1461437	9/8/99	SK
Element / item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	16/8/99	SK

CALCULATIONS / WORK

Output / Remarks

Internal Beam



The nett cross-section refered to in the calculations is based on 2.5 mm of corrosion at the bottom flange.

Cumbria County Council | Design & Business Services

Design Services Work Sheet

Sheet No. A/1/3
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Scheme: BRPB
Scheme Ref.: C1461437
Date Prepared: 20/10/99
Prepared by: DK

Element / Item: Hill Cottage Railway Bridge.
Joblog No.: 23342
Date Checked: 21/10/99
Checked by: DK

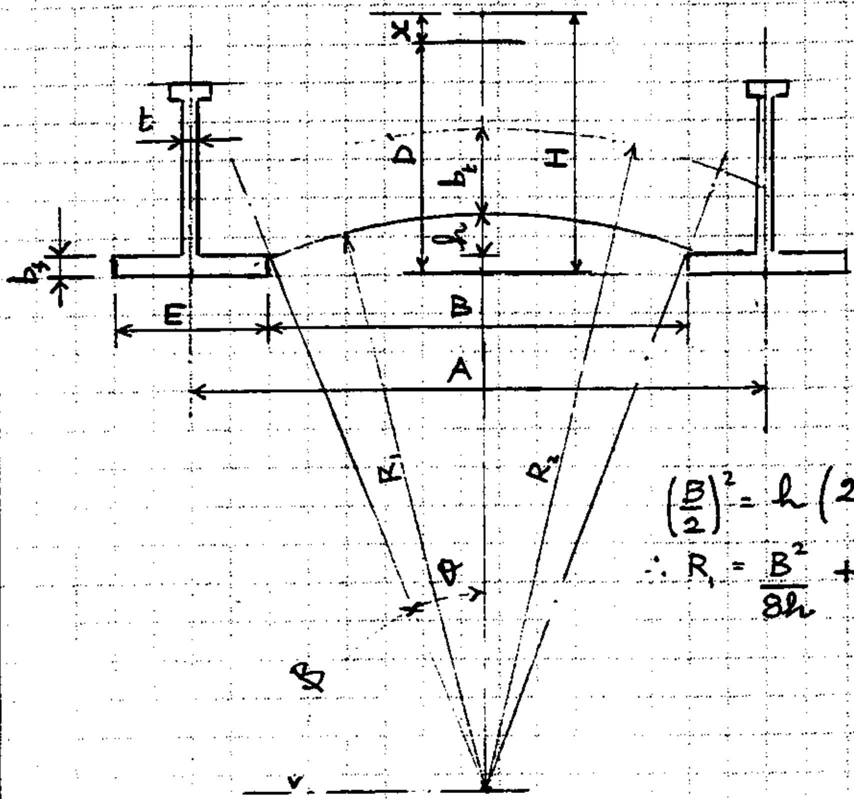
CALCULATIONS / WORK

Output / Remarks

Internal Beam
Dead Loading.

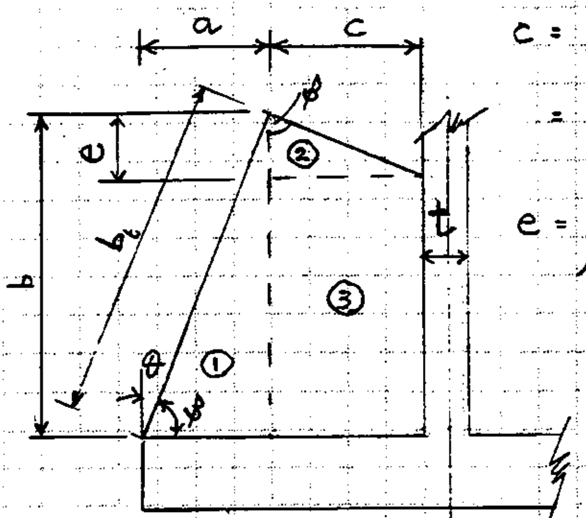
$D' = H - x$

$x = 100$



$$\left(\frac{B}{2}\right)^2 = h\left(2R_1 - h\right)$$

$$\therefore R_1 = \frac{B^2}{8h} + \frac{h}{2}$$



$$c = \frac{E-t}{2} - a$$

$$= \frac{E-t}{2} - b_t \cos\beta$$

$$e = \frac{c}{\tan\beta}$$

$$\text{area } ① = b_t \cos\beta \times b_t \sin\beta \times 0{\cdot}5 = 0{\cdot}5\, b_t^2 \cos\beta \sin\beta$$

$$\text{area } ② = \frac{c^2}{2\tan\beta} = \left(\frac{E-t}{2} - b_t \cos\beta\right)^2 \cdot \frac{1}{2\tan\beta}$$

$$\text{area } ③ = (b - e)c = \left(b_t \sin\beta - \frac{c}{\tan\beta}\right) c$$

Cumbria County Council | Design & Business Services

Design Services Work Sheet

Scheme	Scheme Ref.	Date Prepared	Sheet No. A/1/4 of Sheets Rev. No.
BRPB	C/461437	20/10/99	Prepared by
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	21/10/99	

CALCULATIONS / WORK | Output / Remarks

<u>Internal Beam</u>

<u>Dead Loading</u>.

Area of jack arch between radial lines

$$= (\pi R_2^2 - \pi R_1^2) \times \frac{2\theta}{360}$$

$$= \left[(R_1 + b_t)^2 - R_1^2\right] \frac{\pi\theta}{180}$$

Total area of jack arch

$$= \left[(R_1 + b_t)^2 - R_1^2\right] \frac{\pi\theta}{180} + \left[\sum \text{areas } ① \; ② \; \& \; ③\right] 2$$

area of segment

$$= \frac{2\theta}{360} \times \pi R_1^2 - \frac{B}{2}(R_1 - h)$$

area of filling

= (D × A) – area of segment

– Total area of jack arch

– cross-sectional area of beam

– $(B \times b_f)$

area of surfacing A × x

Cumbria County Council
Design & Business Services

Design Services Work Sheet

Sheet No. A/2
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Rev. No.

Scheme BRPB	Scheme Ref. C146/437	Date Prepared 20/10/99	Prepared by
Element / Item Hill Cottage Railway Bridge	Joblog No. 23342	Date Checked 21/10/99	Checked by

CALCULATIONS / WORK

Output / Remarks

Internal Beam

Dead loading

$h = 9'' - 1\tfrac{3}{4} = 7\tfrac{1}{4}'' = 184{\cdot}1$

$B = 42'' = 1067$

$b_t = 228{\cdot}6$

$$R_1 = \frac{B^2}{8h} + \frac{h}{2} = \frac{1067^2}{8 \times 184{\cdot}1} + \frac{184{\cdot}1}{2} = 865$$

$$\sin\theta = \frac{B}{2R_1} = \frac{1067}{2 \times 865} = 0{\cdot}6168$$

$\therefore \theta = 38{\cdot}08^\circ$

$\cos\theta = 0{\cdot}7871 = \sin\beta$

$\beta = 90 - \theta = 51{\cdot}92^\circ$

$\cos\beta = 0{\cdot}6168 = \sin\theta$

$$\text{area ①} = 0{\cdot}5 b_t \cos\beta \sin\beta$$

$$= 0{\cdot}5 \times 228{\cdot}6^2 \times 0{\cdot}6168 \times 0{\cdot}7871$$

$$= \underline{12685\ \text{mm}^2}$$

$E = 1470 - 1067 = 403$

$t = 38{\cdot}1$

$\tan\beta = 1{\cdot}276$

$$\text{area ②} = \left(\frac{E-t}{2} - b_t \cos\beta\right)^2 \cdot \frac{1}{2\tan\beta}$$

$$= \left[\frac{364{\cdot}9}{2} - \left(228{\cdot}6 \times 0{\cdot}6168\right)\right]^2 \cdot \frac{1}{2 \times 1{\cdot}276}$$

$$= \underline{673\ \text{mm}^2}$$

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. A/2/1
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Rev. No.

Scheme	Scheme Ref.	Date Prepared	Prepared by
BRPB	C 1461437	20/10/99	SL
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	21/10/99	SL

CALCULATIONS / WORK

Output / Remarks

$$c = \frac{E-t}{2} - b_t \cos\beta$$

$$= \frac{364{\cdot}9}{2} - (228{\cdot}6 \times 0{\cdot}6168)$$

$$= 41{\cdot}4$$

$$e = \frac{c}{\tan\beta} = \frac{41{\cdot}4}{1{\cdot}276} = 32{\cdot}4$$

area ③ $= (b - e)c$

$$= (b_t \sin\beta - e)c$$

$$= [(228{\cdot}6 \times 0{\cdot}7871) - 32{\cdot}4]\,41{\cdot}4$$

$$= \underline{6108\ mm^2}$$

$$\left[\Sigma \text{ areas } ① \ ② \ \& \ ③\right] 2$$

$$= (12685 + 673 + 6108)\,2$$

$$= 38932\ mm^2 = \underline{0{\cdot}038932\ m^2}$$

area of jack arch between radial lines

$$= \left[(R_1 + b_t)^2 - R_1^2\right] \frac{\pi\theta}{180}$$

$$= \left[(865+229)^2 - 865^2\right] \times \pi \times \frac{38{\cdot}08}{180}$$

$$= 298156\ mm^2 = \underline{0{\cdot}298156\ m^2}$$

Total area of jack arch

$$= 0{\cdot}298156 + 0{\cdot}038932 = 0{\cdot}337088\ m^2$$

Cross-sectional area of beam

$$= \underline{0{\cdot}036011\ m^2}$$

area of segment

$$= \frac{\theta}{180} \times \pi R_1^2 - \frac{B}{2}(R_1 - h)$$

$$= \left(\frac{38{\cdot}08}{180} \times \pi \times 865^2\right) - \left(\frac{1067}{2} \times 680{\cdot}9\right)$$

$$= 134026\ mm^2 = \underline{0{\cdot}134026\ m^2}$$

Cumbria County Council
Design & Business Services

Design Services Work Sheet

Sheet No. A/2/2
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BRPB	C1461437	20/10/99	
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	21/10/99	

CALCULATIONS / WORK

Output / Remarks

area of filling

$= (D' \times A) - \text{area of segment}$

$- \text{Total area of jack arch}$

$- \text{cross-sectional area of beam}$

$- (B \times b_f)$

$= (0{\cdot}638 \times 1{\cdot}470) - 0{\cdot}134026$

$- 0{\cdot}337088 - 0{\cdot}036011$

$- (1{\cdot}067 \times 0{\cdot}03945)$

$= \underline{0{\cdot}388642\,m^2}$

area of surfacing

$= 1{\cdot}470 \times 0{\cdot}100 = \underline{0{\cdot}1470\,m^2}$

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. A/3
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Scheme: BRPB

Scheme Ref.: C146/437

Date Prepared: 20/10/99

Prepared by: SK

Element / Item: Hill Cottage Railway Bridge

Joblog No.: 23342

Date Checked: 21/10/99

Checked by: SK

CALCULATIONS / WORK

Output / Remarks

DL + SDL

Jack arch	23·54 × 0·337088	=	7·935
Fill (conc)	23·54 × 0·388642	=	9·149
Surfacing	23·54 × 0·1470	=	3·460
Beam	70·61 × 0·036011	=	2·543

Assessment loads

	γ_{f1}	γ_{f3}	Q_k	$Q_k \gamma_{f1} \gamma_{f3}$
Jack arch	1·0	1·0	7·935	7·935
Fill (conc)	1·0	1·0	9·149	9·149
Surfacing	1·5	1·0	3·460	5·190
Beam	1·0	1·0	2·543	2·543
				24·817

$$M_{DL+SDL} = \frac{wl^2}{8} = \frac{24{\cdot}817 \times 7{\cdot}82^2}{8} = 189{\cdot}70 \text{ kNm}$$

$$V_{DL+SDL} = \frac{wl}{2} = \frac{24{\cdot}817 \times 7{\cdot}82}{2} = 97{\cdot}03 \text{ kN}$$

Location: **INTERNAL BEAM** @ Midspan d=508mm

Gross cross-section.

Properties of any plane section

The section is defined by coordinates of corner points taken in anti-clockwise order round the section. The cross section is kept to the left of the edge running from a previous point to the next point. The section is closed when the original point is specified again.

Coordinates of points in order:

Point 1 :	X-coordinate	x(1)=0 mm
	Y-coordinate	y(1)=0 mm
Point 2 :	X-coordinate	x(2)=406.4 mm
	Y-coordinate	y(2)=0 mm
Point 3 :	X-coordinate	x(3)=406.4 mm
	Y-coordinate	y(3)=44.45 mm
Point 4 :	X-coordinate	x(4)=222.25 mm
	Y-coordinate	y(4)=44.45 mm
Point 5 :	X-coordinate	x(5)=222.25 mm
	Y-coordinate	y(5)=469.9 mm
Point 6 :	X-coordinate	x(6)=254 mm
	Y-coordinate	y(6)=469.9 mm
Point 7 :	X-coordinate	x(7)=254 mm
	Y-coordinate	y(7)=508 mm
Point 8 :	X-coordinate	x(8)=152.4 mm
	Y-coordinate	y(8)=508 mm
Point 9 :	X-coordinate	x(9)=152.4 mm
	Y-coordinate	y(9)=469.9 mm
Point 10 :	X-coordinate	x(10)=184.15 mm
	Y-coordinate	y(10)=469.9 mm
Point 11 :	X-coordinate	x(11)=184.15 mm
	Y-coordinate	y(11)=44.45 mm
Point 12 :	X-coordinate	x(12)=0 mm
	Y-coordinate	y(12)=44.45 mm
Point 13 :	X-coordinate	x(13)=0 mm
	Y-coordinate	y(13)=0 mm

Sectional properties

Cross-sectional area	38145 mm² ~ Gross Section Area
Second moments of area (inertias)	Ixx=1.1594E+9 mm⁴ Iyy=253919597 mm⁴
Product of inertia $\int dA.xy$	Ixy=0.71526E-6 mm⁴
Distance of centroid from origin	X=203.2 mm Y=169.43 mm

X and Y are principal axes.

$$Z_c = \frac{1{\cdot}1594E\,9}{508-169{\cdot}43} = 3424402 \text{ mm}^3$$

338·57

No650

$$Z_t \quad \frac{1{\cdot}1594\,E9}{169{\cdot}43} = 6842944 \text{ mm}^3$$

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. A/5 of Sheets

Rev. No.

Scheme	Scheme Ref.	Date Prepared	Prepared by
BRPB	C1461437	9/8/99	SK
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	21/10/99	SK

CALCULATIONS / WORK | Output / Remarks

Internal Beam.

i) Gross cross-section with enhancement.

$\frac{D}{d} = \frac{663}{508} = 1{\cdot}31$

$Z_{c_{LL}} = 3424402 \times 1{\cdot}31 = 4485967 \text{ mm}^3$ A/4

$Z_{t_{LL}} = 6842944 \times 1{\cdot}31 = 8964257 \text{ mm}^3$ A/4

DL + SDL stresses.

$f_{bc} = \frac{189{\cdot}70 \times 10^6}{3424402} = 55{\cdot}40 \text{ N/mm}^2$ A/3

$f_{bt} = \frac{189{\cdot}70 \times 10^6}{6842944} = 27{\cdot}72 \text{ N/mm}^2$

$f_s = \frac{V}{d_w t} = \frac{97{\cdot}03 \times 10^3}{425{\cdot}45 \times 38{\cdot}1} = 5{\cdot}99 \text{ N/mm}^2$ A/3

stresses available for LL

$f_{bc} = 154 - 55{\cdot}40 = 98{\cdot}60 \text{ N/mm}^2$

$f_{bt} = 46 - 27{\cdot}72 = 18{\cdot}28 \text{ N/mm}^2$

$f_s = 46 - 5{\cdot}99 = 40{\cdot}01 \text{ N/mm}^2$

} But subjected to further restrictions

Cumbria County Council
Design & Business Services

Design Services Work Sheet

Sheet No. A/5/1
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Scheme	Scheme Ref.	Date Prepared	Prepared by
BRPB	C1461437	9/8/99	
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	21/10/99	

CALCULATIONS / WORK

Output / Remarks

Internal Beam.

3) Nett cross-section with enhancement

$\frac{D}{d} = 1{\cdot}31$

$Z_{c_{LL}} = 3362443 \times 1{\cdot}31 = 4404800 \text{ mm}^3$ A/6/1 & A/1

$Z_{t_{LL}} = 6310967 \times 1{\cdot}31 = 8267367 \text{ mm}^3$ " "

DL + SDL stresses

$f_{bc} = \frac{189{\cdot}70 \times 10^6}{3362443} = 56{\cdot}42 \text{ N/mm}^2$

$f_{bt} = \frac{189{\cdot}70 \times 10^6}{6310967} = 30{\cdot}06 \text{ N/mm}^2$

$f_s = 5{\cdot}99$ as for gross cross-section. (no web corrosion assumed)

stresses available for LL

$f_{bc} = 154 - 56{\cdot}42 = 97{\cdot}58 \text{ N/mm}^2$

$f_{bt} = 46 - 30{\cdot}06 = 15{\cdot}94 \text{ N/mm}^2$

$f_s = 40{\cdot}01$ as for gross cross-section

But subjected to further restrictions

No. C&D C/DES1 REV C (6/99)

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. A/6
of Sheets
Rev. No.

Scheme: BRPB

Scheme Ref.: C1461437

Date Prepared: 9/8/99

Prepared by

Element / Item: Hill Cottage Railway Bridge

Joblog No.: 23342

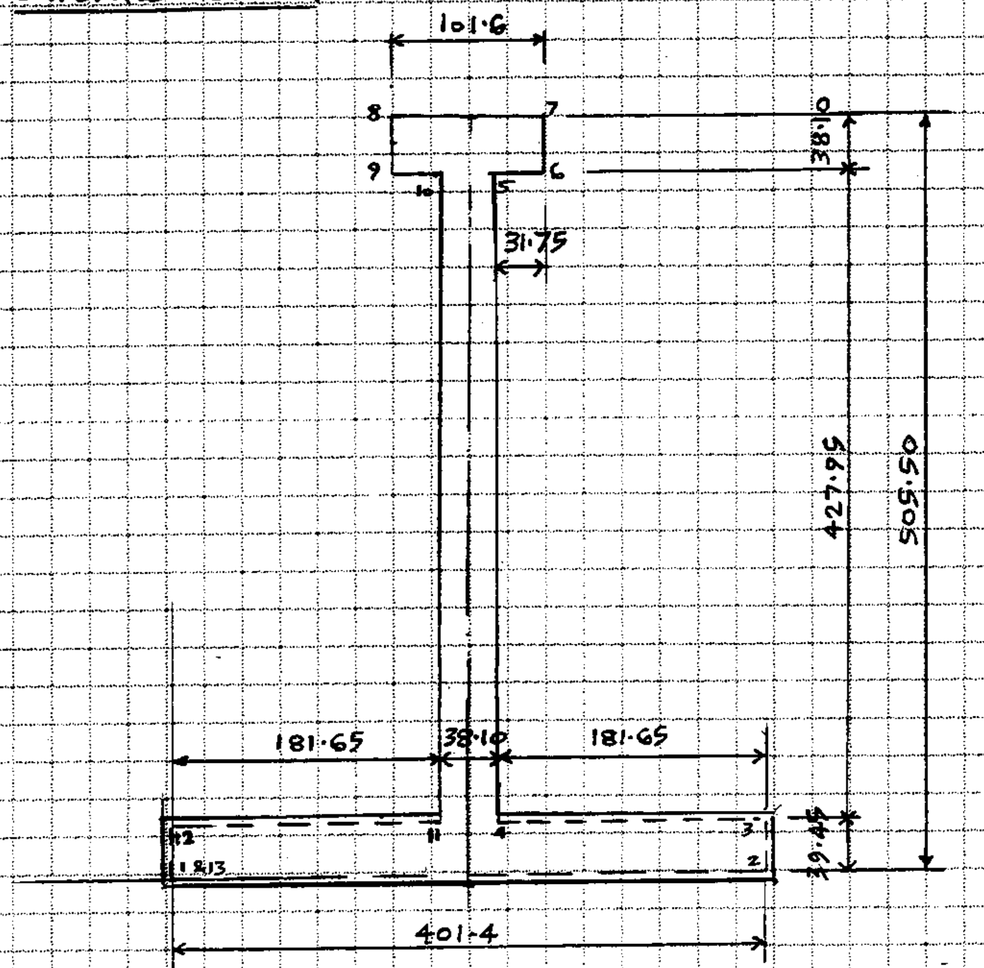
Date Checked: 16/8/99

Checked by

CALCULATIONS / WORK

Output / Remarks

Internal Beam.



2.5mm of corrosion to bottom flange

point	co-ordinates	
	x	y
1	0	0
2	401.4	0
3	401.4	39.45
4	219.75	39.45
5	219.75	467.4
6	251.5	467.4
7	251.5	505.5
8	149.9	505.5
9	149.9	467.4
10	181.65	467.4
11	181.65	39.45
12	0	39.45
13	0	0

DESIGN SERVICES
BRITISH RAIL PROPERTY BOARD
HILL COTTAGE RAILWAY BRIDGE
CORRODED SECTION PROPERTIES

Made by: JK A/6/1
Date:
Ref No: 23342

Office: 5598

Location: INTERNAL BEAM @ Midspan d = 505.50mm (Corroded Section)

Properties of any plane section — Nett Cross-section

The section is defined by coordinates of corner points taken in anti-clockwise order round the section. The cross section is kept to the left of the edge running from a previous point to the next point. The section is closed when the original point is specified again.

Coordinates of points in order:

Point 1	: X-coordinate	x(1)=0 mm
	Y-coordinate	y(1)=0 mm
Point 2	: X-coordinate	x(2)=401.40 mm
	Y-coordinate	y(2)=0 mm
Point 3	: X-coordinate	x(3)=401.40 mm
	Y-coordinate	y(3)=39.45 mm
Point 4	: X-coordinate	x(4)=219.75 mm
	Y-coordinate	y(4)=39.45 mm
Point 5	: X-coordinate	x(5)=219.75 mm
	Y-coordinate	y(5)=467.4 mm
Point 6	: X-coordinate	x(6)=251.5 mm
	Y-coordinate	y(6)=467.4 mm
Point 7	: X-coordinate	x(7)=251.5 mm
	Y-coordinate	y(7)=505.5 mm
Point 8	: X-coordinate	x(8)=149.9 mm
	Y-coordinate	y(8)=505.5 mm
Point 9	: X-coordinate	x(9)=149.9 mm
	Y-coordinate	y(9)=467.4 mm
Point 10	: X-coordinate	x(10)=181.65 mm
	Y-coordinate	y(10)=467.4 mm
Point 11	: X-coordinate	x(11)=181.65 mm
	Y-coordinate	y(11)=39.45 mm
Point 12	: X-coordinate	x(12)=0 mm
	Y-coordinate	y(12)=39.45 mm
Point 13	: X-coordinate	x(13)=0 mm
	Y-coordinate	y(13)=0 mm

Sectional properties

Cross-sectional area	36011 mm²
Second moments of area (inertias)	Ixx=1.1089E+9 mm⁴ Iyy=217919155 mm⁴
Product of inertia $\int dA.xy$	Ixy=-0.47684E-6 mm⁴
Distance of centroid from origin	X=200.7 mm Y=175.71 mm

X and Y are principal axes.

No650

$$Z_c = \frac{1.1089E9}{505.5 - 175.71} = 3362443 \text{ mm}^3$$

$$Z_t = \frac{1.1089E9}{175.71} = 6310967 \text{ mm}^3$$

Cumbria County Council **Design Services Work Sheet**		Design & Business Services	Sheet No. B/1 of Sheets Rev. No.
Scheme BRPB	Scheme Ref. C1461437	Date Prepared 10/8/99	Prepared by
Element / Item Hill Cottage Railway Bridge	Joblog No. 23342	Date Checked 16/8/99	Checked by
CALCULATIONS / WORK			Output / Remarks

'e

Internal Beams.

Live Loading.

carriageway width 2.80m

No. of notional lanes 1No.

Loaded length 7.82m

Nom. HA UDL. $\omega = 336\left(\frac{1}{7.82}\right)^{0.67}$

$= 84.70$ kN/m.

nom KEL / lane = 120kN.

Adjustment factor for loaded length ≤ 20m = 1.46

Adjusted UDL $= \frac{84.70}{1.46} = 58.01$ kN/m

" KEL $= \frac{120}{1.46} = 82.19$ kN/lane

These relate to a 2.5m wide lane.

$$M_{LL} = \frac{wl^2}{8} + \frac{Wl}{4}$$

$$= \frac{58.01 \times 7.82^2}{8} + \frac{82.19 \times 7.82}{4}$$

$$= 443.43 + 160.68$$

$= 604.11$ kNm / 2.5m lane

ℓ 2.8 $S_{LL} = \frac{wl}{2} = \frac{58.01 \times 7.82}{2} = 226.82$ kN / 2.5m lane

" $S_K = 82.19$ kN / 2.5m lane.

Cumbria County Council

Design & Business Services

Design Services Work Sheet

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Rev. No.

Scheme: BRPB
Scheme Ref.: C1461437
Date Prepared: 10/8/99
Prepared by: SL
Element / Item: Hill Cottage Railway Bridge
Joblog No.: 23342
Date Checked: 21/10/99
Checked by: SL

de

CALCULATIONS / WORK

Output / Remarks

9 16/97
'l 2·6

Simple Distribution methods

The nominal live load bending moment applied to an internal girder under a traffic lane can be obtained by multiplying the gross moment by the appropriate factor from Fig 2/2

Girder spacing 1·47 m
Effective span 7·82 m

Graph a) Single lane loading.

$K_L = 0{\cdot}32$

$M_{LL} = 604{\cdot}11$ kNm — B/1

$M'_{LL} = 604{\cdot}11 \times 0{\cdot}32 = 193{\cdot}32$ kNm. — B/2/1

Consider traffic/surface condition to be (L_p)

$M''_{LL} = 193{\cdot}32 \times 0{\cdot}87 = 168{\cdot}19$ kNm.
↖ K for 40 Tonnes (L_p)

Case 1 gross-section & Case 3 nett section.

$f_{bt'_{LL}} = \dfrac{193{\cdot}32 \times 10^6}{8964257} = 21{\cdot}57 \text{ N/mm}^2$ — Gross-section A/5

$f_{bt_{DL+SDL}} = 27{\cdot}72 \text{ N/mm}^2 = f_d$ — A/5

'l 4·10

$f_L = 24{\cdot}6 - 0{\cdot}44 f_d$

$= 24{\cdot}6 - (0{\cdot}44 \times 27{\cdot}72) = 12{\cdot}40 \text{ N/mm}^2$ — Gross section

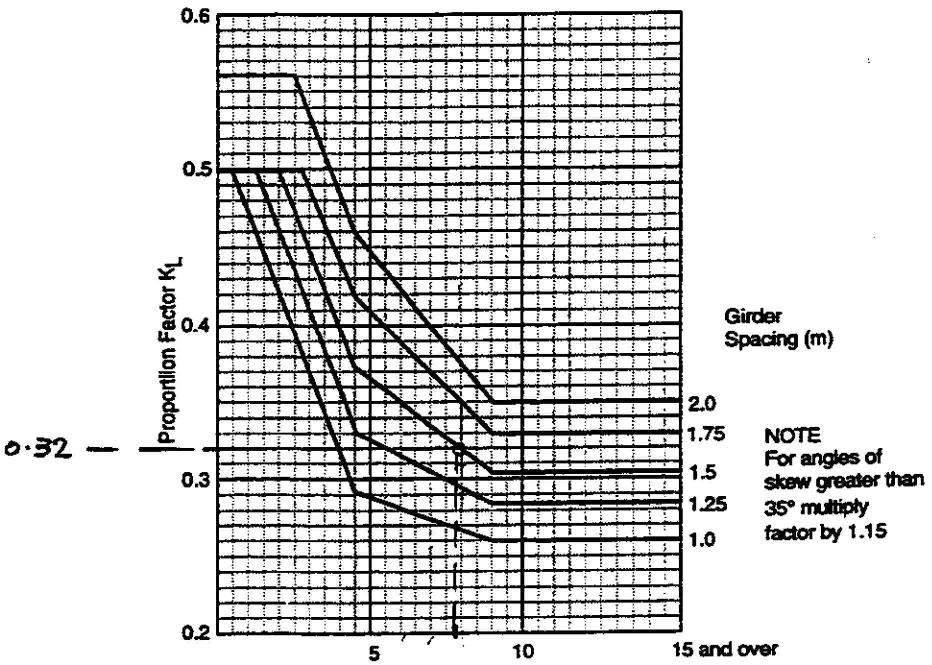
$\text{"} \quad - (0{\cdot}44 \times 30{\cdot}06) = 11{\cdot}37 \text{ "}$ — nett section

or $f_L = 19{\cdot}6 - 0{\cdot}76 f_d$

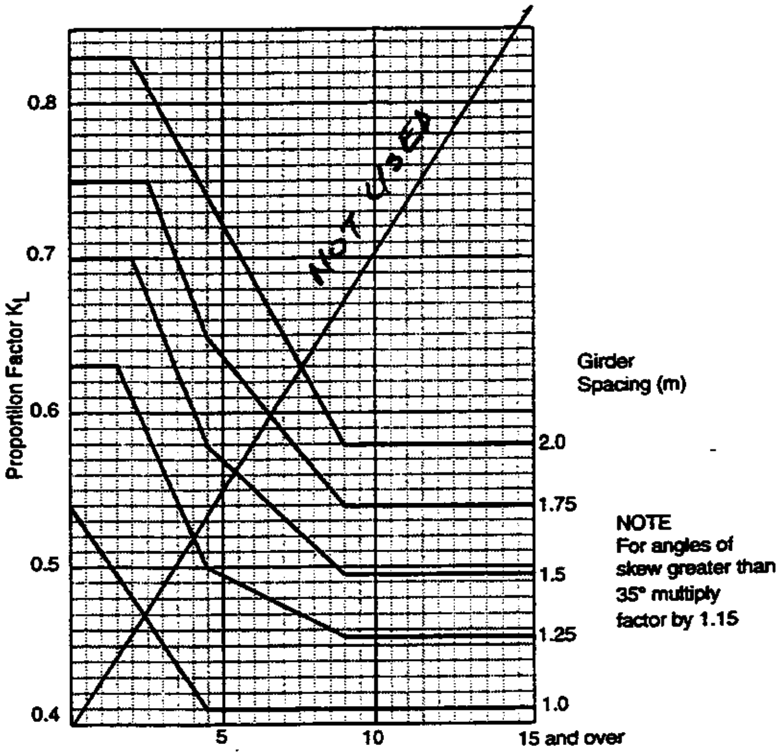
$= 19{\cdot}6 - (0{\cdot}76 \times 27{\cdot}72) = -1{\cdot}47 \text{ N/mm}^2$ — Gross-section

Tensile stress due to LL
$= 21{\cdot}57 \text{ N/mm}^2 > \underline{12{\cdot}40 \text{ N/mm}^2}$ unsuitable for K = 1 (L_p) — Gross-section
$> \underline{11{\cdot}37 \text{ N/mm}^2}$ " — nett-section.

B/2/1



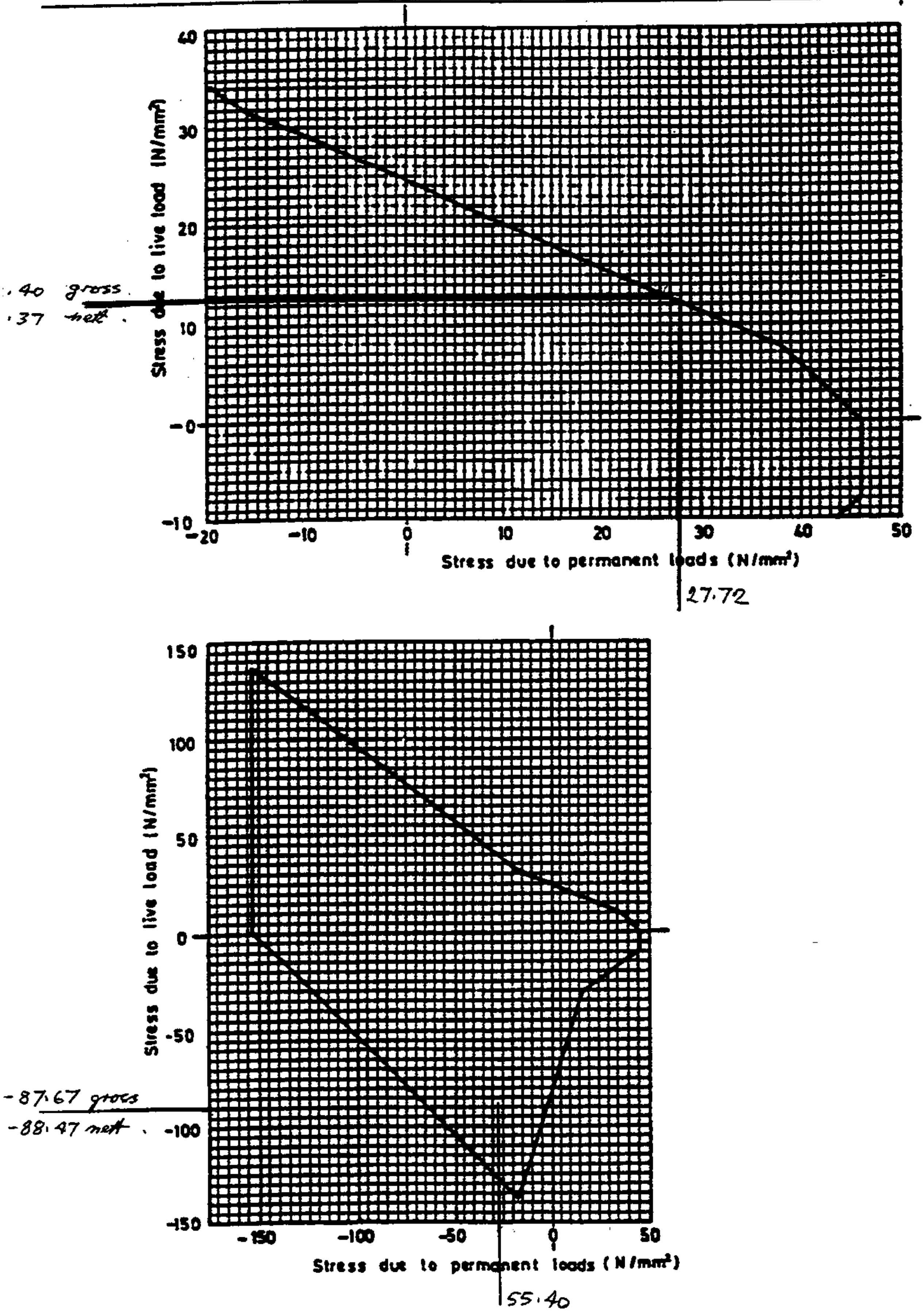
(a) Single Lane Loading



(b) Multiple Lane Loading

Figure 2/2 Proportion Factors for Internal Longitudinal Girders

B/2/2



.40 gross
.37 nett
27.72

-87.67 gross
-88.47 nett
55.40

Figure 4.1 Permissible Stresses in Cast Iron

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BRPB	C1461437	10/8/99	DK
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Hill Cottage Railway Bridge	23342	21/10/99	DK

le

CALCULATIONS / WORK — Output / Remarks

$f_{bc' \, LL} = \frac{193.32 \times 10^6}{4485967} = 43.09 \text{ N/mm}^2$ — A/5

$f_{be \, DL+SDL} = 55.40 \text{ N/mm}^2 = f_d$ — Gross section

56.42 " — Nett section

l 4·10 $f_L = -43.9 + 0.79 f_d$

$= -43.9 + (0.79 \times -55.40) = -87.67 \text{ N/mm}^2$ — Gross section

" $+ (0.79 \times -56.42) = -88.47$ " — Nett section

or $f_L = -81.3 + (3.15 \times -55.40) = -255.81 \text{ N/mm}^2$
Gross section but ignore.

Compressive stress due to LL

$= 43.09 \text{ N/mm}^2 < 87.67 \text{ N/mm}^2$ ∴ OK — Gross section

< 88.47 " for K=1.0 (L_p) — Nett section

check $55.40 + 87.67 = 143.07 < 154$ ∴ OK — Gross section

limiting stress $< 154 \text{ N/mm}^2$ $56.42 + 88.47 = 144.89 <$ " — Nett section

<u>Longitudinal Members</u> —— <u>Shear</u>

l 2·8 nominal shear on longitudinal member ≥ 2 m

$S_L = K_L S_u + 0.5 S_k$

S_L = shear on longitudinal member (kN)

K_L = appropriate proportion factor from Figs 2/2 or 2/3

S_u = gross shear of one 2·5 m notional lane of UDL. (kN)

S_k = value of KEL for one 2·5m notional lane (kN)

$S_L = \frac{wl}{2} \cdot K_L + 0.5 \times 82.19$

$= \frac{58.01 \times 7.82}{2} \times 0.32 + 41.095$ — B/1

$= \underline{113.68 \text{ kN}}$

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CALCULATIONS / WORK			Output / Remarks

$S_L'' = 113.68 \times 0.87 = 98.90$ kN

$f_s' = \dfrac{113.68 \times 10^3}{425.45 \times 38.1} = 7.01$ N/mm^2 (for both gross and nett cross-section) A/5

Shear stress due to (DL + SDL) + LL

$= 5.99 + 7.01 = 13.00$ N/mm^2

< 46 N/mm^2 ∴ OK for $K = 1.0$ (L_p)

but check also:

cl 4.11 $q_L \le 24.6 - 0.44 q_d$ N/mm^2

$24.6 - (0.44 \times 5.99) = 21.96$ N/mm^2

> 7.01 N/mm^2 ∴ OK. for $K = 1.0$ (L_p)

As corrosion was only assumed at the surfaces of the bottom flange, the shear stress for gross and nett cross-sections can be considered to be same.

Shear Resistance $V_b = t_w d_w \times \dfrac{46}{\sqrt{3}} \times 10^{-3}$ kN

(providing that the web is fully supported laterally as for case of compact section)

$= 38.1 \times 425.45 \times \dfrac{46}{\sqrt{3}} \times 10^{-3}$

$= 430$ kN (upper bound)

> 113.68 kN $+ 97.03$

Adjusted HA Loading DL+SDL

∴ Adequate shear resistance is provided.

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Construction Services

Consultancy & Design Work Sheet

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Date Checked: 21/10/99
Checked by: SL

de

CALCULATIONS / WORK

Output / Remarks

Internal Beam – assessment capacity wrt tensile stress in bottom flange.

Case 1

$f_L < 46 - f_{bt}$

$12{\cdot}40 < 46 - 27{\cdot}72 = 18{\cdot}28$ N/mm² gross-section

A/5 & B/2

$11{\cdot}37 < 46 - 30{\cdot}06 = 15{\cdot}94$ " nett section

A/5/1 & B/2

$f_{bt}' = \dfrac{193{\cdot}32\times10^6}{8964257} = 21{\cdot}57$ N/mm² $\therefore C = \dfrac{12{\cdot}40}{21{\cdot}57} = 0{\cdot}575$

Group 1 FE

Case 2

$f_{bt}' = \dfrac{193{\cdot}32\times10^6}{6842944} = 28{\cdot}25$ N/mm² $\therefore C = \dfrac{12{\cdot}40}{28{\cdot}25}$ $0{\cdot}439$

7.5 Tonnes.

Case 3

$f_{bt}' = \dfrac{193{\cdot}32\times10^6}{8267367} = 23{\cdot}38$ N/mm² $\therefore C = \dfrac{11{\cdot}37}{23{\cdot}38} = 0{\cdot}486$

Group 1 FE

Case 4

$f_{bt}' = \dfrac{193{\cdot}32\times10^6}{6310967} = 30{\cdot}63$ $\therefore C = \dfrac{11{\cdot}37}{30{\cdot}63} = 0{\cdot}370$

7.5 Tonnes.

B/5/1

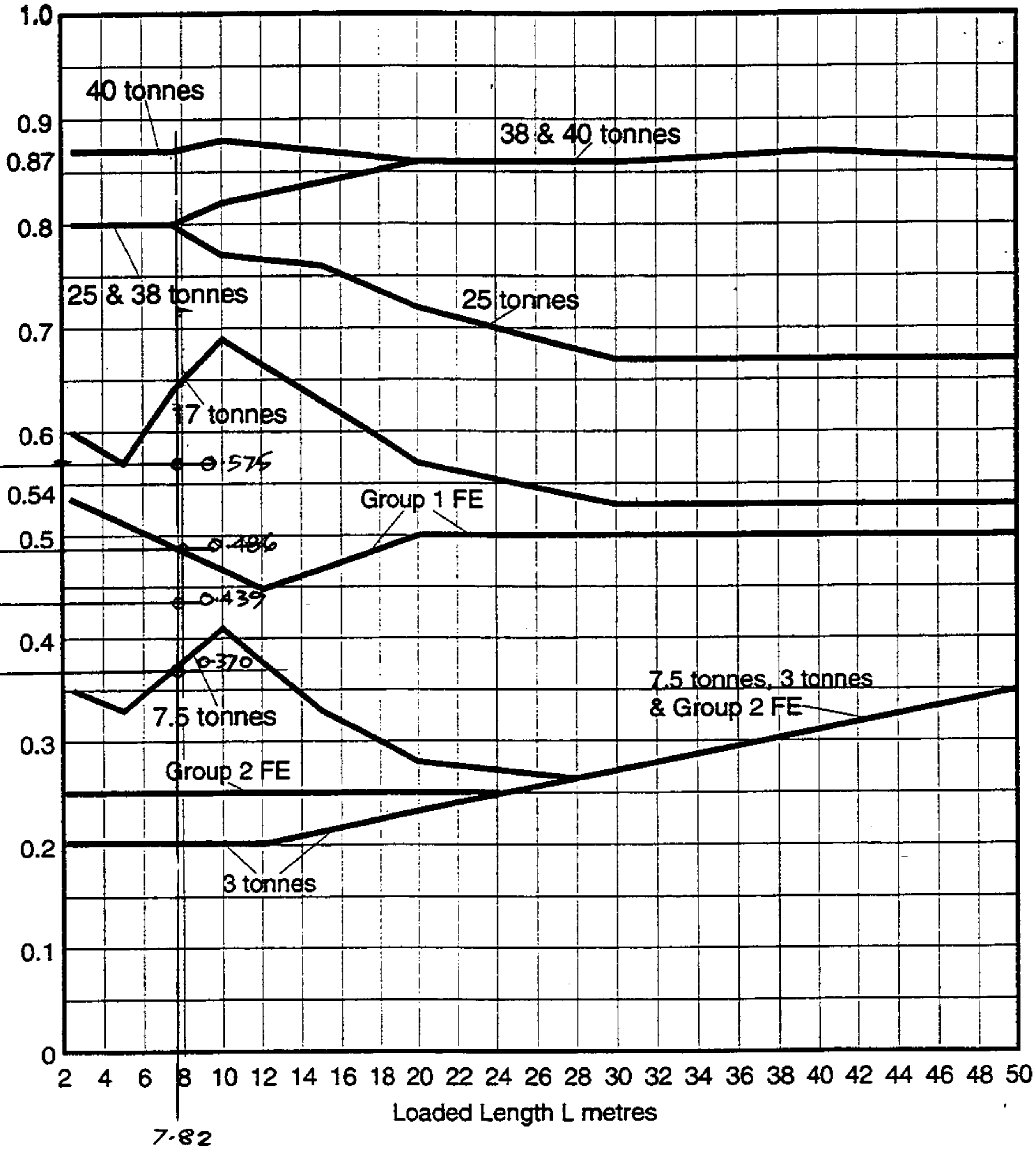

FIG 5/4. K Factors for Low Traffic Poor Surface (Lp)

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Construction Services

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Prepared by:
Element / Item: Hill Cottage Railway Bridge
Joblog No.: 23342
Date Checked: 21/10/99
Checked by:

de
f.

CALCULATIONS / WORK

Output / Remarks

Internal Beam - assessment capacity wrt compressive stress in top flange

Case 1

$f_c = 87.67 < 157 - 55.40 = 98.60 \text{ N/mm}^2$ B/3 & A/5

$f_{bc}' = \frac{193.32 \times 10^6}{4485967} = 43.09 \text{ N/mm}^2$

$\therefore \quad C = \frac{87.67}{43.09} > 1.0$

∴ compressive stress well within acceptable limit.

Case 4 (worst case)

$f_c = 88.47 < 154 - 56.42 = 97.58 \text{ N/mm}^2$ B/3 & A/5/1

$f_{bc} = \frac{193.32 \times 10^6}{3362443} = 57.49 \text{ N/mm}^2$

$\therefore \quad C = \frac{88.47}{57.49} > 1.0$

∴ compressive stress well within acceptable limit for Adjusted HA Loading.

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Design & Business Services

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Checked by:

CALCULATIONS / WORK

Output / Remarks

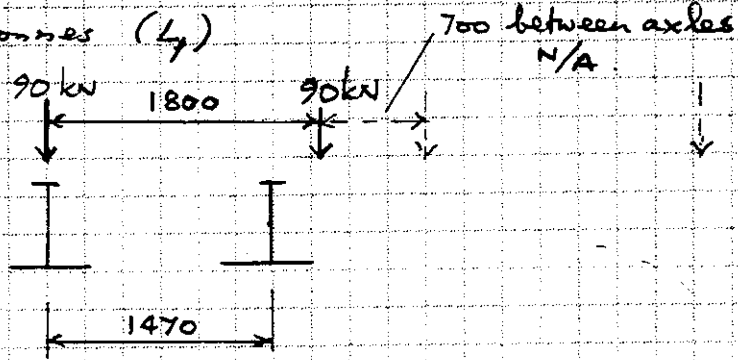
1/97
5.31-5.33

Single Axle and Single Wheel Loads.

le 5/3/1

Nominal Single Axle Loads

For 40 Tonnes (L_y)



As only 1 No axle can be placed transversely on the 2.80m carriageway the effect on the critical beam is the same as that of single wheel load.

As span of 7.82m is large compared with patch loading produced by distribution of Single Wheel Load, consider as point load.

Assessment load = $90 \times \overset{\gamma_{f1}}{1.0} = 90$ k
(at mid-span)

Moment at mid-span $= \frac{wl}{4} = \frac{90 \times 7.82}{4} = 175.95$ kNm

16/97
2.22.

Distributed moment at mid-span $= 175.95\ K_L$ $K_L = 0.32$

$= \underline{56.30 \text{ kNm}}$.

Consider: Case 3 Nett cross-section with enhancement.

$f_{bt} = 30.06$ N/mm^2 $= f_d$ A/5/1
DL+SDL   B/2

$f_{bt'}{}_{LL} = \frac{56.30 \times 10^6}{8267367} = 6.81$ N/mm^2

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Design & Business Services

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CALCULATIONS / WORK

Output / Remarks

$f_t = 24.6 - 0.44 f_d$

$= 24.6 - (0.44 \times 30.06) = 11.37 \ N/mm^2$

Tensile stress due to Single Wheel Load
$= 6.81 \ N/mm^2 < 11.37 \ N/mm^2$

∴ Suitable for 40 Tonnes (L_p)
Single Wheel Load.

Compressive stress not critical.

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ode
f.

CALCULATIONS / WORK

Output / Remarks

Longitudinal Cast Iron Edge Beam.

Consider the following cases: — Z values

1) Gross cross-section with enhancement — Z_c 5781554 mm^3
Z_t 7726687
2) Gross cross-section without enhancement — Z_c 5255958
Z_t 7024261
3) Nett cross-section with enhancement — Z_c 5643855
Z_t 7087953
4) Nett cross-section without enhancement — Z_c 5130777
Z_t 6443594

For "enhancement" see BD 21/97 Cl 7.13.

Enhancement factor for Edge Beam = 1.10 — A/1/1

NB. Ref. Drg C37/87 states that girder details are as for C37/94 ie Gills Railway Bridge.

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Hill Cottage Railway Bridge	23342	21/10/99	SL

CALCULATIONS / WORK | Output / Remarks

Edge Beam

Cross-sectional areas:

Edge beam	$0.03773\ m^2$
Masonry parapet 1.130×0.45	0.5085
Half area of jack arch	0.1690
Half filling (conc) for Internal Beam	0.1940
Verge filling (soil) $0.042 \times 1.45 \times 0.5$	0.0305

Dead loading.

Edge beam	70.61×0.03773	$= 2.66\ kN/m.$
Masonry parapet	23.54×0.5085	$= 11.97$
Jack arch	23.54×0.1690	$= 3.98$
Filling (conc)	23.54×0.1940	$= 4.57$
(soil)	17.66×0.0305	0.54
		23.72

$$M_{DL+SDL} = \frac{wl^2}{8} = \frac{23.72 \times 7.82^2}{8} = 181.32\ kNm.$$

$$V_{DL+SDL} = \frac{wl}{2} = \frac{23.72 \times 7.82}{2} = 92.75\ kN$$

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Design & Business Services

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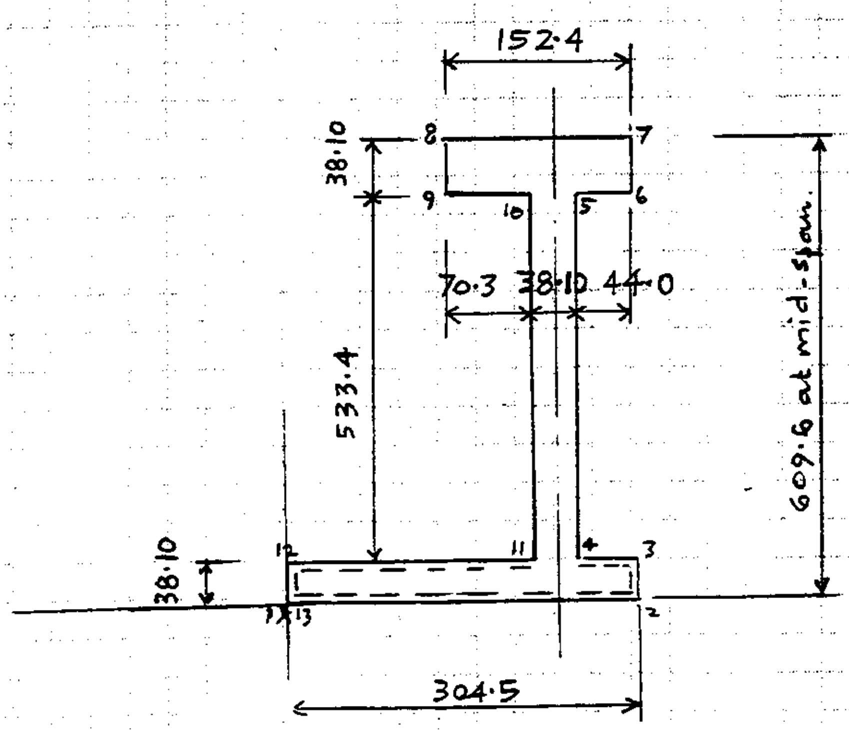
Hill Cottage Railway Bridge	23342	4/10/99	SK

CALCULATIONS / WORK

Output / Remarks

Edge Beam

Gross-section



	co-ordinates.	
point	x	y
1	0	0
2	304·5	0
3	304·5	38·1
4	260·5	38·1
5	260·5	571·5
6	304·5	571·5
7	304·5	609·6
8	152·1	609·6
9	152·1	571·5
10	222·4	571·5
11	222·4	38·1
12	0	38·1
13	0	0

C/2/1

BRPB
Hill Cottage Railway Bridge
Edge Beam
gross-section at centre of span

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Location:

Properties of any plane section

The section is defined by coordinates of corner points taken in anti-clockwise order round the section. The cross section is kept to the left of the edge running from a previous point to the next point. The section is closed when the original point is specified again.

Coordinates of points in order:

Point 1 :	X-coordinate	x(1)=0 mm
	Y-coordinate	y(1)=0 mm
Point 2 :	X-coordinate	x(2)=304.5 mm
	Y-coordinate	y(2)=0 mm
Point 3 :	X-coordinate	x(3)=304.5 mm
	Y-coordinate	y(3)=38.1 mm
Point 4 :	X-coordinate	x(4)=260.5 mm
	Y-coordinate	y(4)=38.1 mm
Point 5 :	X-coordinate	x(5)=260.5 mm
	Y-coordinate	y(5)=571.5 mm
Point 6 :	X-coordinate	x(6)=304.5 mm
	Y-coordinate	y(6)=571.5 mm
Point 7 :	X-coordinate	x(7)=304.5 mm
	Y-coordinate	y(7)=609.6 mm
Point 8 :	X-coordinate	x(8)=152.1 mm
	Y-coordinate	y(8)=609.6 mm
Point 9 :	X-coordinate	x(9)=152.1 mm
	Y-coordinate	y(9)=571.5 mm
Point 10 :	X-coordinate	x(10)=222.4 mm
	Y-coordinate	y(10)=571.5 mm
Point 11 :	X-coordinate	x(11)=222.4 mm
	Y-coordinate	y(11)=38.1 mm
Point 12 :	X-coordinate	x(12)=0 mm
	Y-coordinate	y(12)=38.1 mm
Point 13 :	X-coordinate	x(13)=0 mm
	Y-coordinate	y(13)=0 mm

Sectional properties

Cross-sectional area	37730 mm2
Second moments of area (inertias)	Ixx=1.8327E+9 mm4 Iyy=163923798 mm4
Product of inertia $\int dA.xy$	Ixy=225121001 mm4
Distance of centroid from origin	X=212 mm Y=260.91 mm
Principal second moments of area	Iu=1.8625E+9 mm4 Iv=134087601 mm4

$$Z_c = \frac{1.8327E9}{609.6-260.91} = 5255958 \text{ mm}^3$$

$$Z_b = \frac{1.8327E9}{260.91} = 7024261 \text{ mm}^3$$

C/2/2

BRPB
Hill Cottage Railway Bridge
Edge Beam
gross-section at centre of span

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Angle of principal U
counter-clockwise from XX-axis -7.5496 degrees

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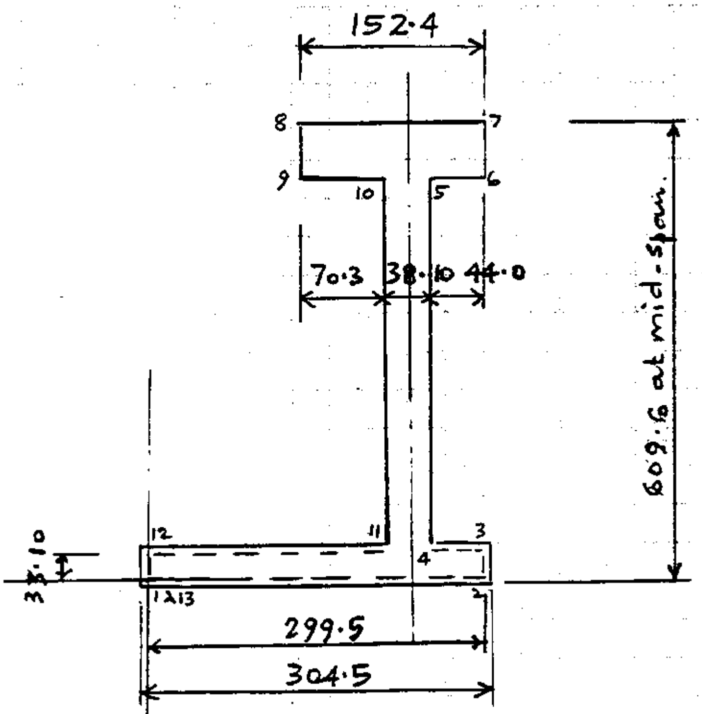
CALCULATIONS / WORK | Output / Remarks

Edge Beam

nett-section.



point	coordinates x	coordinates y
1	0	0
2	299·5	0
3	299·5	33·10
4	258·0	33·10
5	258·0	569·0
6	302·0	569·0
7	302·0	607·1
8	149·6	607·1
9	149·6	569·0
10	219·9	569·0
11	219·9	33·10
12	0	33·10
13	0	0

C/3/1

BRPB
Hill Cottage Railway Bridge
Edge Beam
nett-section at centre of span

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Location:

Properties of any plane section

The section is defined by coordinates of corner points taken in anti-clockwise order round the section. The cross section is kept to the left of the edge running from a previous point to the next point. The section is closed when the original point is specified again.

Coordinates of points in order:

Point 1 :	X-coordinate	x(1)=0 mm
	Y-coordinate	y(1)=0 mm
Point 2 :	X-coordinate	x(2)=299.5 mm
	Y-coordinate	y(2)=0 mm
Point 3 :	X-coordinate	x(3)=299.5 mm
	Y-coordinate	y(3)=33.10 mm
Point 4 :	X-coordinate	x(4)=258.0 mm
	Y-coordinate	y(4)=33.10 mm
Point 5 :	X-coordinate	x(5)=258.0 mm
	Y-coordinate	y(5)=569.0 mm
Point 6 :	X-coordinate	x(6)=302.0 mm
	Y-coordinate	y(6)=569.0 mm
Point 7 :	X-coordinate	x(7)=302.0 mm
	Y-coordinate	y(7)=607.1 mm
Point 8 :	X-coordinate	x(8)=149.6 mm
	Y-coordinate	y(8)=607.1 mm
Point 9 :	X-coordinate	x(9)=149.6 mm
	Y-coordinate	y(9)=569.0 mm
Point 10 :	X-coordinate	x(10)=219.9 mm
	Y-coordinate	y(10)=569.0 mm
Point 11 :	X-coordinate	x(11)=219.9 mm
	Y-coordinate	y(11)=33.10 mm
Point 12 :	X-coordinate	x(12)=0 mm
	Y-coordinate	y(12)=33.1 mm
Point 13 :	X-coordinate	x(13)=0 mm
	Y-coordinate	y(13)=0 mm

Sectional properties

Cross-sectional area	36138 mm2
Second moments of area (inertias)	Ixx=1.7341E+9 mm4 Iyy=142157014 mm4
Product of inertia $\int dA.xy$	Ixy=198989348 mm4
Distance of centroid from origin	X=212.37 mm Y=269.12 mm
Principal second moments of area	Iu=1.7586E+9 mm4 Iv=117660360 mm4

$$Z_c = \frac{1.7341\ E9}{607.10 - 269.12} = 5130777\ mm^3$$

$$Z_t = \frac{1.7341\ E9}{269.12} = 6443594\ mm^3$$

C/3/2

BRPB
Hill Cottage Railway Bridge
Edge Beam
nett-section at centre of span

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Angle of principal U
counter-clockwise from XX-axis -7.0181 degrees

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CALCULATIONS / WORK

Output / Remarks

Edge Beam.

1) Gross cross-section with enhancement

$\frac{D}{d} = 1.10$ A/1/1

$Z_{c_{LL}} = 5255958 \times 1.10 = 5781554 \text{ mm}^3$

$Z_{t_{LL}} = 7024261 \times 1.10 = 7726687 \text{ mm}^3$

DL + SDL stresses.

$f_{bc} = \frac{181.32 \times 10^6}{5255958} = 34.50 \text{ N/mm}^2$

$f_{bt} = \frac{181.32 \times 10^6}{7024261} = 25.81 \text{ N/mm}^2$

$f_s = \frac{V}{d_w t} = \frac{92.75 \times 10^3}{533.4 \times 38.10} = 4.56 \text{ N/mm}^2$

stresses available for LL

$f_{bc} = 154 - 34.50 = 119.50 \text{ N/mm}^2$

$f_{bt} = 46 - 25.81 = 20.19 \text{ N/mm}^2$

$f_s = 46 - 4.56 = 41.44 \text{ N/mm}^2$

But subjected to further restrictions.

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CALCULATIONS / WORK			Output / Remarks

Edge Beam

3) Nett cross-section with enhancement

$$\frac{D}{d} = 1.10$$

$$\underset{LL}{Z_c} = 5130777 \times 1{\cdot}10 = 5643855 \text{ mm}^3$$

$$\underset{LL}{Z_t} = 6443594 \times 1{\cdot}10 = 7087953 \text{ mm}^3$$

DL + SDL stresses.

$$f_{bc} = \frac{181{\cdot}32 \times 10^6}{5130777} = 35{\cdot}34 \text{ N/mm}^2$$

$$f_{bt} = \frac{181{\cdot}32 \times 10^6}{6443594} = 28{\cdot}14 \text{ N/mm}^2$$

$$f_s = \frac{V}{d_w t} = \frac{92{\cdot}75 \times 10^3}{535{\cdot}9 \times 38{\cdot}10} = 4{\cdot}54 \text{ N/mm}^2$$

stresses available for LL

$$\left.\begin{aligned} f_{bc} &= 154 - 35{\cdot}34 = 118{\cdot}66 \text{ N/mm}^2 \\ f_{bt} &= 46 - 28{\cdot}14 = 17{\cdot}86 \text{ N/mm}^2 \\ f_s &= 46 - 4{\cdot}54 = 41{\cdot}46 \text{ N/mm}^2 \end{aligned}\right\} \text{but subjected to further restrictions}$$

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BRPB	C1461437	30/9/99	DK
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	4/10/99	DK

ode
ef.

CALCULATIONS / WORK

Output / Remarks

Edge Beam.

A 16/97
cl 2·7

The penultimate beam is between the nearside wheels and the edge beam and therefore the latter need not be examined for live load on the carriageway.

3D21/97
cl 5·35

As the edge beam is a non-cantilevered member an appropriate accidental vehicle will be selected and applied in accordance with Appendix D.

As the Loading assessment for the Internal Beam resulted in a 'Restricted Assessment Live Loading Level' of 7·5 Tonnes for Case 2, the Edge Beam will be checked for 7·5 Tonnes, data for which is taken from Appendix D Table D3.

Volume 3 Section 4
Part 3 BD 21/97 — **Appendix I**

D4. Vehicle Nominal Loading

The nominal loading in each lane shall be as follows:

a. Single vehicle - An impact factor of 1.8 shall be applied to the most critical axle of the vehicle positioned at the most onerous part of the influence line diagram. See Chapter 14 of reference 4. The factored axle and remaining unfactored axles shall be taken as the nominal loads.

b. Convoy of vehicles - The unfactored axle weights shall be taken as the nominal loads.

The partial factors for loads given in this Standard shall be applied for deriving assessment load effects.

Assessment Live Loading Level *	Vehicle Ref	Vehicle Gross Weight *	No Axles	AXLE WEIGHTS AND SPACINGS										
				01 (m)	W1 *	A1 (m)	W2 *	A2 (m)	W3 *	A3 (m)	W4 *	A4 (m)	W5 *	02 (m)
25	RA	20.32	1	1.0	4.06	2.18	8.13	1.02	8.13	-	-	-	-	1.0
	RB	24.38	3	1.0	6.10	2.70	9.14	1.2	9.14	-	-	-	-	1.0
	RC	24.39	3	1.0	6.10	3.60	+ 10.16	1.5	+ 8.13	-	-	-	-	1.0
	RD	24.39	3	1.0	6.39	3.60	+ 10.50	1.5	+ 7.50	-	-	-	-	1.0
17	RE	17.00	2	1.0	6.50	3.0	10.50	-	-	-	-	-	-	1.0
7.5	RF	7.50	2	1.0	6.0	2.0	1.50	-	-	-	-	-	-	1.0
3	RG	3.00	2	0.75	2.10	2.0	0.90	-	-	-	-	-	-	0.75

+ Note: W2 and W3 are interchangeable to determine the most adverse effect

Table D3 C&U Vehicles to be Considered When Assessing for Restricted Assessment Live Loading Levels

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Design & Business Services

Design Services Work Sheet

Sheet No. C/7
of Sheets
Rev. No.

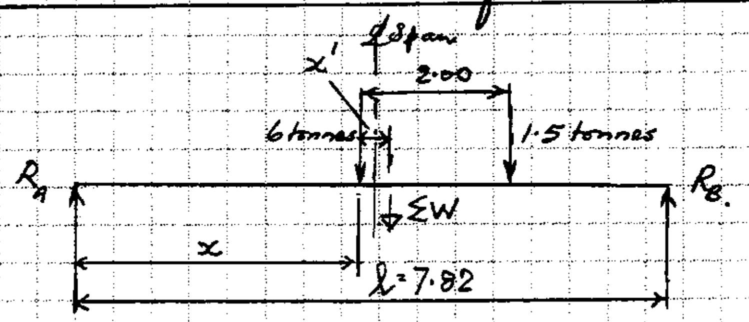
Scheme: BRPB
Scheme Ref.: C1461437
Date Prepared: 30/9/99
Prepared by:

Element / Item: Hill Cottage Railway Bridge
Joblog No.: 23342
Date Checked: 4/10/99
Checked by:

CALCULATIONS / WORK

Output / Remarks

Locate 7.5 Tonne load for max BM



apply 1.8 impact factor to 6 tonne load

$1.8 \times 6.0 = 10.8$ tonnes.

$1.5 \times 2.0 = (10.8 + 1.5)\, x'$

$\therefore \; x' = 0.244$

$R_A = \frac{l - x'}{2l} \times \Sigma W$

$x = \frac{l - x'}{2}$

$M_{LL} = \frac{(l - x')^2}{4l} \cdot \Sigma W$

$= \frac{(7.82 - 0.244)^2}{4 \times 7.82} \times 12.3 = 22.569$ tm

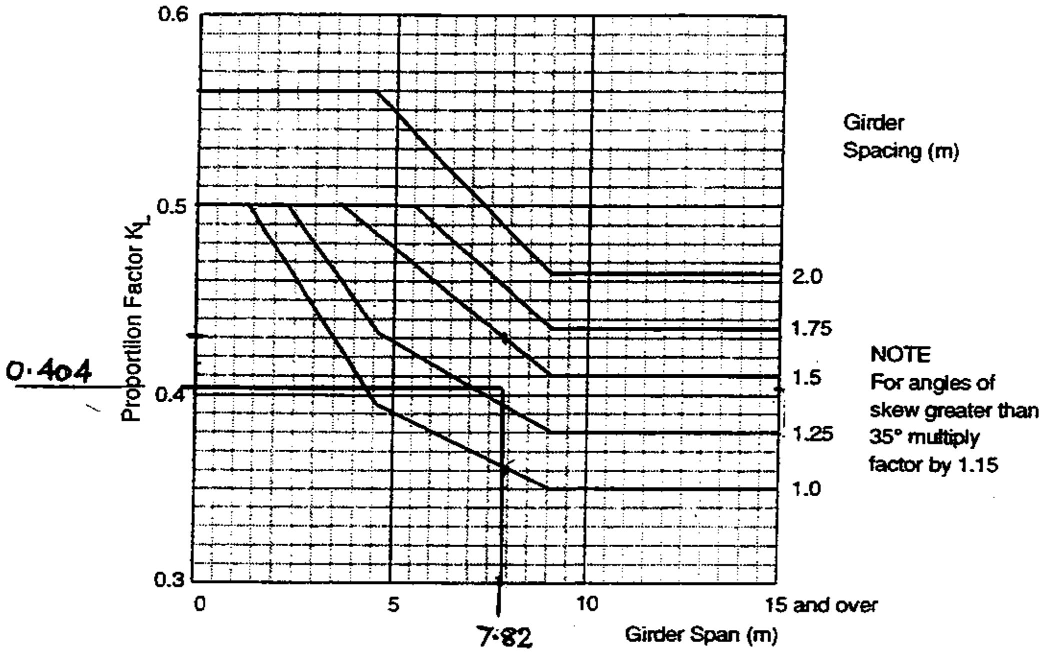
$= 22.569 \times 9.807$ kNm $= 221.33$ kNm

Graph a) Single lane loading

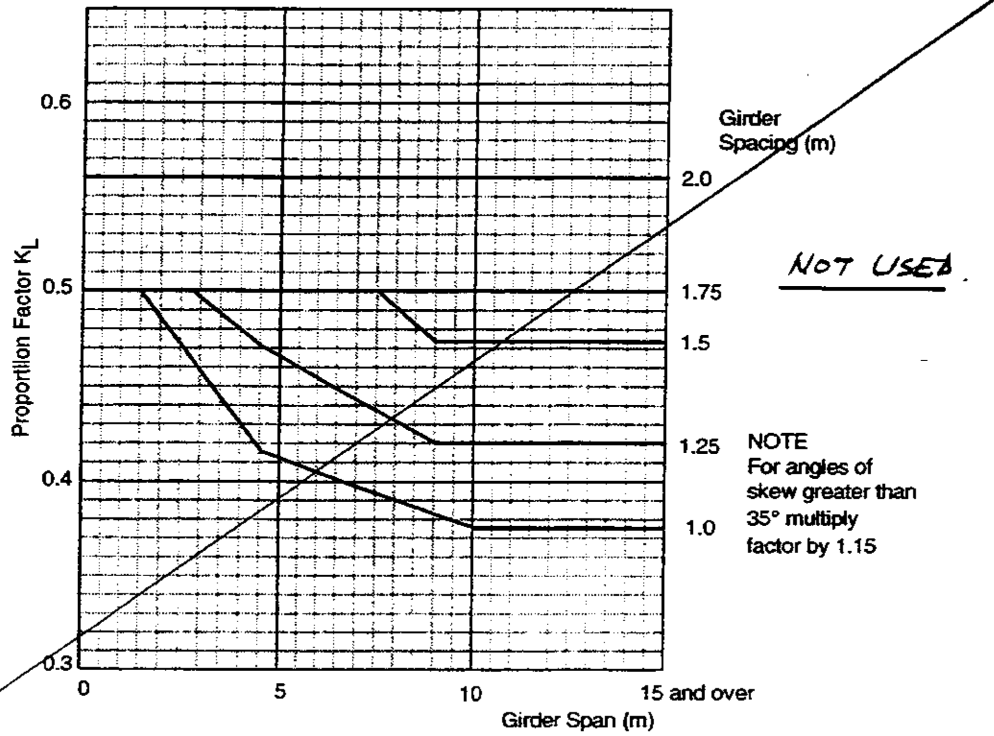
$K_L = 0.404$

$M'_{LL} = 221.33 \times 0.404 = 89.42$ kNm.

No. C&D C/DES1 REV C (6/99)



(a) Single Lane Loading



NOT USED.

(b) Multiple Lane Loading

Figure 2/3 Proportion Factors for External Longitudinal Girders

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Design & Business Services

Design Services Work Sheet

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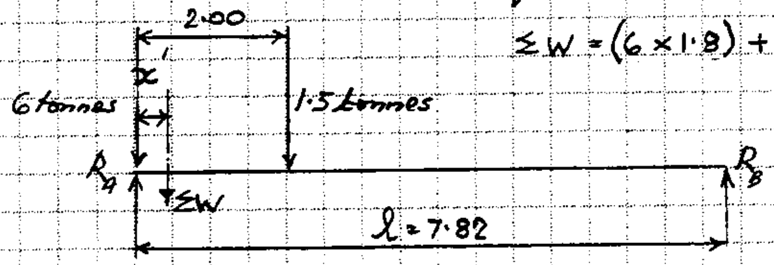
Scheme	Scheme Ref.	Date Prepared	Prepared by
BRPB	C1461437	30/9/99	JK
Element / Item	**joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	4/10/99	JK

CALCULATIONS / WORK

Output / Remarks

Locate 7·5 Tonne load for max. SF.



$\Sigma W = (6 \times 1{\cdot}8) + 1{\cdot}5 = 12{\cdot}3$ tonnes

$$R_A = \frac{l - x'}{l} \times \Sigma W$$

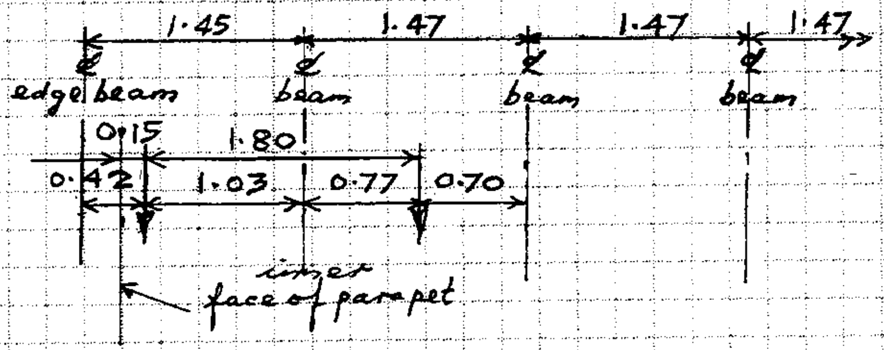
$$= \frac{7{\cdot}82 - 0{\cdot}244}{7{\cdot}82} \times 12{\cdot}3 = 11{\cdot}916\ t$$

$$= 11{\cdot}916 \times 9{\cdot}807\ kN = 116{\cdot}86\ kN.$$

$$\therefore S = 116{\cdot}86 \times K_L$$

$$= 116{\cdot}86 \times 0{\cdot}404 = 47{\cdot}21\ kN / \text{Edge Beam}.$$

Justification for using K_L for Accidental Vehicle calculations:



Multiplying factor by statics

$$= \frac{1{\cdot}03}{1{\cdot}45} \times 0{\cdot}5 = 0{\cdot}355 < 0{\cdot}404 \therefore OK.$$

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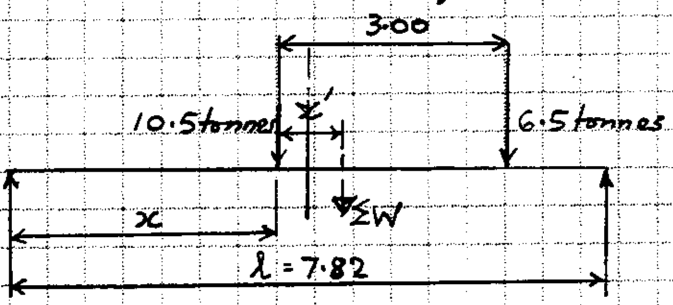
Element / Item Hill Cottage Railway Bridge	Joblog No. 23342	Date Checked 4/10/99	Checked by
CALCULATIONS / WORK			Output / Remarks

Locate 17.0 Tonne load for max. BM



apply 1.8 impact factor to 10.5 tonne load

$1.8 \times 10.5 = 18.9$ tonnes

$6.5 \times 3.0 = (18.9 + 6.5)x'$

$\therefore x' = 0.768$

$R_A = \frac{l - x'}{2l} \times \Sigma W$

$x = \frac{l - x'}{2}$

$M_u = \frac{(l - x')^2}{4l} \cdot \Sigma W$

$= \frac{(7.82 - 0.768)^2}{4 \times 7.82} \times 25.4 = 40.382$ tm

$= 40.382 \times 9.807$ kNm $= 396.03$ kNm.

Graph a) Single lane loading

$K_L = 0.404$

$M'_u = 396.03 \times 0.404 = 160.00$ kNm.

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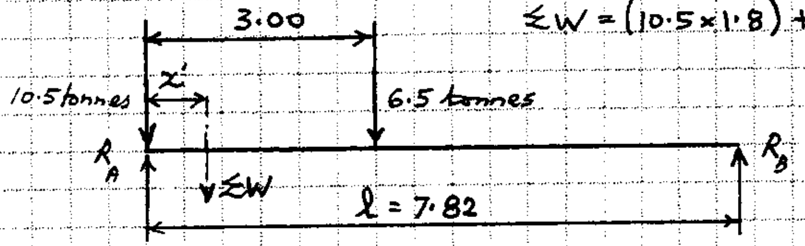
Date Prepared: 30/9/99
Prepared by:
Element / Item: Hill Cottage Railway Bridge
Joblog No.: 23342
Date Checked: 4/10/99
Checked by:

CALCULATIONS / WORK

Output / Remarks

Locate 17.0 Tonne load for max SF



$\Sigma W = (10.5 \times 1.8) + 6.5 = 25.4$ tonnes.

$$R_A = \frac{l - x'}{l} \times \Sigma W$$

$$= \frac{7.82 - 0.768}{7.82} \times 25.4 = 22.905\ t$$

$$= 22.905 \times 9.807\ kN = 224.63\ kN$$

$$\therefore S = 224.63 \times 0.404 = 90.75\ kN$$

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Scheme	Scheme Ref.	Date Prepared	Prepared by
BRPB	C1461437	30/9/99	SK
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	4/10/99	

ode
f.

CALCULATIONS / WORK

Output / Remarks

Case 1 (Check 7.5 Tonnes wrt bending)

$f'_{bt\,LL} = \frac{89.42 \times 10^6}{7726687} = 11.57\ N/mm^2$ c/7

$f_{bt\,DL+SDL} = 25.81\ N/mm^2 = f_d$ c/4

cl 4.10 $f_L = 24.6 - 0.44 f_d$

$= 24.6 - (0.44 \times 25.81) = 13.24\ N/mm^2$

or $f_L = 19.6 - 0.76 f_d$

$= 19.6 - (0.76 \times 25.81) = -0.02\ N/mm^2$

Tensile stress due to LL
$= 11.57\ N/mm^2 < 13.24\ N/mm^2$

∴ OK for 7.5 Tonnes Accidental Vehicle.

$f'_{bc\,LL} = \frac{89.42 \times 10^6}{5781554} = 15.47\ N/mm^2$

$f_{bc\,DL+SDL} = 34.50\ N/mm^2 = f_d$ c/4

$f_L = -43.9 + 0.79 f_d$

$= -43.9 + (0.79 \times -34.50) = -71.16\ N/mm^2$

or $f_L = -81.3 + (3.15 \times -34.50) = -189.98\ N/mm^2$

Compressive stress due to LL
$= 15.47\ N/mm^2 < 71.16\ N/mm^2$

∴ OK for 7.5 Tonnes Accidental Vehicle

check limiting stress $< 154\ N/mm^2$

$34.50 + 71.16 = 105.66\ N/mm^2$

Cumbria County Council
Design & Business Services
Design Services Work Sheet

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Scheme: BRPB
Scheme Ref.: C1461437
Date Prepared: 30/9/99
Prepared by: JK.
Element / Item: Hill Cottage Railway Bridge
Joblog No.: 23342
Date Checked: 4/10/99
Checked by: JL

CALCULATIONS / WORK

Output / Remarks

Case 2 (Check 7.5 Tonnes wrt bending)

$$f_{bt'_{LL}} = \frac{89.42\times10^6}{7024261} = 12.73\ N/mm^2$$

$$f_{bt_{DL+SDL}} = 25.81\ N/mm^2 = f_d$$ C/4

bl 4·10

$$f_L = 24.6 - 0.44 f_d$$
$$= 24.6 - (0.44\times25.81) = 13.24\ N/mm^2$$

Tensile stress due to LL
$= 12.73\ N/mm^2 < \underline{13.24\ N/mm^2}$

∴ OK for 7.5 Tonnes Accidental Vehicle

$$f_{bc'_{LL}} = \frac{89.42\times10^6}{5255958} = 17.01\ N/mm^2$$

$$f_{bc_{DL+SDL}} = 34.50\ N/mm^2 = f_d$$ C/4

$$f_L = -71.16\ N/mm^2$$ C/11

Compressive stress due to LL
$= \underline{17.01\ N/mm^2 < 71.16\ N/mm^2}$

∴ OK for 7.5 Tonnes Accidental Vehicle

check limiting stress ✓
$< 154\ N/mm^2$

$34.50 + 71.16 = 105.66\ N/mm^2$

Max. compressive bending stress
$= 34.50 + 17.01 = 51.51\ N/mm^2$
$< 105.66\ N/mm^2$ ∴ OK

DESIGN SERVICES

Cumbria County Council

Design & Business Services

Design Services Work Sheet

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Scheme	Scheme Ref.	Date Prepared	Prepared by
BRPB	C1461437	30/9/99	DK
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	4/10/99	

CALCULATIONS / WORK

Output / Remarks

Case 3   Check 7.5 Tonnes wrt bending

$$f_{bt_{LL}} = \frac{89.42 \times 10^{6}}{7087953} = 12.62\ N/mm^{2}$$

$$f_{bt_{DL+SDL}} = 28.14\ N/mm^{2}$$ C/5

Cl 4.10 $f_L = 24.6 - 0.44 f_d$

$= 24.6 - (0.44 \times 28.14) = 12.22\ N/mm^{2}$

Tensile stress due to LL
$= 12.62\ N/mm^{2} > 12.22\ N/mm^{2}$

Unsuitable for 7.5 Tonnes
Accidental Vehicle
OK for 3.0 Tonnes AV

$$f_{bc'} = \frac{89.42 \times 10^{6}}{5643855} = 15.84\ N/mm^{2}$$

$$f_{bc_{DL+SDL}} = 35.34\ N/mm^{2} = f_d$$ C/5

$f_L = -43.9 + 0.79 f_d$

$= -43.9 + (0.79 \times {}^{-}35.34) = -71.82\ N/mm^{2}$

Compressive stress due to LL
$= 15.84\ N/mm^{2} < 71.82\ N/mm^{2}$

∴ OK for 7.5 Tonnes
Accidental Vehicle

check
limiting
stress
$< 154\ N/mm^{2}$ $35.34 + 71.82 = 107.16\ N/mm^{2}$

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Scheme BRPB	Scheme Ref. C14G1437	Date Prepared 30/9/99	Sheet No. C/14 of Sheets Rev. No.
Element / Item Hill Cottage Railway Bridge	Joblog No. 23342	Date Checked 4/10/99	Prepared by Checked by

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CALCULATIONS / WORK

Output / Remarks

<u>Case 4</u> <u>Check 7.5 Tonnes wrt bending</u>

$f_{bt\,LL} = \frac{89.42 \times 10^6}{6443594} = 13.88 \; N/mm^2$

$f_{bt\,DL+SDL} = 28.14 \; N/mm^2$

l 4.10 $f_L = 24.6 - 0.44 f_d$

$= 24.6 - (0.44 \times 28.14) = 12.22 \; N/mm^2$

Tensile stress due to LL
$= 13.88 \; N/mm^2 > 12.22 \; N/mm^2$

∴ <u>Unsuitable for 7.5 Tonnes</u>
<u>accidental Vehicle.</u>
<u>OK for 3.0 Tonnes AV</u>

$f_{bc}' = \frac{89.42 \times 10^6}{5130777} = 17.43 \; N/mm^2$

$f_{bc\,DL+SDL} = 35.34 \; N/mm^2 = f_d$

$f_L = -71.82 \; N/mm^2$

Compressive stress due to LL
$= \underline{17.43 \; N/mm^2 < 71.82 \; N/mm^2}$

∴ <u>OK for 7.5 Tonnes</u>
<u>accidental Vehicle.</u>

check
limiting
stress/
$< 154 N/mm^2$

$35.34 + 71.82 = 107.16 \; N/mm^2$

Cumbria County Council | Design & Business Services

Design Services Work Sheet

Sheet No. C/15
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Scheme: BRPB
Scheme Ref.: C146/437
Date Prepared: 30/9/99
Prepared by:
Element / Item: Hill Cottage Railway Bridge
Joblog No.: 23342
Date Checked: 4/10/99
Checked by:

CALCULATIONS / WORK | Output / Remarks

Case 1 (Check 17.0 Tonnes wrt bending)

$f_{bt_{LL}}' = \frac{160.00\times10^6}{7726687} = 20.71\ N/mm^2$

$f_{bt_{DL+SDL}} = 25.81\ N/mm^2 = f_d$ — C/4

$f_L = 24.6 - 0.44 f_d$

$= 24.6 - (0.44\times25.81) = 13.24\ N/mm^2$

Tensile stress due to LL
$= 20.71\ N/mm^2 > 13.24\ N/mm^2$

∴ Unsuitable for 17.0 Tonnes Accidental Vehicle.

% overstress in f_L for 17 Tonnes $= \frac{20.71 - 13.24}{13.24}\times100 = 56.4\%$.

% overstress in $f_d + f_L$ for 17 Tonnes $= \frac{(25.81+20.71)-(25.81+13.24)}{(25.81+13.24)}\times100$

$= 19.1\%$

& $f_{bt_{LL}}' + f_d = 20.71 + 25.81 = 46.52\ N/mm^2$
$> 46.$

Cumbria County Council

Design & Business Services

Design Services Work Sheet

Sheet No. C/16

of Sheets

Rev. No.

Scheme	Scheme Ref.	Date Prepared	Prepared by
BRPB	C1461437	4/10/99	SK
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	5/10/99	SK

CALCULATIONS / WORK

Output / Remarks

Case 3 (Check 17.0 Tonnes wrt bending)

$$f_{bt_{LL}}' = \frac{160.00 \times 10^6}{7087953} = 22.57\ N/mm^2$$

$$f_{bt_{DL+SDL}} = 28.14\ N/mm^2 = f_d$$

$$f_L = 24.6 - 0.44 f_d$$

$$= 24.6 - (0.44 \times 28.14) = 12.22\ N/mm^2$$

Tensile stress due to LL $= 22.57\ N/mm^2 > 12.22\ N/mm^2$

∴ Unsuitable for 17.0 Tonnes Accidental Vehicle

% overstress in f_L for 17.0 Tonnes $= \frac{22.57 - 12.22}{12.22} \times 100 = 84.7\%$

% overstress in $f_d + f_L$ $= \frac{(28.14 + 22.57) - (28.14 + 12.22)}{(28.14 + 12.22)} \times 100$

$= 25.6\%$

& $f_{bt_{LL}}' + f_d = 22.57 + 28.14 = 50.71\ N/mm^2$

> 46

Cumbria County Council
Design & Business Services

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Scheme: BRPB
Scheme Ref.: C1461437
Date Prepared: 30/9/99
Prepared by:

Element / Item: Hill Cottage Railway Bridge
Joblog No.: 23342
Date Checked: 4/10/99
Checked by:

CALCULATIONS / WORK

Output / Remarks

Shear Stress check at Support for 7.5 Tonnes AWL.

Shear stress due to DL & SDL $= 4.56\ N/mm^2$ — c/4

Shear stress due to 7.5 Tonnes AWL

$$= \frac{47.21 \times 10^3}{533.4 \times 38.10} = 2.32\ N/mm^2$$

$$\overline{\underline{6.88}}\ N/mm^2$$

$< 46\ N/mm^2$ ∴ OK.

Cumbria County Council
Design & Business Services
Design Services Work Sheet

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Scheme BRPB	Scheme Ref. C1461437	Date Prepared 1/10/99	Prepared by
Element / Item Hill Cottage Railway Bridge	Joblog No. 23342	Date Checked 4/10/99	Checked by

CALCULATIONS / WORK

Output / Remarks

Stability of Edge Beams.

Tie-rods

There are 3 No. tie-rods in each end bay of the deck.
(see sheet 18 and photograph no 6 on sheet 60)
These contribute to the stability of the edge beams, in addition to the frictional forces set-up at the end supports.

Destabilizing forces to be considered are :

(i) Horizontal thrust on edge beam produced by retained fill material, surfacing and self weight of Jack arch.

(ii) Horizontal thrust on edge beam produced by the appropriate Accidental Vehicle.

(i) Using parabolic arch formula for UDL, from Roark

$$H = \frac{wl^2}{8f}$$

weight of retained filling in end bay = 5.0 × 2 = 10.00 kN/m C/1/1
say.

weight of jack-arch = 3.98 × 2 = 7.96 kN/m

17.96 kN/m nom.

$$\therefore W = 17.96 \times \overset{\gamma_{fl}}{1.2} = 21.55 \text{ kN/m}$$

$$w = \frac{W}{l} = \frac{21.55}{1.45} = 14.86 \text{ kN/m.}$$

Rise of jack-arch = 0.30 m.
(to mid depth of barrel)

$$\therefore H = \frac{14.86 \times 1.45^2}{8 \times 0.30} = 13.02 \text{ kN/m.}$$

Cumbria County Council
Design & Business Services

Design Services Work Sheet

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Scheme: BRPB
Scheme Ref.: C1461437
Date Prepared: 1/10/99
Prepared by:
Element / Item: Hill Cottage Railway Bridge
Joblog No.: 23342
Date Checked: 4/10/99
Checked by:

CALCULATIONS / WORK

Output / Remarks

ii) Consider 7.5 Tonne Accidental Vehicle

$W_1 = 6.0 \times 1.8 \times 9.807 = 105.92$ kN.
impacted

$W_2 = 1.5 \times 9.807 = 14.71$ kN.

Assessment loads.

$W_1' = 105.92 \times \overset{\gamma_{fl}}{1.5} = 158.88$ kN

$W_2' = 14.71 \times 1.5 = 22.06$ kN.

Using parabolic arch formula for central point load, from 'Roark'

$$H = \frac{25Wl}{128h}$$

Horizontal thrust produced by W_1' $= \frac{25 \times 158.88 \times 1.45}{128 \times 0.30} = 149.98$ kN.

Horizontal thrust produced by W_2' $= \frac{25 \times 22.06 \times 1.45}{128 \times 0.30} = 21.32$ kN.

$\overline{171.30}$ kN

Total horizontal thrust on edge beam $= (13.02 \times 7.82) + 171.30$ kN

$= \underline{273.12 \text{ kN}}$.

Cumbria County Council | Design & Business Services

Design Services Work Sheet

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Scheme	Scheme Ref.	Date Prepared	Prepared by
BRPB	C146/437	1/10/99	Dk
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	4/10/99	Dk

CALCULATIONS / WORK | Output / Remarks

Stabilizing forces to be considered are:

(i) Residual strength of tie-rods.

(ii) Frictional forces at end supports.

(i) Tie-rods originally 1" dia = 25.4mm dia.

Diameter of tie-rods as measured = 19.0mm.

f_y = 220 N/mm^2

γ_m = 1.2

γ_{f3} = 1.1

Assessment resistance of tie-rods 19mm dia

$$= \frac{\pi d^2}{4} \times \frac{220}{1.2 \times 1.1} \times 10^{-3} \text{ kN}$$

= 47.25 kN.

3 No. tie-rods

∴ Total resistance = 3 × 47.25 = 141.75 kN.

$$\left(\text{Initial total resistance}\right) = \left(\frac{25.4}{19.0}\right)^2 \times 141.75 = 253.33 \text{ kN}$$

Frictional force at end support, required for lateral stability of edge beam = (273.12 − 141.75)0.05

= 65.69 kN. D/2

Cumbria County Council | Design & Business Services

Design Services Work Sheet

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Rev. No.

Scheme BRPB	Scheme Ref. C/461437	Date Prepared 1/10/99	Prepared by
Element / Item Hill Cottage Railway Bridge	Joblog No. 23342	Date Checked 4/10/99	Checked by

CALCULATIONS / WORK | Output / Remarks

Initially, calculate the frictional resistance at end support due to DL + SDL.

$w = 23{\cdot}72 \times \overset{\gamma_{fl}}{1{\cdot}2} = 28{\cdot}46$ kN/m. c/1/1

End reaction $= \dfrac{wl}{2} = \dfrac{28{\cdot}46 \times 7{\cdot}82}{2}$

$= 111{\cdot}28$ kN.

Frictional resistance $= 111{\cdot}28 \times \mu$

$= 111{\cdot}28 \times \overset{say}{0{\cdot}35}$

$= 38{\cdot}95$ kN.

$< 65{\cdot}69$ kN.

∴ inadequate.

Residual deficiency in frictional resistance
$= 65{\cdot}69 - 38{\cdot}95 = 26{\cdot}74$ kN

Reaction from live load to produce this deficiency
$= \dfrac{26{\cdot}74}{0{\cdot}35} = 76{\cdot}40$ kN

> min. reaction from 7·5 Tonne Accidental Vehicle

∴ 3No. 19 mm dia tie-rods are inadequate for 7·5 Tonne Accidental Vehicle Assessment capacity.

Cumbria County Council
Design & Business Services

Design Services Work Sheet

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Scheme	Scheme Ref.	Date Prepared	Prepared by
BRPB.	C1461437	1/10/99	
Element / Item	**Joblog No.**	**Date Checked**	**Checked by**
Hill Cottage Railway Bridge	23342	4/10/99	

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CALCULATIONS / WORK

Output / Remarks

Check 7.5 Tonne accidental Vehicle assuming that the 3No 19mm dia tie-rods are replaced by 3No 25mm dia. of similar material.

Total horizontal thrust on edge beam = 273.12 kN   D/2

Resistance of 3No 25mm dia. tie rods

$= \frac{25.0^2}{25.4^2} \times 253.33 = 245.41$ kN

Frictional force at end support required for lateral stability of edge beam

$= (273.12 - 245.41)\,0.5 = 13.86$ kN.

< frictional resistance due to DL + SDL = 38.95 kN.   Resistance due to LL neglected

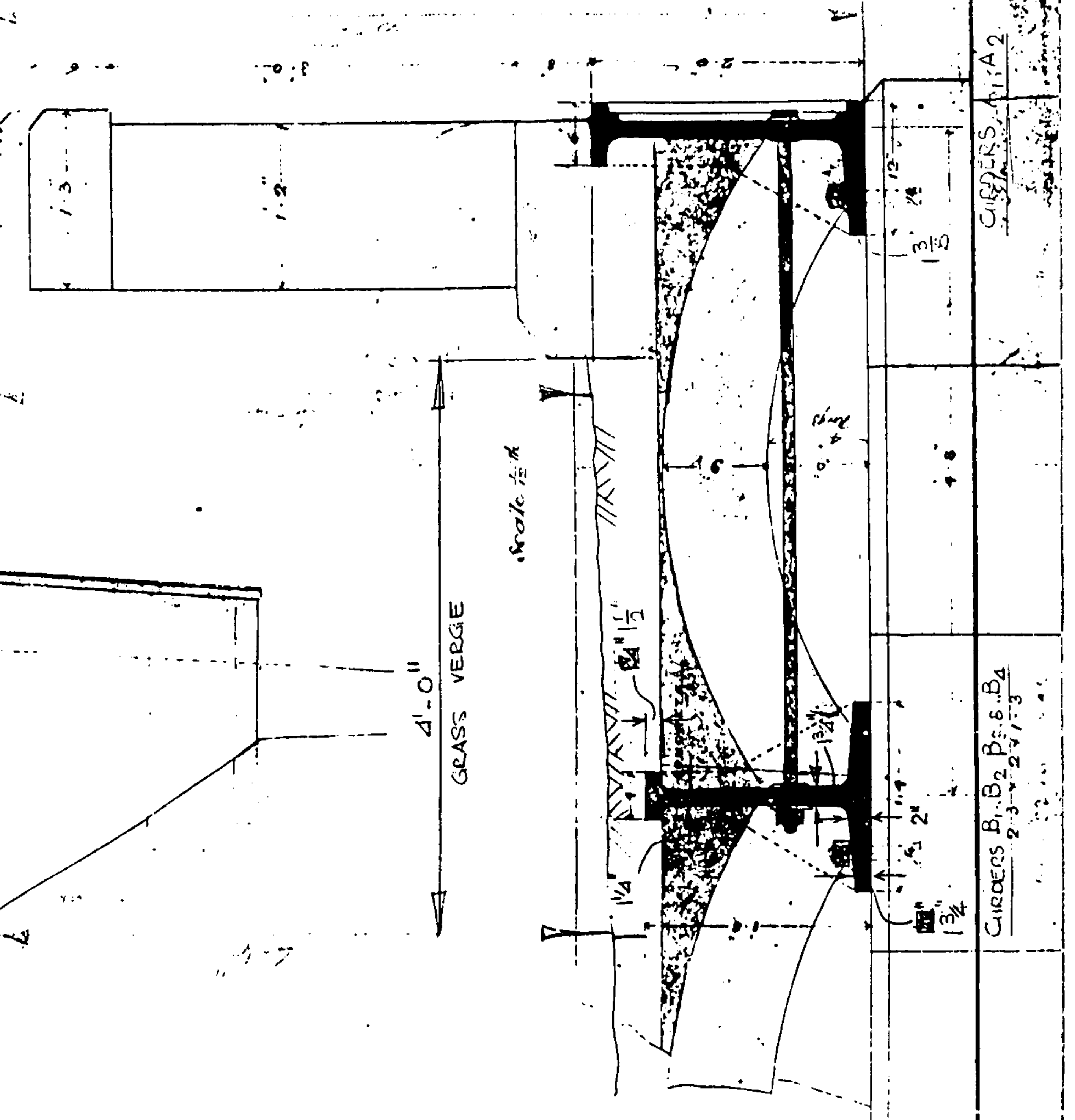
∴ 3No. 25mm dia replacement tie-rods would be adequate for 7.5 Tonne accidental Vehicle assessment capacity.

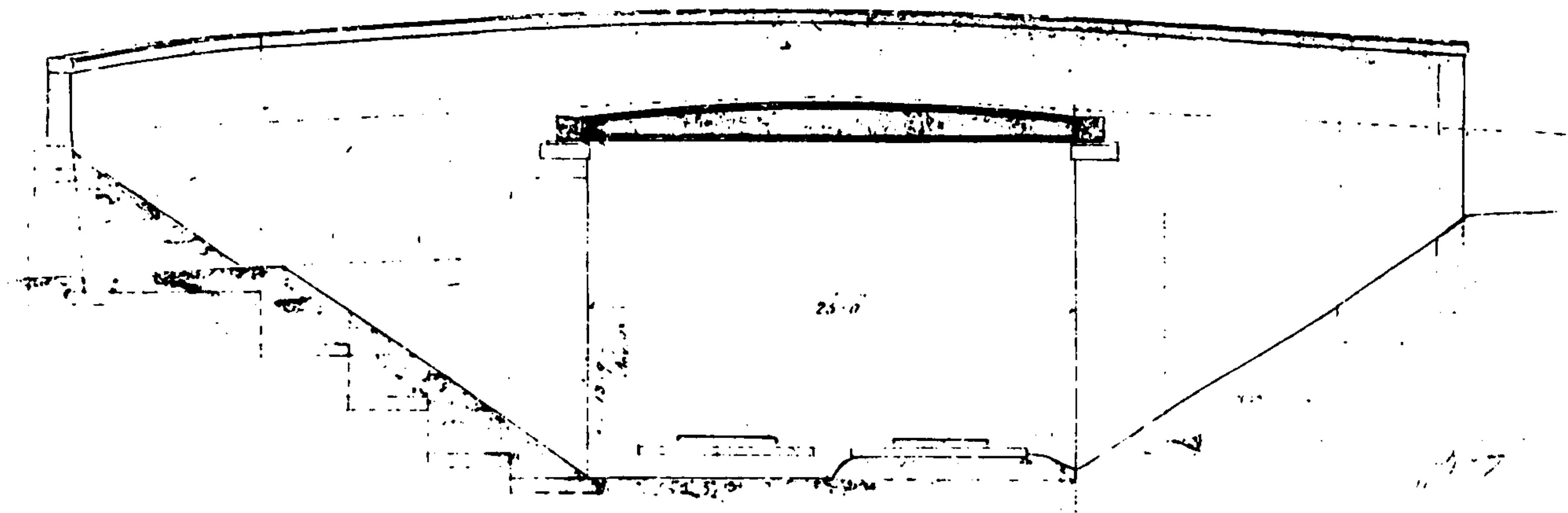
RECORD DRAWINGS

C. K. & P. Ry. THRELKELD & TROUTBECK DOUBLING

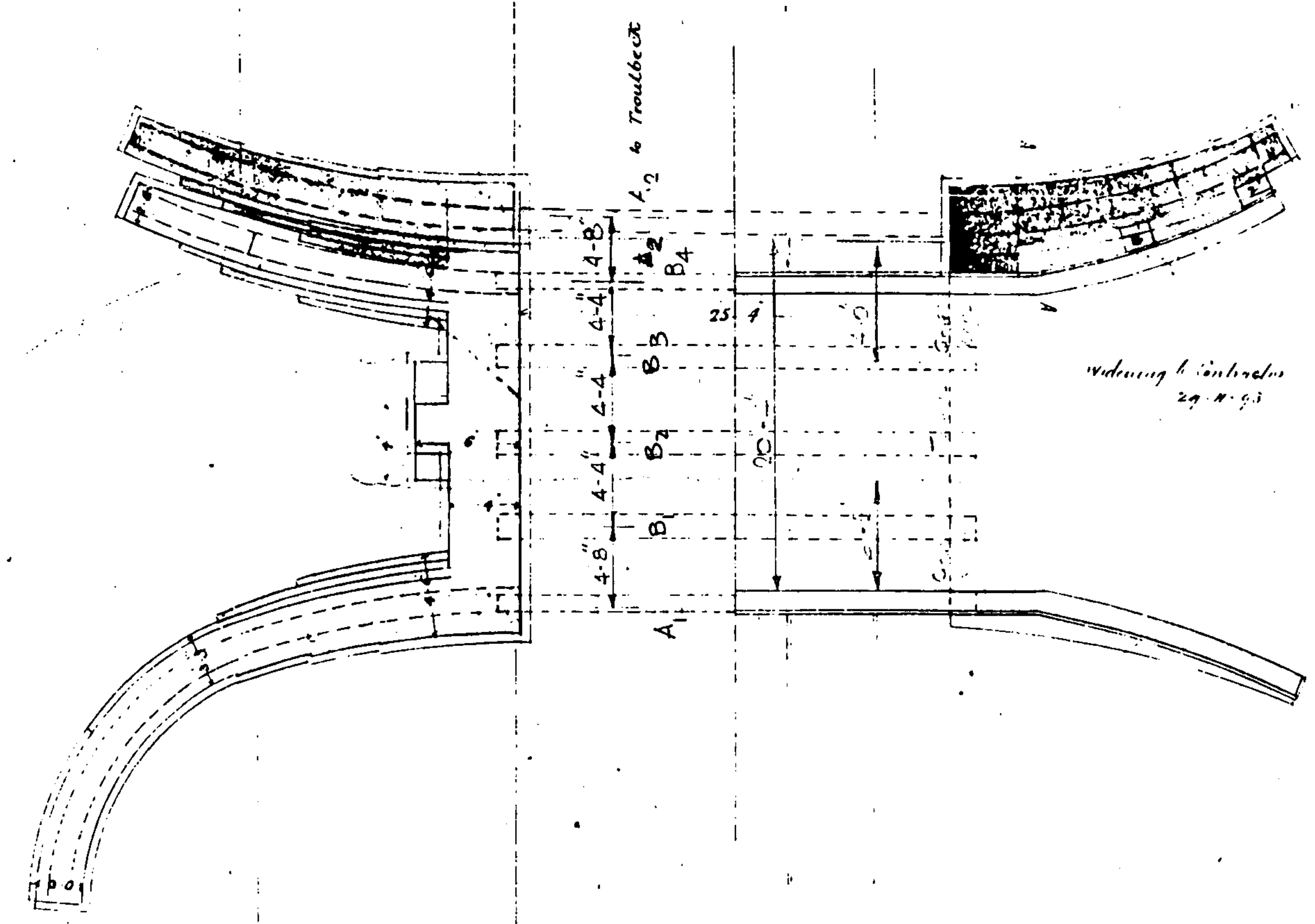
Bridge under Public Road at 20 miles 12½ chains

C37/94

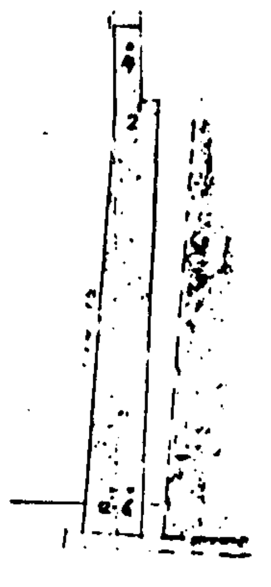




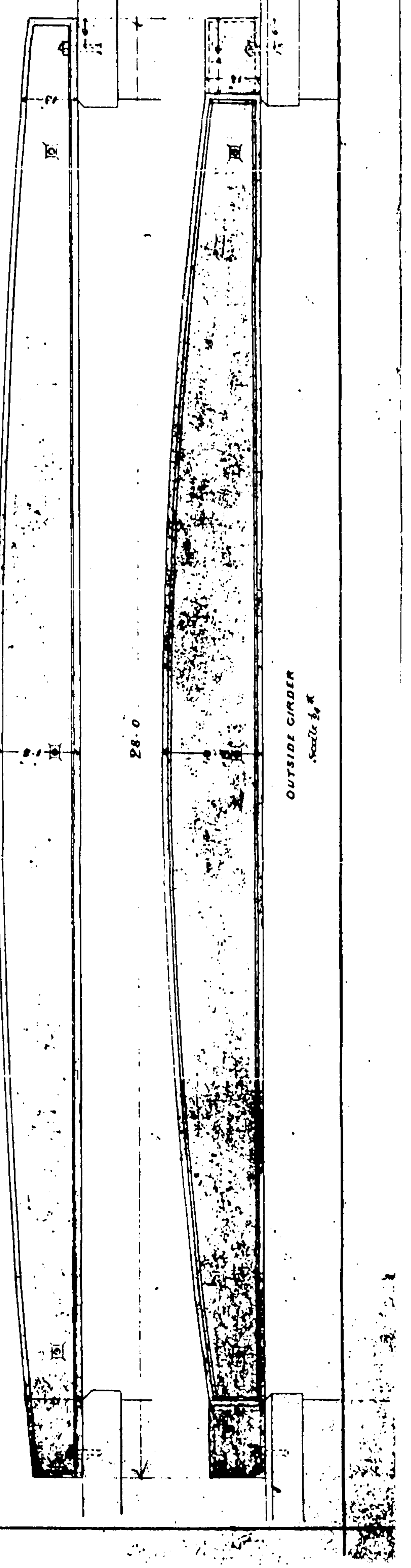
ELEVATION



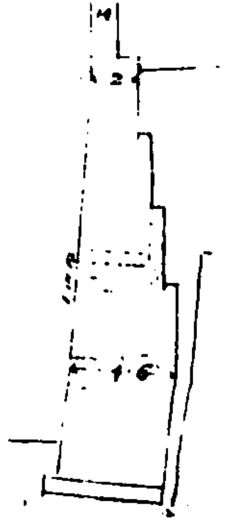
PLAN

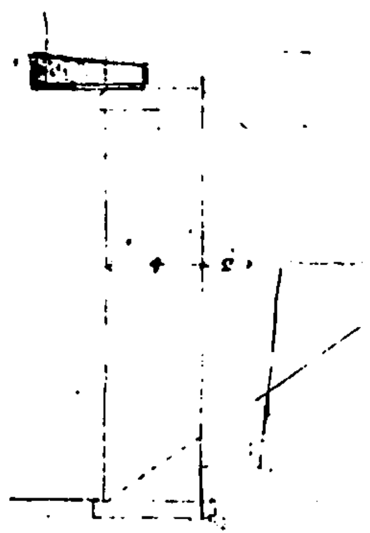


WINGWALL A-A

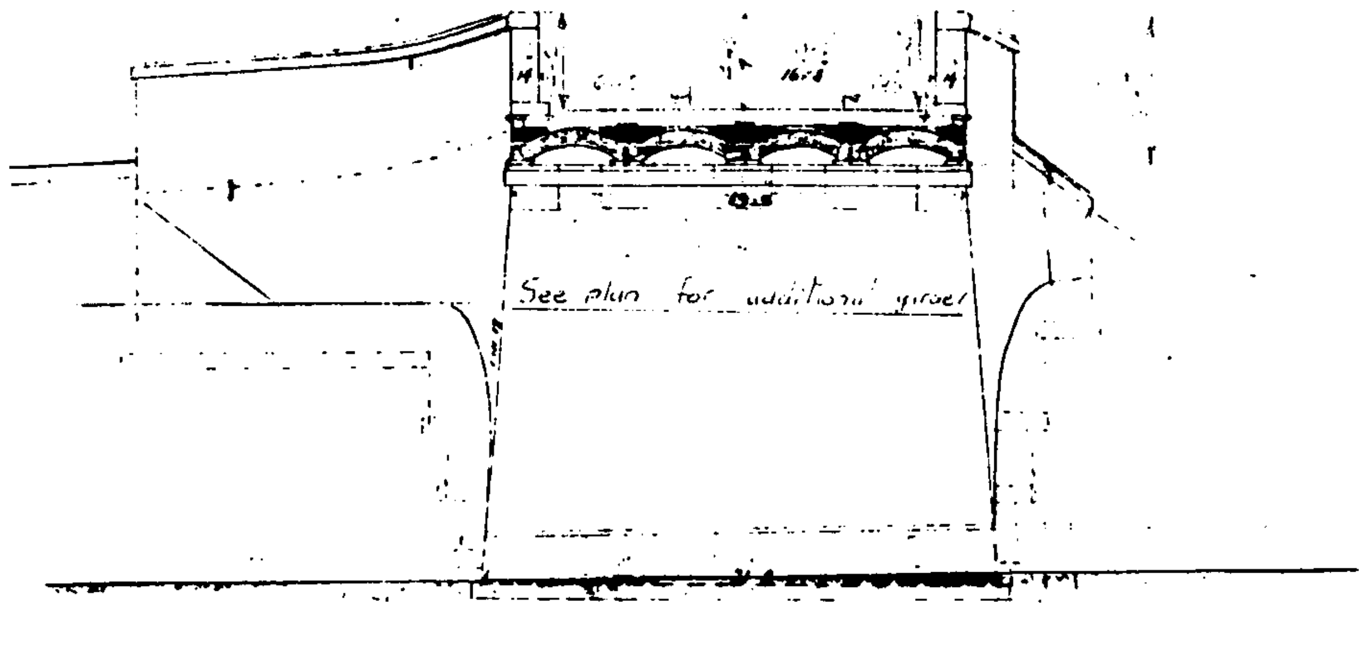


Additional girder A_2 shewn in red on plan. See part section for amended details of girders B_1, B_2, B_3 and B_4. H.C. 29/1/69





WINGWALL ——— ABUTMENT



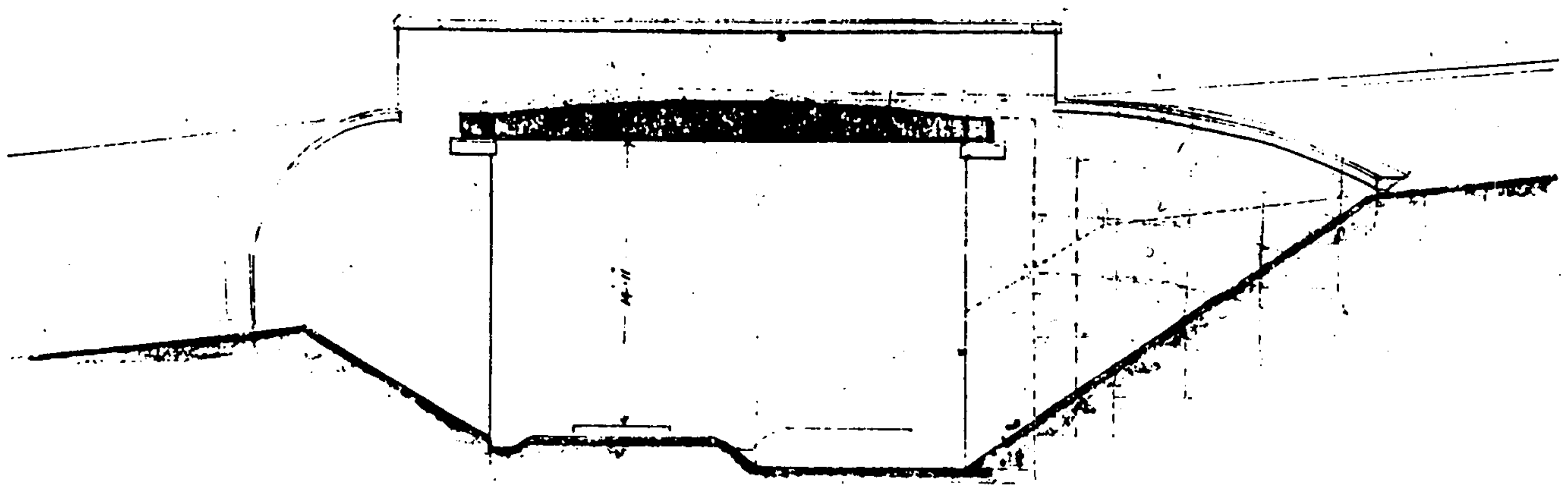
SECTION

C. K. & P. RY. THRELKELD & TROUTBECK DOUBLING

Public Road Bridge at 18m. 35chs.

Nº 87

C37/87



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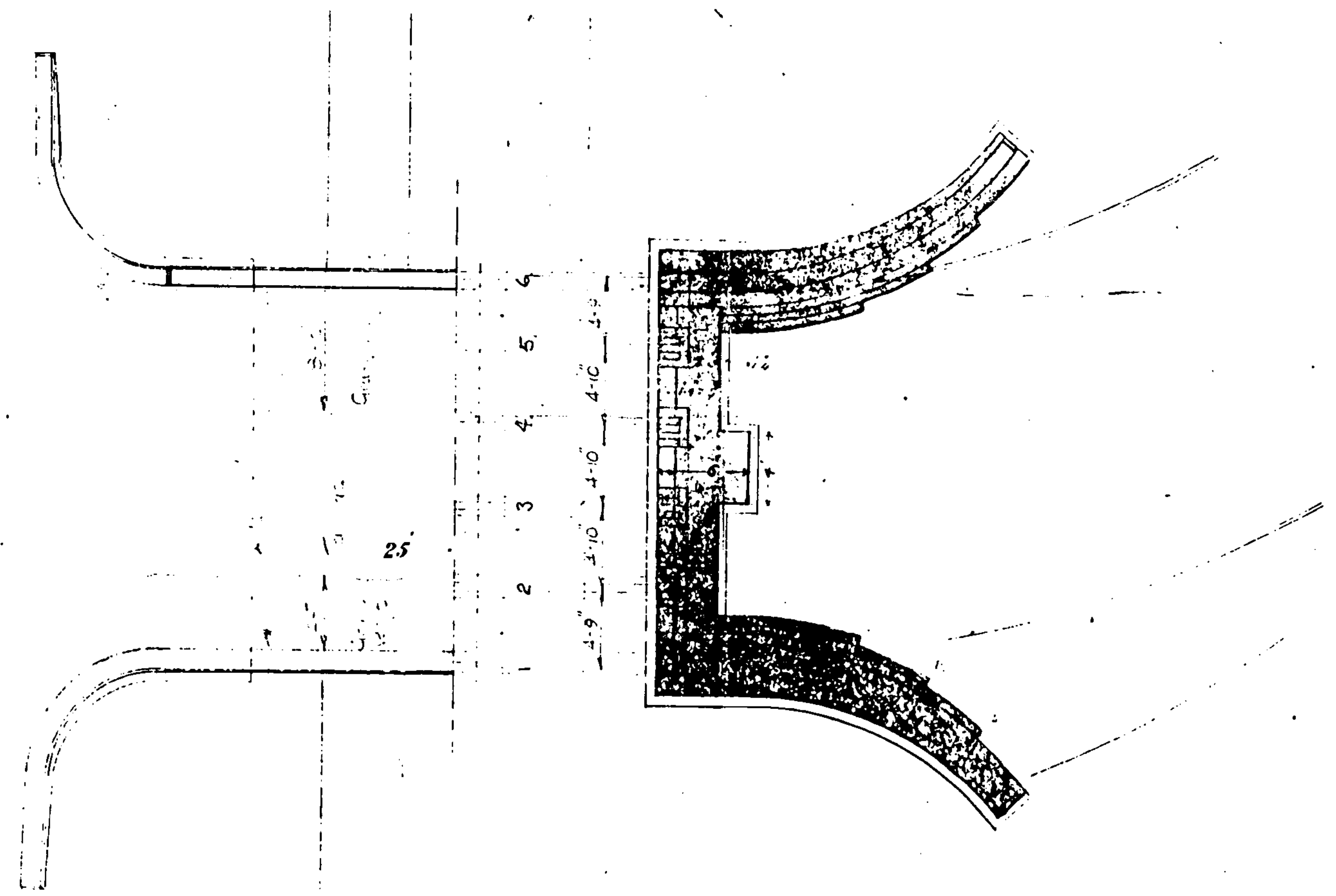


PLAN

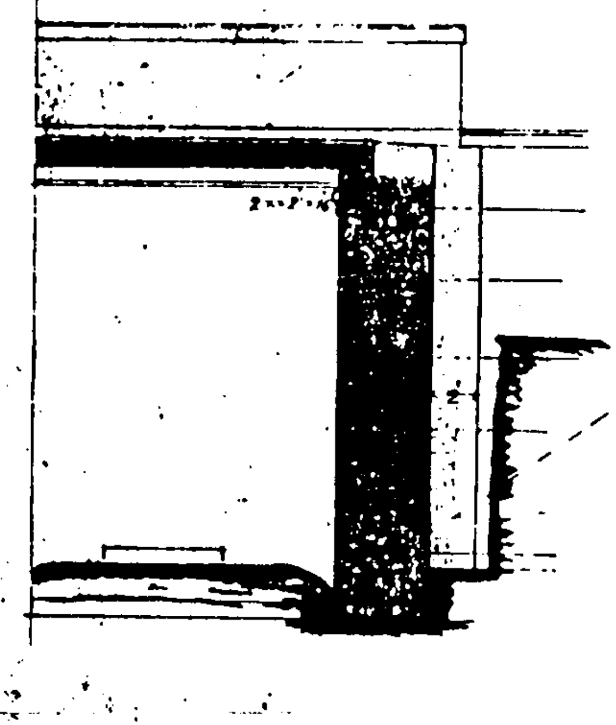
For Girder details see C 37/94
H.C

C37/94

↓

Girders & Brick Arching similar to those of Bridge 20m 12½c

[illegible]



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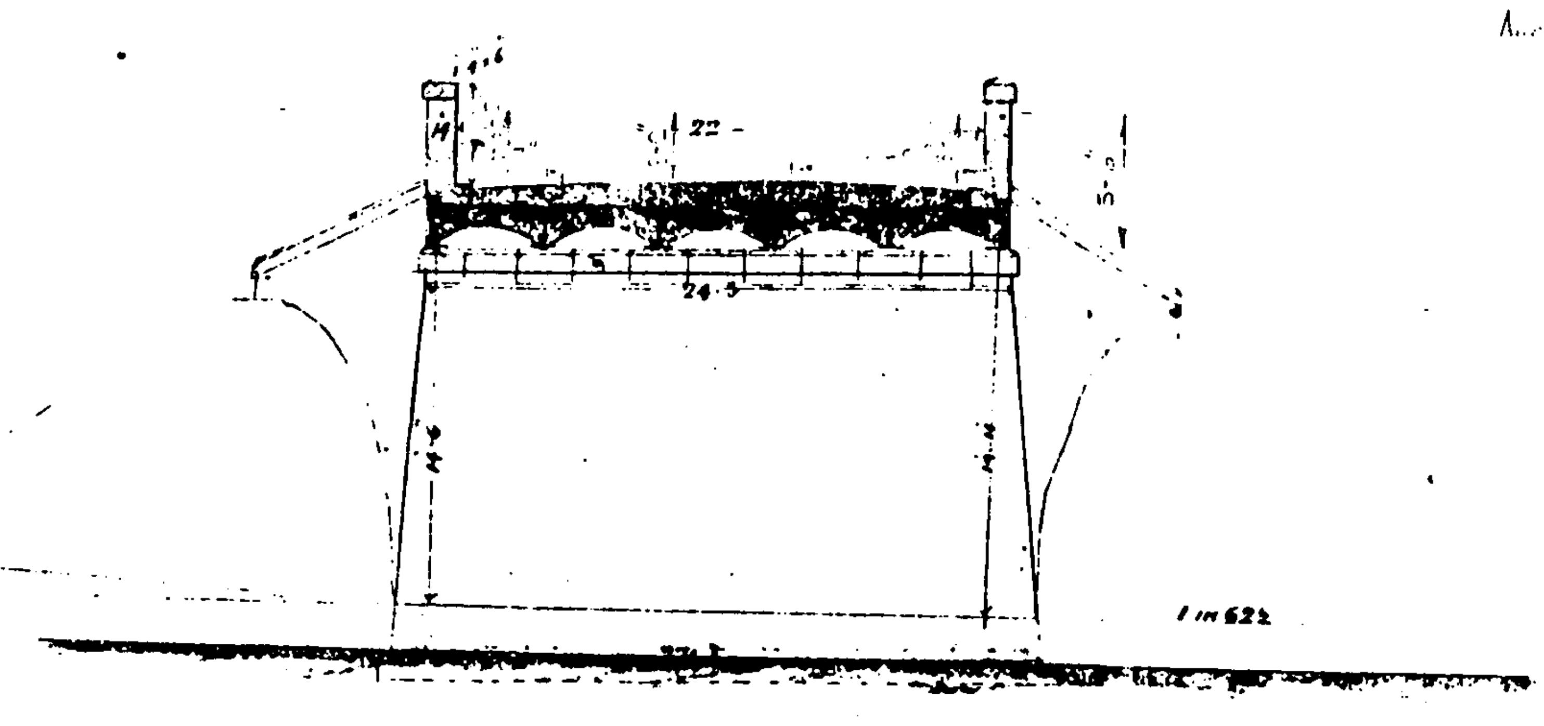
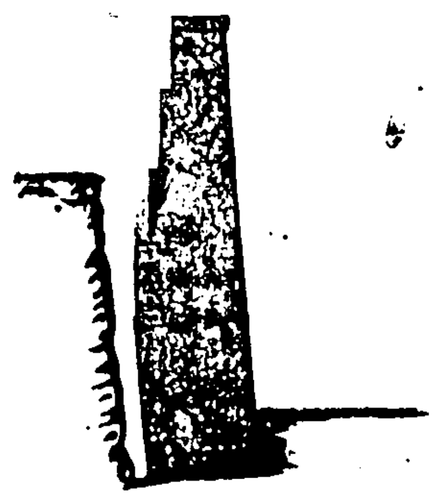


SECTION



WINGWALL

CKP BR 87

INDEX	BRIDGE Nº	NIA	
C37	87	Calc'd.	P.I.
		Ch'd.	J.E.C.
		Date	7.2.69

NORMAL LOADS

To MoT. Code BE4

CAPACITY OF C. I. LONGITUDINAL **GIRDER No.** 3 **SPAN No.**

From Abnormal Assessment

Span	=	25·18	ft.	L
Girder Spacing	=	4·83	ft.	S
Section Modulus	=	418·	ins^3	Z
Revised Modulus $25/20 \times 418$	=	524·0	ins^3	Z'
Stress available for Live Load	=	0·97	tons/in.^{2}	fL

$$\frac{Z \text{ or } Z' \times fL}{12 \times Jn} = \cancel{\frac{\quad \times \quad}{12 \times \quad} = \underline{\quad}} \text{ Double Lane} \qquad \frac{524 \times 0·97}{12 \times 0·32} = \underline{132} \text{ Single Lane}$$

MoT graph 1 or 2.

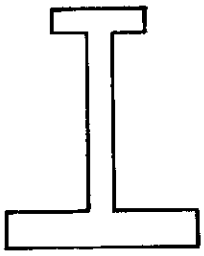
NOTICE PLATE FIGURE

Double	Single
~~T1~~	F.S.T.

Ckd
BR 87

ZDI	C.I. GIRDER.	INDEX C37	BRIDGE Nº 87
	LINE COCKERMOUTH, KESWICK + PENRITH		
	MEMBER C.I. LONGITUDINAL GIRDER Nº SPAN Nº	CALCULATED P.I.	CHECKED Y.E.L. DATE 7.2.69

To M.o.T. Code BE4



4 " x 1½ " TOP FLANGE

16¾" x 1½ " WEB (TAKE MEAN THICKNESS)

16 " x 1¾ " BOTTOM FLANGE

ITEM	SECTION	AREA A	y"	Ay^2	I_{CG} INS⁴	AY
TOP FLANGE	4" x 1½"	6·0	+9·125	500	1·13	54·8
WEB	16¾" x 1½"	25·15			588	
BOTTOM FLANGE	16" x 1¾"	28·0	-9·25	2400	7·15	-259
	GROSS	59·15		2900	596·3	-204·2.

GROSS AREA OF TENSION FLANGE G = INS²

$+Ay^2 =$ 2900·

$I_{NA} =$ 3496·3

$-A\bar{y}^2 =$ -706

$I_{NA_1} =$ 2788·3

$\bar{y} = \frac{\Sigma AY}{A} = \frac{-204.2}{59.15} = -3.46$"

−TOTAL AREA OF RIVET HOLES

= (+) = x = INS²

NETT AREA OF TENSION FLANGE N =

FOR UNSYMMETRICAL SECTIONS ONLY

Y_T = 6·67 INS Y_C = INS

$Z_T = \frac{I_{NA}\text{ OR }I_{NA1}}{Y_T} \times \frac{N}{G} = \frac{2788}{6.67} \times \text{———} = 418$ INS³

$Z_C = \frac{I_{NA}\text{ OR }I_{NA1}}{Y_C} = \text{———} =$ INS³

DEAD LOAD

SPAN (SEE RULES) 25·0 + 1·08/6 = 25·18 FT. L

TYPE OF D.L.	LENGTH FT.	x WIDTH FT.	x DEPTH FT.	x DENSITY lb Ft⁻³	WEIGHT lb
JACK ARCH	25·18	5·0	0·75	140	13200
CONCRETE	25·18	4·83	0·25	150	4,550
FILL	25·18	4·83	0·46	135	7550
TARMAC	25·18	4·83	0·333	144	5840

GIRDER INCLUDING 2½% FOR STIFFENERS

$= 3.2 \times \Sigma A \times L = 3.2 \times$ 59·15 x 25·18 = 4760

TOTAL = 35,900 W

STRESSES DUE TO DEAD LOAD

TENSION: $\frac{W \times L}{1493 \times Z_T} = \frac{35900 \times 25.18}{1493 \times 418} =$ 1·44 TON IN⁻² f_t

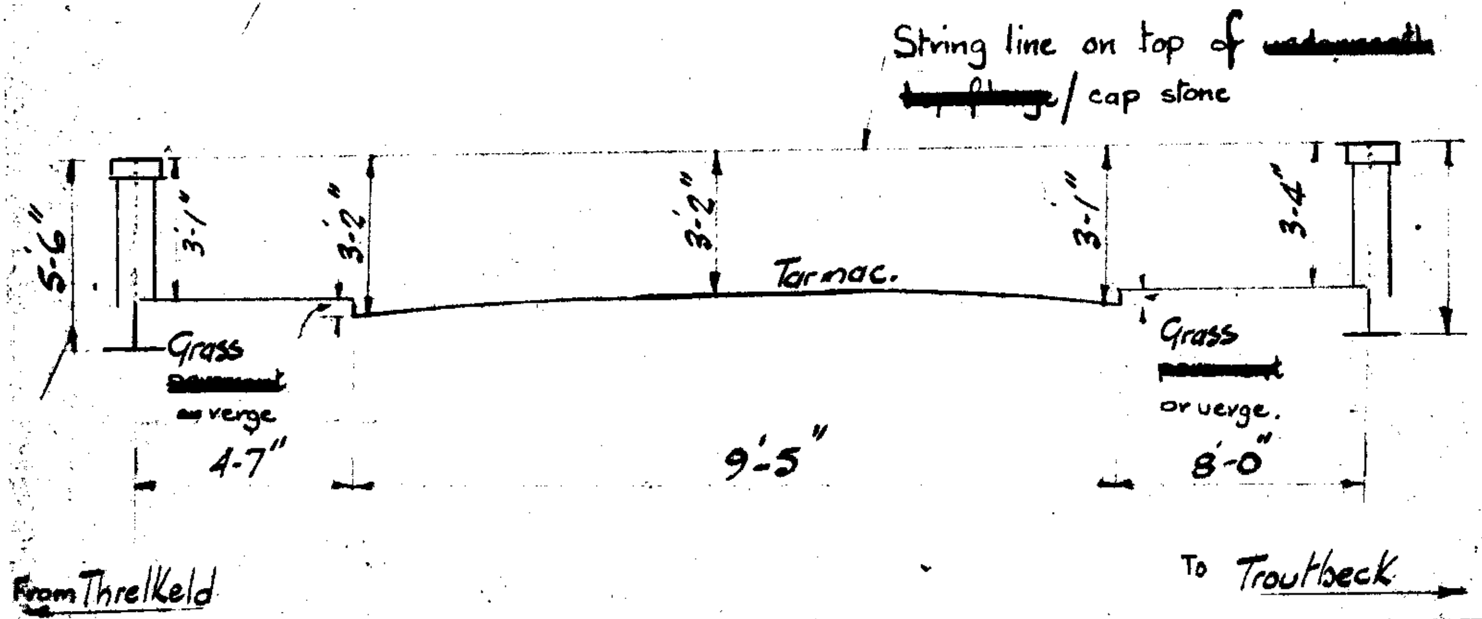
COMP. : $\frac{W \times L}{1493 \times Z_C} =$ ——— = . TON IN⁻² f_c

Stress available = 0·97 T/in²

MINI ASSESSMENT

CONSTRUCTION [AS ON CARD]	CONSTRUCTION [WHEN DIFFERENT]
C.I. longitudinal girders and brick jack arches.	

ROAD WIDTHS & DEAD LOAD DEPTHS



BEARING DETAILS } IF POSSIBLE	HARD	SOFT	MATERIAL :- IF POSSIBLE
	✓		Stone

CONDITION Good. Jack arches require pointing.

No. OF LINES	2
IS TRACK CLOSED	No
ANY INFORMATION ON LINE CLOSURE	

REMARKS

Road Classification :- Unclassified

LINE Cockermouth, Keswick & Penrith | DATE 5.3.68 | REF. C 37 | No. 87

C37

B.R. 12327/7

BRITISH RAILWAYS [illegible] REGION Lancaster DISTRICT

SHEET No. 1 OF 1

BRIDGE CULVERT AND RETAINING WALL EXAMINATION REPORT

NAME [illegible] AT [illegible] Ms. [illegible] Chs. BRIDGE No. 37

ON [illegible] LINE BETWEEN [illegible] & [illegible]

TYPE OF UNDER/OVER BRIDGE C.I. Girder Brick Jack arches

CARRYING [illegible] OVER [illegible]

MASONRY, BRICK & CONCRETE WORK

Condition of Part	G = Good F = Fair P = Poor	Condition of Part	G = Good F = Fair P = Poor	Condition of Part	G = Good F = Fair P = Poor
1 ARCH RING		14 STRUTS		27 CONCRETE DECK SLABS	
2 SPANDRELS		15 BEARING STONES	G	28 SPANDREL TIE BOLTS	
3 PARAPETS	G	16 HAUNCHING TO GIRDER		29 JACK ARCH TIE BOLTS	G
4 ABUTMENTS	G	17 TROUGH FILLING		30 SMOKE PLATES & FITTINGS	
5 WING WALLS	G	18 BALLAST WALLS		31 C.I. Girders	G
6 PILASTERS		19 JACK ARCHES	G	32	
7 PIERS		20 GIRDER ENCASING		33	
8 CROSSHEADS		21 DRAINAGE	G	34	
9 RELIEVING ARCHES		22 FIXINGS for PIPES & CABLES		35	
10 PILES		23 ROAD SURFACE	G	36	
11 FOUNDATIONS	N.I.	24 CONCRETE MAIN GIRDERS		37	
12 SCOUR		25 CONCRETE CROSS GIRDERS		38 POINTING	F
13 INVERT		26 CONCRETE STRINGERS		39 LOAD RESTRICTION PLATES	

REMARKS (Refer to parts by above numbers)

COMMENTS:— Good condition.

EXAMINED BY [redacted] ON Nov.69 (Date)

RECOMMENDATIONS:—

SIGNED ....(Inspector, Supervisor or Technical Asst.)..................(Date)

ACTION TO BE TAKEN:—

No Action

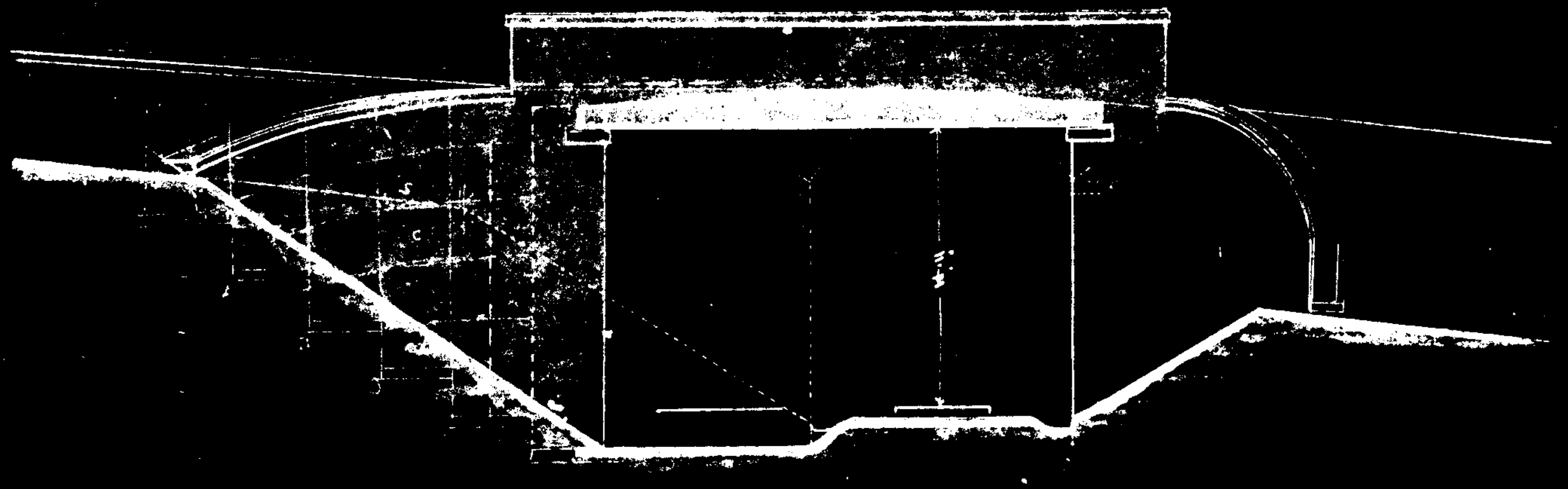
SIGNE [redacted]

C. K. & P. Ry. Threlkeld & Troutbeck Doubling

Public Road Bridge at 18m. 35chs.

No 87

C31/87



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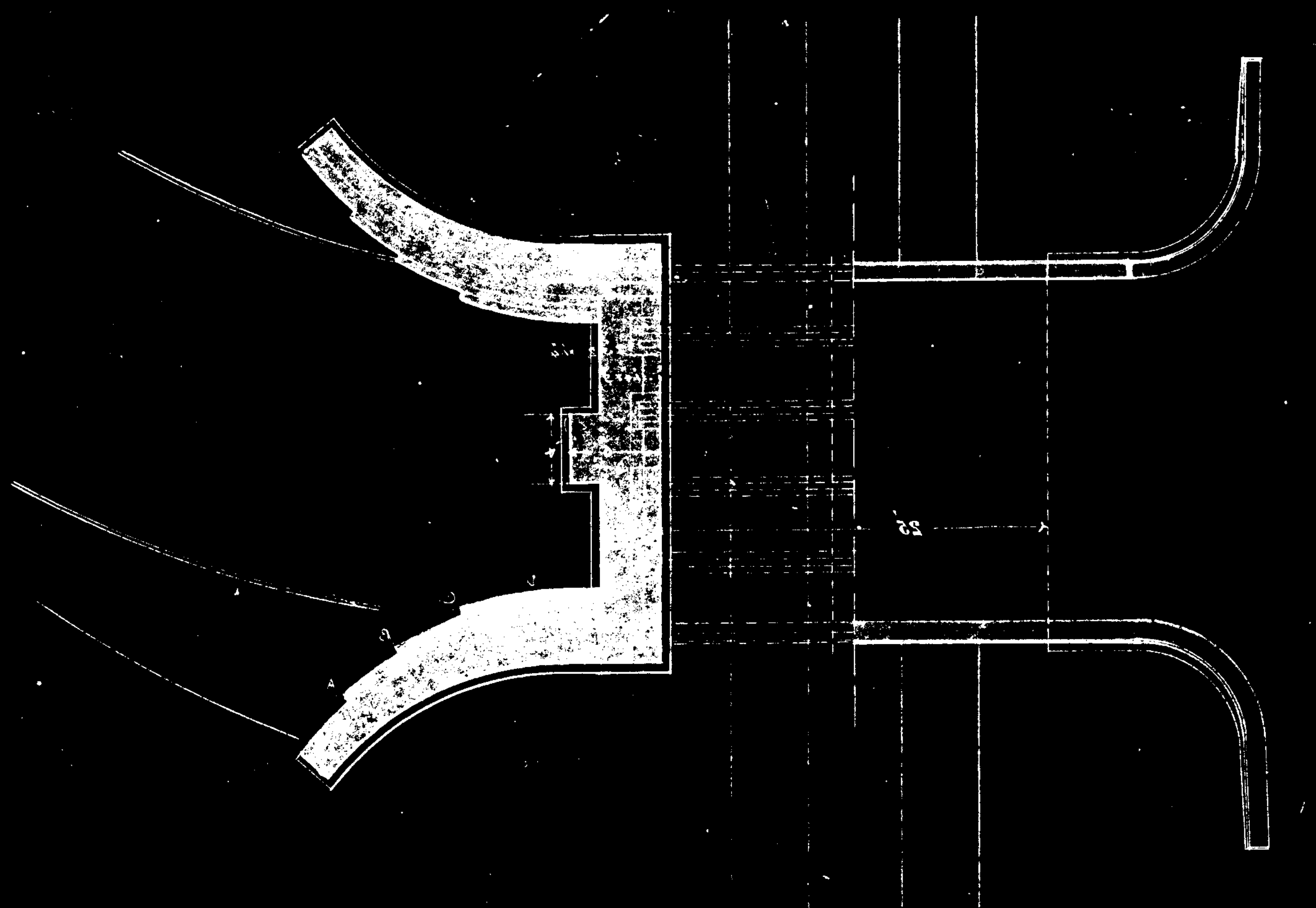
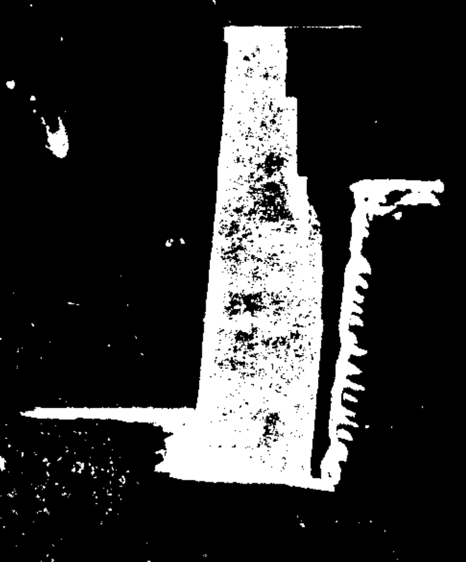
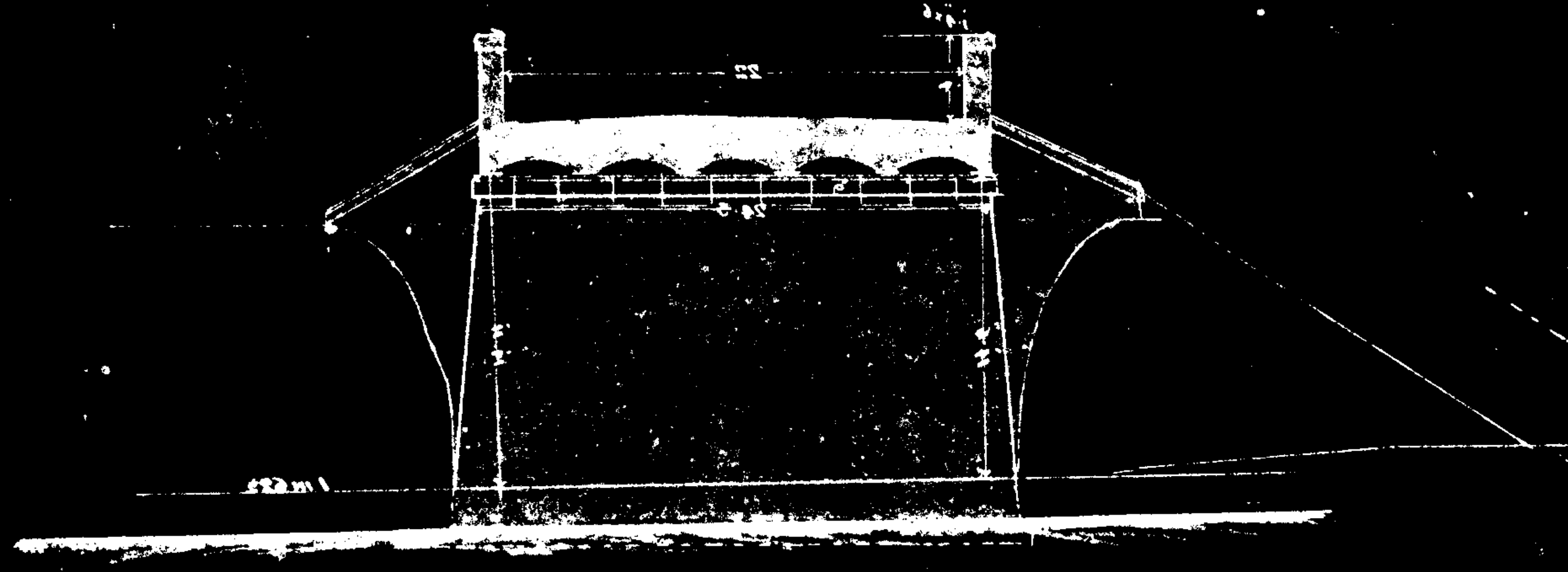


PLAN

Girders & Brick Arching similar to those of Bridge 20m 12½c



WINGWALL



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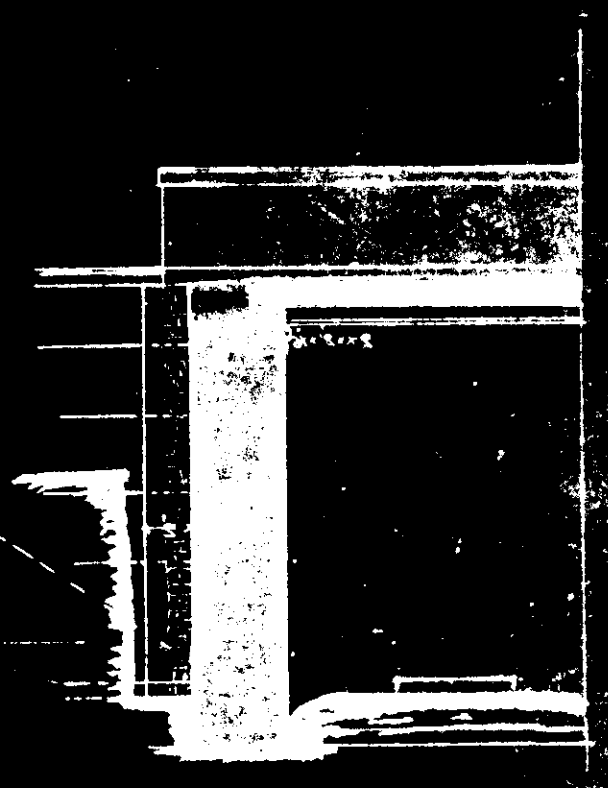


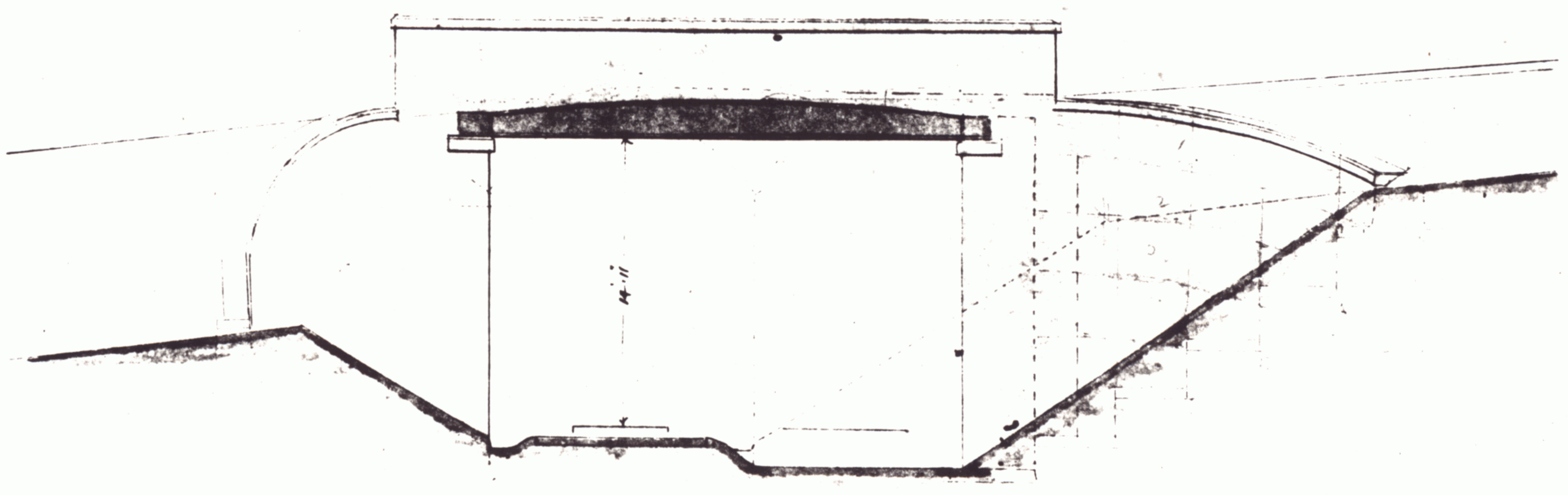
ABUTMENT

C. K. & P. RY. THRELKELD & TROUTBECK DOUBLING

Public Road Bridge at 18m. 35chs.

Nº 87

C37/87



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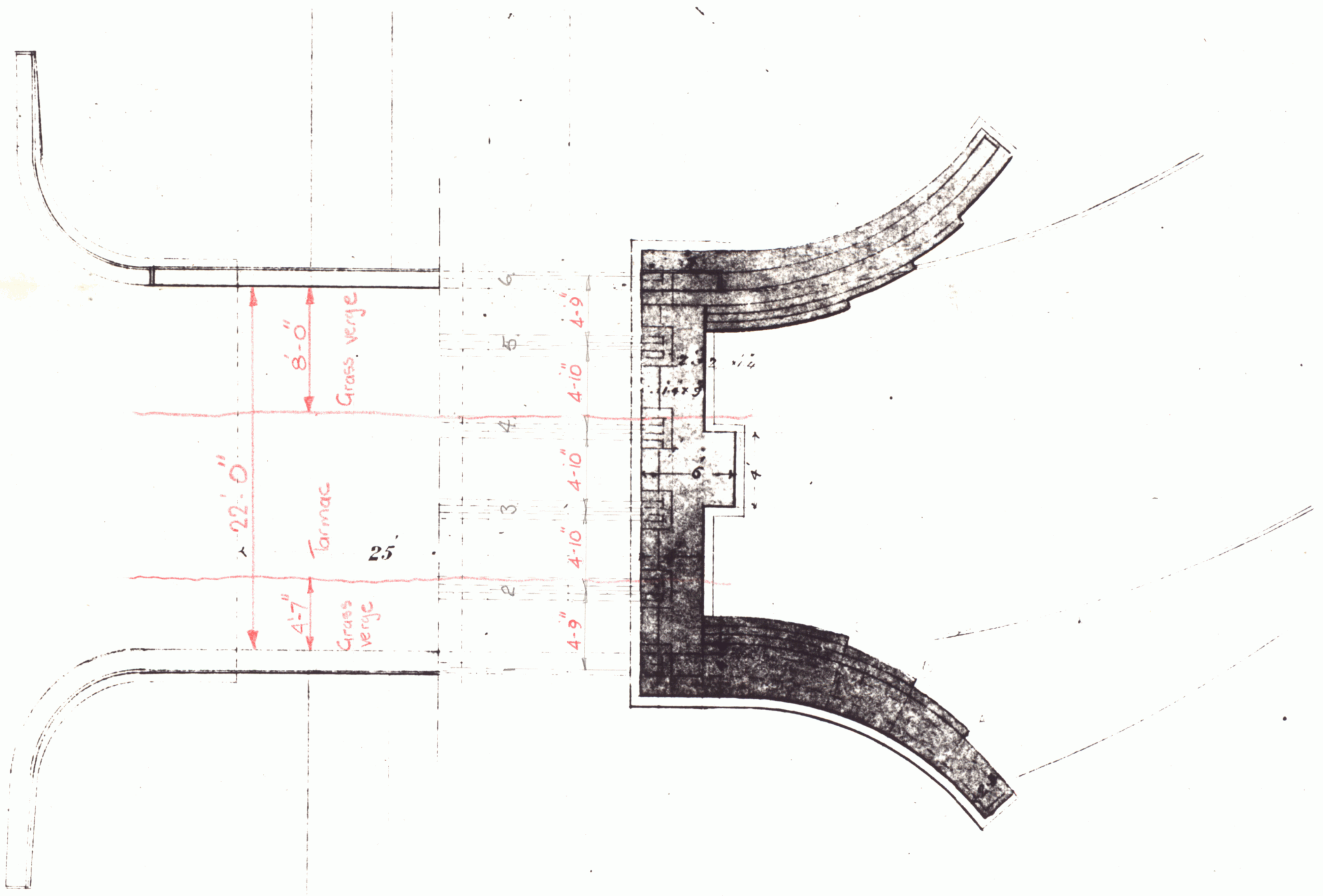


PLAN

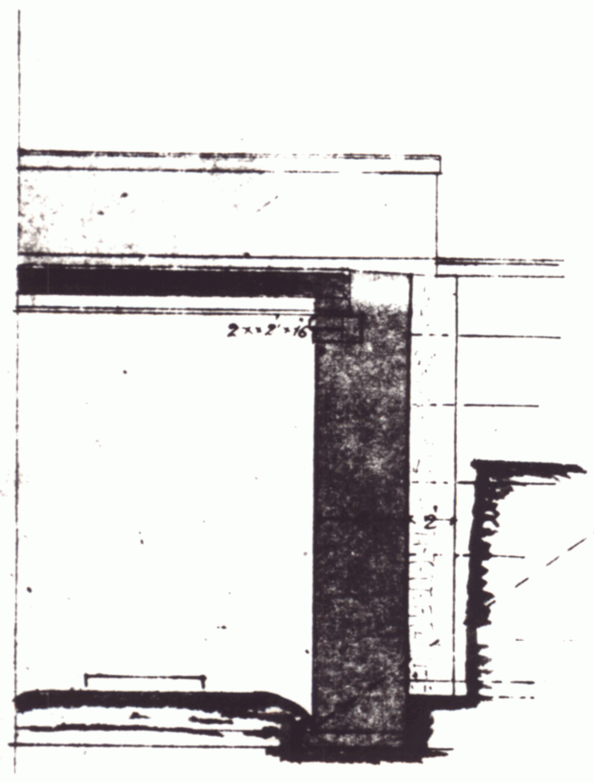
For Girder details see C37/94
H.C

C37/94

↓

Girders & Brick Arching similar to those of Bridge 20m 12¼c

Amendments in red added 5.3.68 H.C



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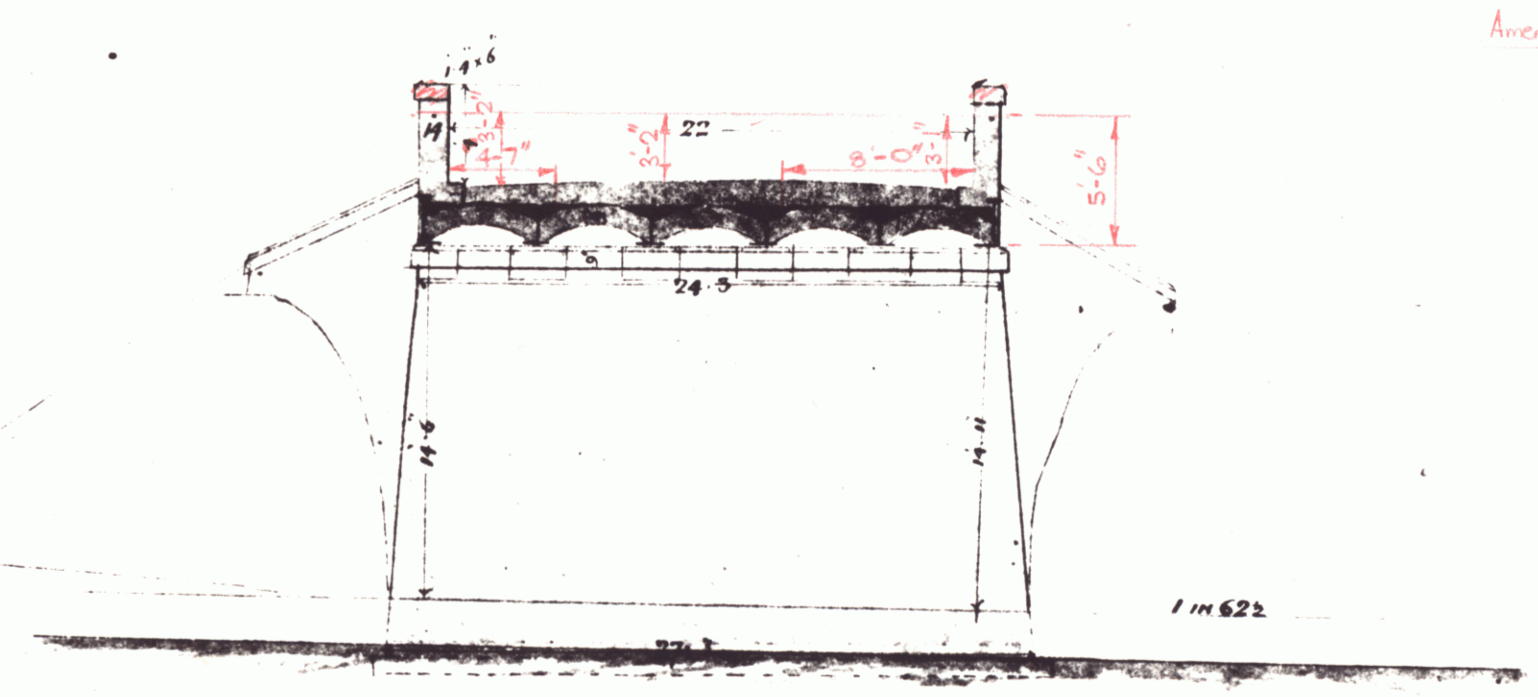

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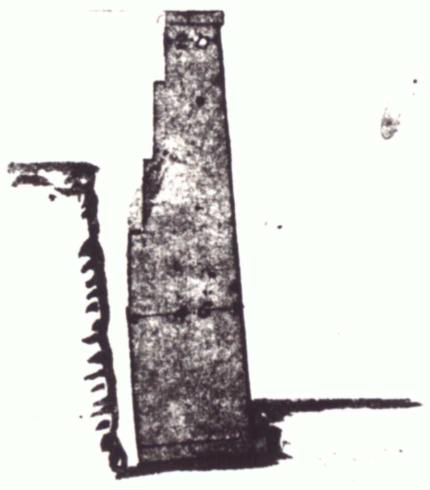


WINGWALL

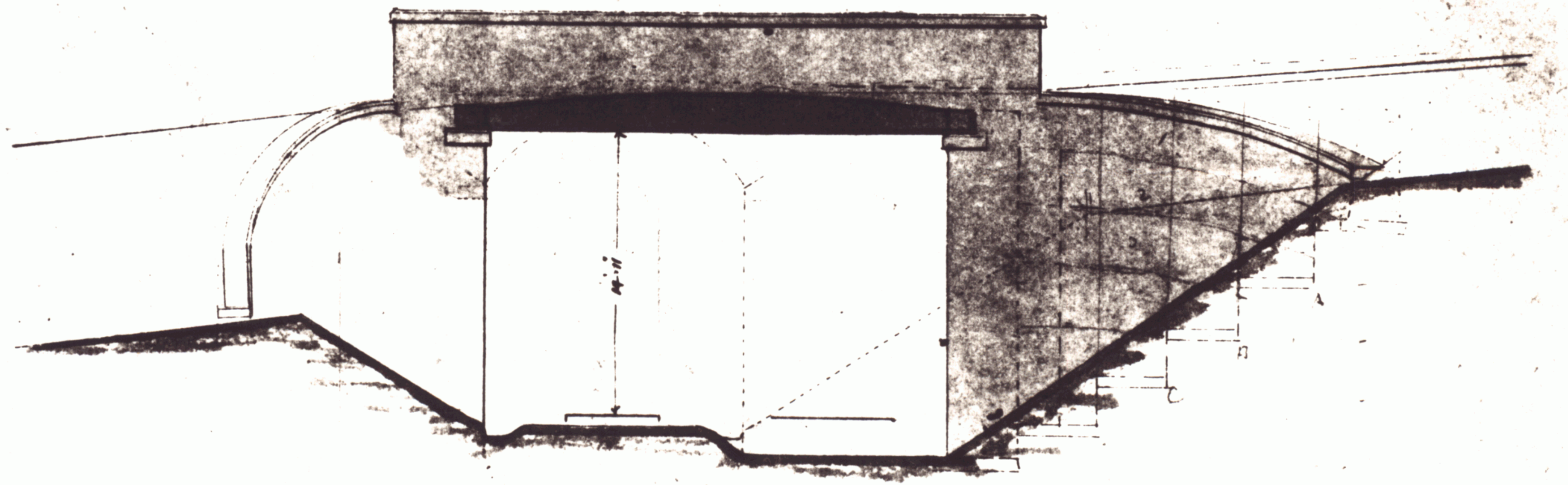
C. K. & P. RY. THRELKELD & TROUTBECK DOUBLING

Public Road Bridge at 18m. 35chs.

Nº 87

Copy Regd 21/8/93

C37/87



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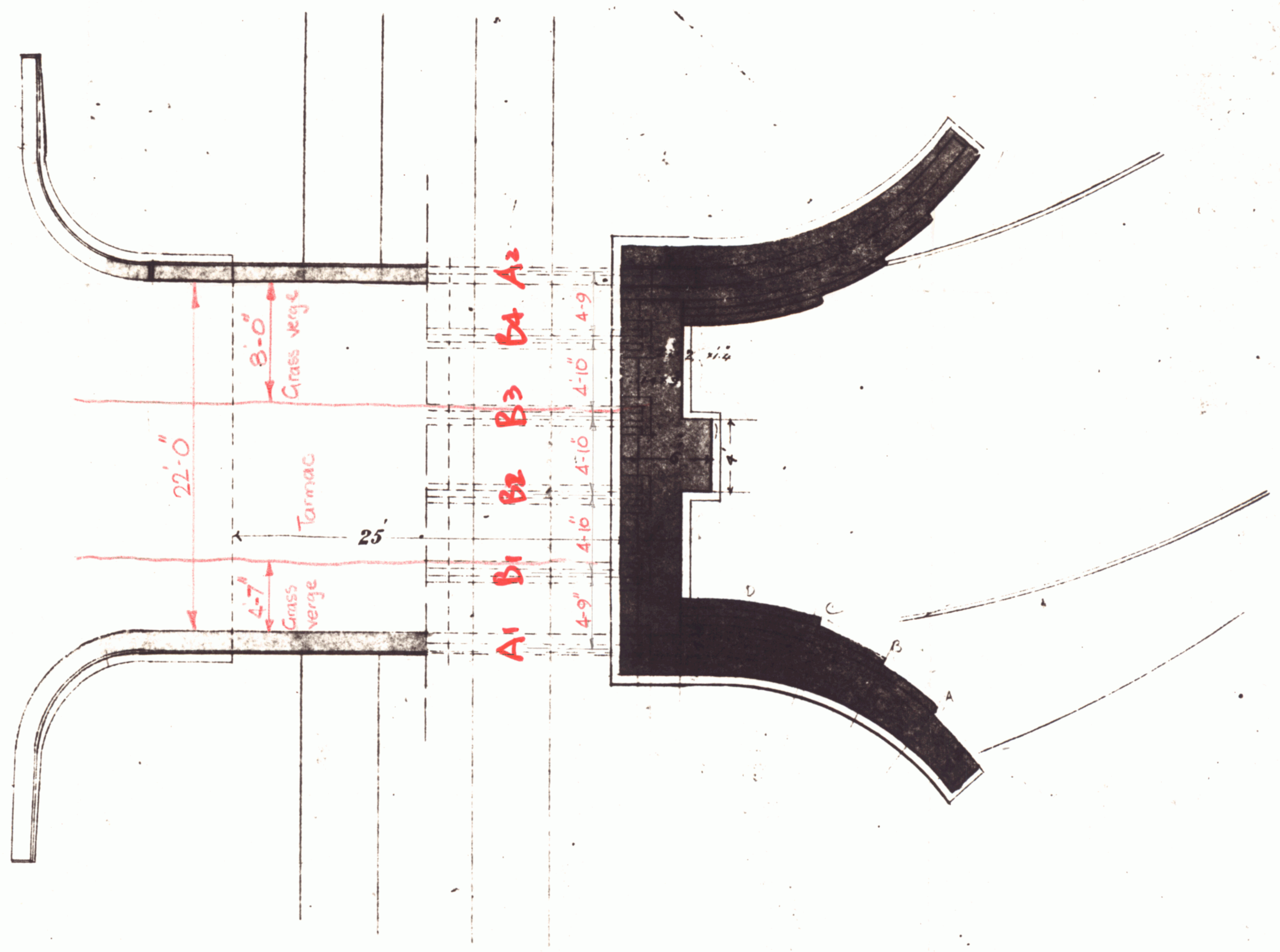


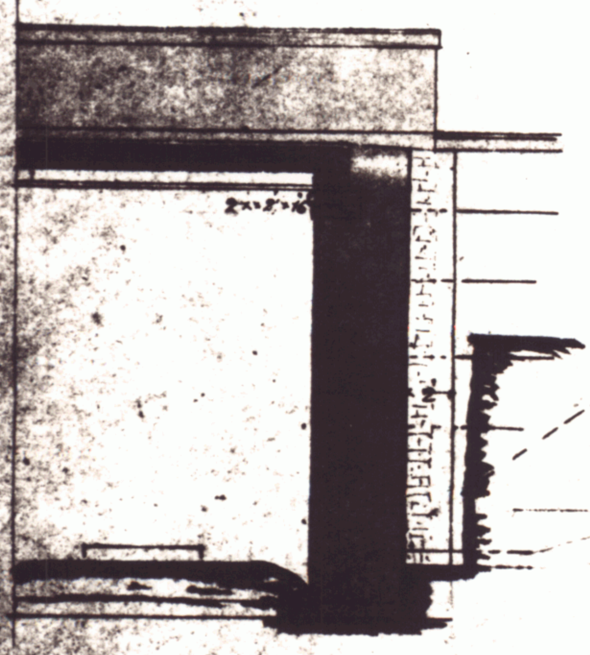
PLAN

For Girder details see C 37/94
H.C

C37/94

Girders & Brick Arching similar to those of Bridge 20m 12½c

Amendments in red added 5-3-68 H.C



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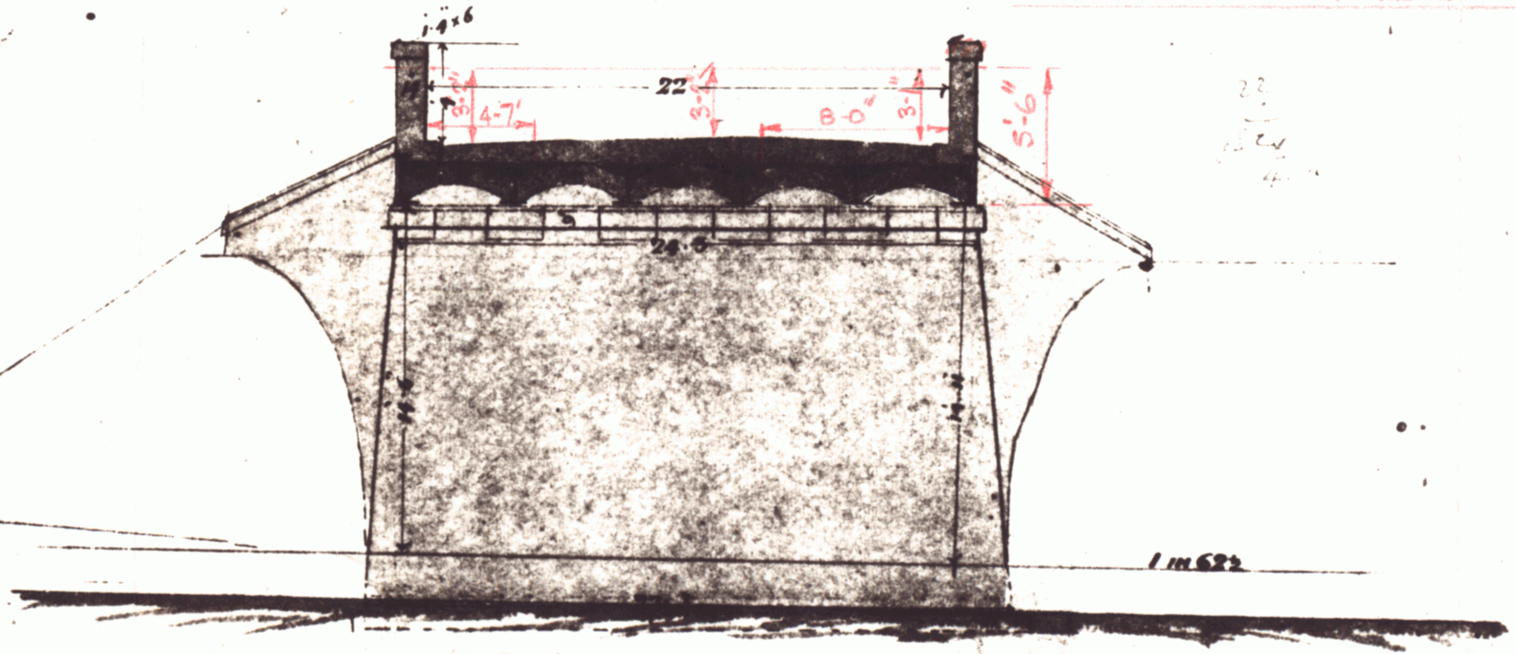

SECTION

WINGWALL