Davies Torres Design Ltd
Clarence House
Church Street
Nailsworth
Gloucestershire
GL6 0BP

01453 350 546

Project: The Old Forge

Project Ref: 200814

Calculations for: Resin Beam Connections for Replacement Beams RevA

Client: Property Repair Systems

Date: September 2020

Davies Torres Design Ltd Clarence House Church Street, Nailsworth GL6 0BP	Project The Old Forge				Job Ref. 200814	
	Section Introduction				Sheet no./rev. 1/A	
	Calc. by RD	Date 29/09/20	Chk'd by	Date	App'd by	Date

Proposals

It is proposed to carry out resin beam strengthening at The Old Forge.

Calculations carried out in conjunction with Property Repair Systems proposals and sketch details.

References

BS6399-1: 1996 Loading for Buildings – Code of Practice for dead and imposed loads
BS5268-2:2002 Structural use of timber – Code of practice for permissible stress design
BS449-2:1969 The use of structural steel in building
Structural Engineers Pocket Book, 2nd Ed. - Cobb

Revisions

RevA – Repair proposal amended to replace timber with suitable size and installed in three sections for access connected by resin/bars.

Calculations prepared by

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MEng PhD CEng MIStructE

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Contents

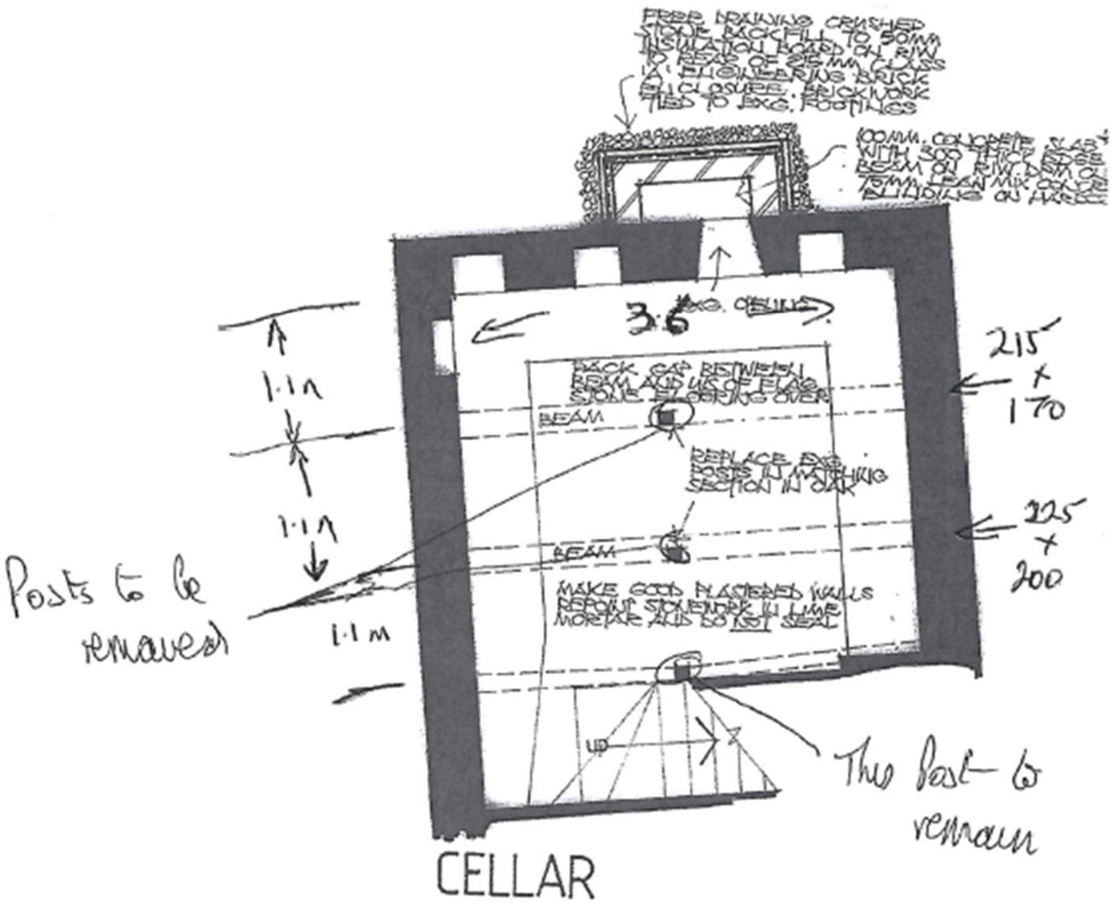
Dead Loads

Floor Existing

75mm Flagstones between beams	1.50	kN/m^2
		kN/m^2
		kN/m^2
		kN/m^2
	1.50	**kN/m^2 on plan**

Existing Beam Assessment

Assess existing beam with central supporting post removed.



Load take down

Beams				
Item	**Load per sqm**	**Width/Height**	**Load per m**	**Category**
Floor Imposed	1.50	1.1	1.65	Dead
Floor Dead	1.5	1.1	1.65	Snow

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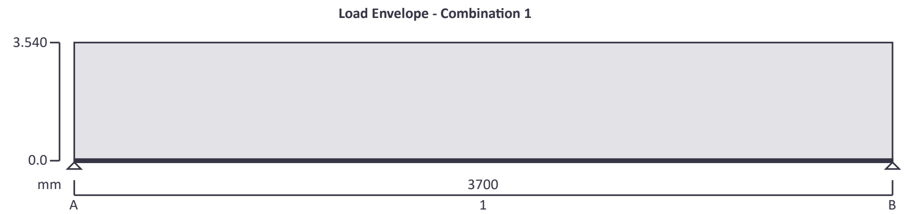
	Calc. by RD	Date 29/09/20	Chk'd by	Date	App'd by	Date

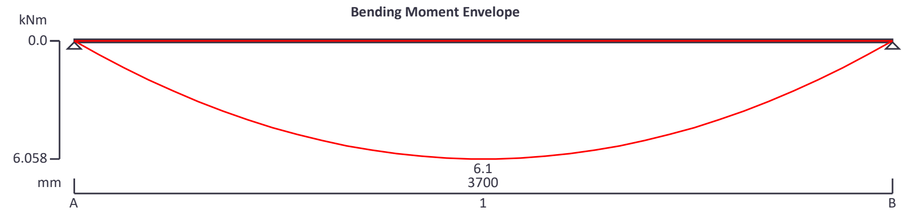
Total Dead Load	1.65	kN/m
Total Imposed and Snow	1.65	kN/m
Check Total	3.30	kN/m

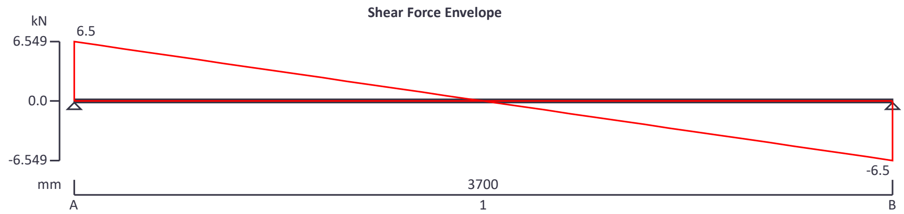
Timber beam analysis & design (BS5268) - Existing Beam

TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002

TEDDS calculation version 1.7.02







Applied loading

Beam loads

Imposed	Imposed full UDL 1.650 kN/m
Dead	Dead full UDL 1.650 kN/m
Self Weight	Dead self weight of beam * 1

Load combinations

Load combination 1	Support A	Dead * 1.00
		Imposed * 1.00
	Span 1	Dead * 1.00
		Imposed * 1.00

Support B Dead * 1.00

Imposed * 1.00

Analysis results

Maximum moment; M_{max} = **6.058** kNm; M_{min} = **0.000** kNm

Design moment; M = max(abs(M_{max}),abs(M_{min})) = **6.058** kNm

Maximum shear; F_{max} = **6.549** kN; F_{min} = **-6.549** kN

Design shear; F = max(abs(F_{max}),abs(F_{min})) = **6.549** kN

Total load on beam; W_{tot} = **13.099** kN

Reactions at support A; R_{A_max} = **6.549** kN; R_{A_min} = **6.549** kN

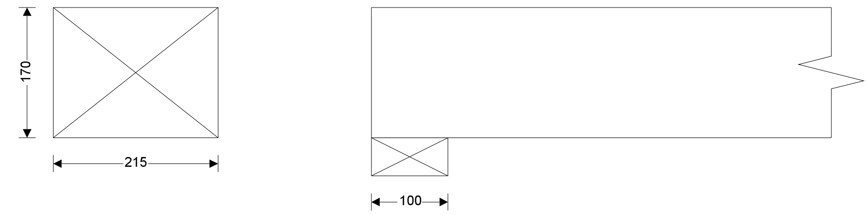
Unfactored dead load reaction at support A; R_{A_Dead} = **3.497** kN

Unfactored imposed load reaction at support A; $R_{A\_Imposed}$ = **3.053** kN

Reactions at support B; R_{B_max} = **6.549** kN; R_{B_min} = **6.549** kN

Unfactored dead load reaction at support B; R_{B_Dead} = **3.497** kN

Unfactored imposed load reaction at support B; $R_{B\_Imposed}$ = **3.052** kN



Timber section details

Breadth of sections; b = **215** mm

Depth of sections; h = **170** mm

Number of sections in member; N = **1**

Overall breadth of member; b_b = N × b = **215** mm

Timber strength class; **D35**

Member details

Service class of timber; **1**

Load duration; **Long term**

Length of span; L_{s1} = **3700** mm

Length of bearing; L_b = **100** mm

Section properties

Cross sectional area of member; A = N × b × h = **36550** mm^2

Section modulus; Z_x = N × b × h^2 / 6 = **1035583** mm^3

Z_y = h × $(N \times b)^2$ / 6 = **1309708** mm^3

Second moment of area; I_x = N × b × h^3 / 12 = **88024583** mm^4

I_y = h × $(N \times b)^3$ / 12 = **140793646** mm^4

Radius of gyration; i_x = √(I_x / A) = **49.1** mm

i_y = √(I_y / A) = **62.1** mm

Modification factors

Duration of loading - Table 17; K_3 = **1.00**

Bearing stress - Table 18; K_4 = **1.00**

Total depth of member - cl.2.10.6; K_7 = $(300\ mm / h)^{0.11}$ = **1.06**

Load sharing - cl.2.9; K_8 = **1.00**

Lateral support - cl.2.10.8

Ends held in position and members held in line, as by direct connection of sheathing, deck or joists

Permissible depth-to-breadth ratio - Table 19; **5.00**

Actual depth-to-breadth ratio; h / (N * b) = **0.79**

PASS - Lateral support is adequate

Compression perpendicular to grain

Permissible bearing stress (no wane); $\sigma_{c\_adm} = \sigma_{cp1} * K_3 * K_4 * K_8$ = **3.400** N/mm^2

Applied bearing stress; $\sigma_{c\_a} = R_{A\_max} / (N * b * L_b)$ = **0.305** N/mm^2

$\sigma_{c\_a} / \sigma_{c\_adm}$ = **0.090**

PASS - Applied compressive stress is less than permissible compressive stress at bearing

Bending parallel to grain

Permissible bending stress; $\sigma_{m\_adm} = \sigma_m * K_3 * K_7 * K_8$ = **11.709** N/mm^2

Applied bending stress; $\sigma_{m\_a} = M / Z_x$ = **5.850** N/mm^2

$\sigma_{m\_a} / \sigma_{m\_adm}$ = **0.500**

PASS - Applied bending stress is less than permissible bending stress

Shear parallel to grain

Permissible shear stress; $\tau_{adm} = \tau * K_3 * K_8$ = **1.700** N/mm^2

Applied shear stress; $\tau_a = 3 * F / (2 * A)$ = **0.269** N/mm^2

τ_a / τ_{adm} = **0.158**

PASS - Applied shear stress is less than permissible shear stress

Deflection

Modulus of elasticity for deflection; $E = E_{min}$ = **6500** N/mm^2

Permissible deflection; $\delta_{adm} = \min(0.551 \text{ in}, 0.003 * L_{s1})$ = **11.100** mm

Bending deflection; δ_{b_s1} = **15.099** mm

Shear deflection; δ_{v_s1} = **0.490** mm

Total deflection; $\delta_a = \delta_{b\_s1} + \delta_{v\_s1}$ = **15.589** mm

δ_a / δ_{adm} = **1.404**

FAIL - Total deflection exceeds permissible deflection

Beam would not be stiff enough to support applied loadings even assuming no notches or reductions in section where the existing post is connected to the beam. Therefore, replace beams with suitable sized section.

Beam Strengthening assuming 8No 20mm bars

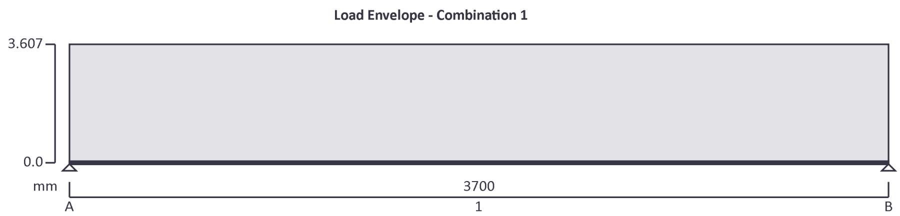
It is proposed to replace the timber beam with a suitable sized section, installed in sections for installation purposes.

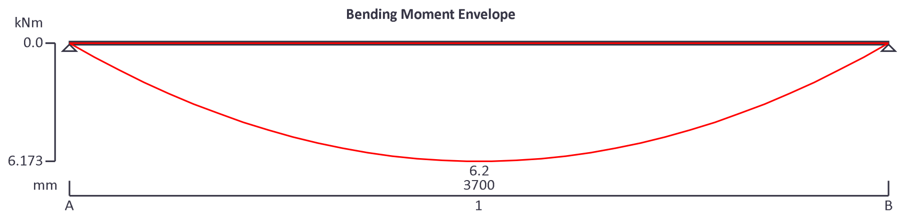
Determine size of required timber using same loadings and span as previous.

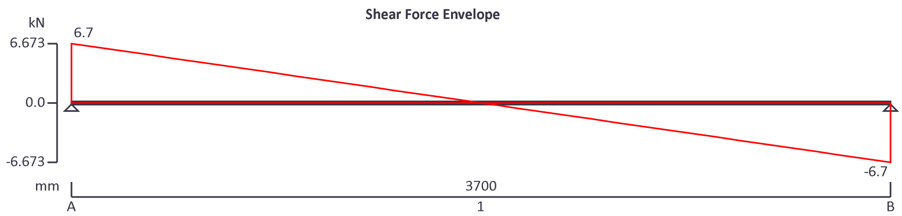
Timber beam analysis & design (BS5268) - New Timber Beam

TIMBER BEAM ANALYSIS & DESIGN TO BS5268-2:2002

TEDDS calculation version 1.7.02







Applied loading

Beam loads

Imposed	Imposed full UDL 1.650 kN/m	
Dead	Dead full UDL 1.650 kN/m	
Self Weight	Dead self weight of beam * 1	

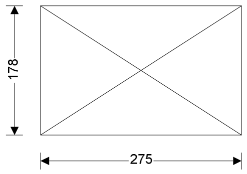
Load combinations

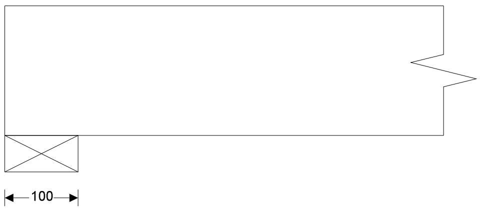
Load combination 1	Support A	Dead * 1.00
		Imposed * 1.00
	Span 1	Dead * 1.00
		Imposed * 1.00

Support B Dead * 1.00
Imposed * 1.00

Analysis results

Maximum moment; M_{max} = **6.173** kNm; M_{min} = **0.000** kNm
Design moment; M = max(abs(M_{max}),abs(M_{min})) = **6.173** kNm
Maximum shear; F_{max} = **6.673** kN; F_{min} = **-6.673** kN
Design shear; F = max(abs(F_{max}),abs(F_{min})) = **6.673** kN
Total load on beam; W_{tot} = **13.347** kN
Reactions at support A; R_{A_max} = **6.673** kN; R_{A_min} = **6.673** kN
Unfactored dead load reaction at support A; R_{A_Dead} = **3.621** kN
Unfactored imposed load reaction at support A; $R_{A\_Imposed}$ = **3.053** kN
Reactions at support B; R_{B_max} = **6.673** kN; R_{B_min} = **6.673** kN
Unfactored dead load reaction at support B; R_{B_Dead} = **3.621** kN
Unfactored imposed load reaction at support B; $R_{B\_Imposed}$ = **3.052** kN





Timber section details

Breadth of sections; b = **275** mm
Depth of sections; h = **178** mm
Number of sections in member; N = **1**
Overall breadth of member; $b_b = N \times b$ = **275** mm
Timber strength class; **D30**

Member details

Service class of timber; **1**
Load duration; **Long term**
Length of span; L_{s1} = **3700** mm
Length of bearing; L_b = **100** mm

Section properties

Cross sectional area of member; $A = N \times b \times h$ = **48950** mm^2
Section modulus; $Z_x = N \times b \times h^2 / 6$ = **1452183** mm^3
$Z_y = h \times (N \times b)^2 / 6$ = **2243542** mm^3
Second moment of area; $I_x = N \times b \times h^3 / 12$ = **129244317** mm^4
$I_y = h \times (N \times b)^3 / 12$ = **308486979** mm^4
Radius of gyration; $i_x = \sqrt{(I_x / A)}$ = **51.4** mm
$i_y = \sqrt{(I_y / A)}$ = **79.4** mm

Modification factors

Duration of loading - Table 17; K_3 = **1.00**
Bearing stress - Table 18; K_4 = **1.00**
Total depth of member - cl.2.10.6; $K_7 = (300 \text{ mm} / h)^{0.11}$ = **1.06**
Load sharing - cl.2.9; K_8 = **1.00**

Lateral support - cl.2.10.8

Ends held in position and members held in line, as by direct connection of sheathing, deck or joists

Permissible depth-to-breadth ratio - Table 19; **5.00**

Actual depth-to-breadth ratio; h / (N * b) = **0.65**

PASS - Lateral support is adequate

Compression perpendicular to grain

Permissible bearing stress (no wane); $\sigma_{c\_adm} = \sigma_{cp1} * K_3 * K_4 * K_8$ = **2.800** N/mm^2

Applied bearing stress; $\sigma_{c\_a} = R_{A\_max} / (N * b * L_b)$ = **0.243** N/mm^2

$\sigma_{c\_a} / \sigma_{c\_adm}$ = **0.087**

PASS - Applied compressive stress is less than permissible compressive stress at bearing

Bending parallel to grain

Permissible bending stress; $\sigma_{m\_adm} = \sigma_m * K_3 * K_7 * K_8$ = **9.532** N/mm^2

Applied bending stress; $\sigma_{m\_a} = M / Z_x$ = **4.251** N/mm^2

$\sigma_{m\_a} / \sigma_{m\_adm}$ = **0.446**

PASS - Applied bending stress is less than permissible bending stress

Shear parallel to grain

Permissible shear stress; $\tau_{adm} = \tau * K_3 * K_8$ = **1.400** N/mm^2

Applied shear stress; $\tau_a = 3 * F / (2 * A)$ = **0.204** N/mm^2

τ_a / τ_{adm} = **0.146**

PASS - Applied shear stress is less than permissible shear stress

Deflection

Modulus of elasticity for deflection; $E = E_{min}$ = **6000** N/mm^2

Permissible deflection; δ_{adm} = min(0.551 in, 0.004 * L_{s1}) = **13.995** mm

Bending deflection; δ_{b_s1} = **11.352** mm

Shear deflection; δ_{v_s1} = **0.404** mm

Total deflection; $\delta_a = \delta_{b\_s1} + \delta_{v\_s1}$ = **11.755** mm

δ_a / δ_{adm} = **0.840**

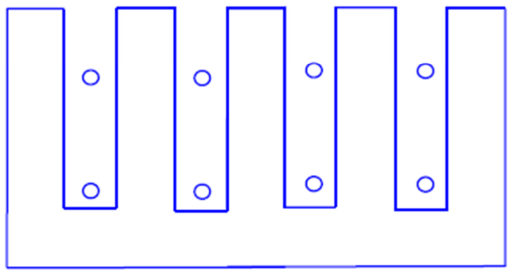
PASS - Total deflection is less than permissible deflection

For resin beam connections, use maximum moment at centre of section. 6.2kNm

TRS TYPE E, 8 SHEAR CONNECTORS for each connection

Beam to be made in 3 sections of 500mm - 1800mm - 1700mm

4 SLOTS in both ends of the centre section, holes in one end of the outer sections to join with the centre section



Refer to proposal sheet included within Appendix for full dimensions

Esteel	205000	N/sqmm
Etimber	6000	N/sqmm
Modular Ratio	34.2	

Tension Steel		
No of Bars per layer	4	
Diameter	20	mm
Total Area per layer	1256.6	sqmm
Equivalent Area	42935.1	sqmm

Compression Steel		
No of Bars	4	
Diameter	20	mm
Total Area	1256.6	sqmm
Equivalent Area	41678.5	sqmm

Bending Moment 6.2 kNm

Dimensions of Timber		
Depth	178	mm
Breadth	275	mm

Depth to Steel		
Compression	44	mm
Tension		
Length of Steel Bars	800	mm
Slot Depth	138	mm
Slot Width	32	mm

Tension Bars	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8	
d	133								mm
d-x	53.98484								mm
EquivArea x (d-x)	2317845								mm^3

Solve for Neutral Axis Depth

x = 79.01516 mm

Qabove NA	2317845
Qbelow NA	2317845

Cracked Section Moment of Inertia

489510864.6 mm^4

Davies Torres Design Ltd Clarence House Church Street, Nailsworth GL6 0BP	Project: The Old Forge				Job Ref.: 200814	
	Section: Beam Strengthening				Sheet no./rev.: 12 /A	
	Calc. by: RD	Date: 29/09/20	Chk'd by	Date	App'd by	Date

Stresses in Bars (Lowest Bars First)

Stress N/sqmm	23.4	
Force per row kN	29.4	

Actual Stresses from Bending		
Timber Compression	1.0	N/sqmm
Tension Steel (Max)	23.4	N/sqmm
Compression Steel	15.2	N/sqmm

Tension Force	29.4	kN
Tension per Bar	7.3	kN

			Allowable for D30 Oak	
Bond Stress into Hole	0.27	N/sqmm	1.40	N/sqmm
Bond Stress into Slot	0.19	N/sqmm	1.40	N/sqmm

Stresses in timber resin connections

Holed Connections

Take area of contact between resin and timber as Circumference of (Bar Dimameter + 2mm) x Embedment Length

Slotted Connections

Take area of contact as slot width x (2xslot width to allow for sides of slot) x Embedment Length

Summary

Upgrade strengthening will be acceptable with 8No 20mm diameter bars at centres as proposed with timber installed in three sections.

Stresses in timber and steel both acceptable

Appendix

Resin Design Methodology

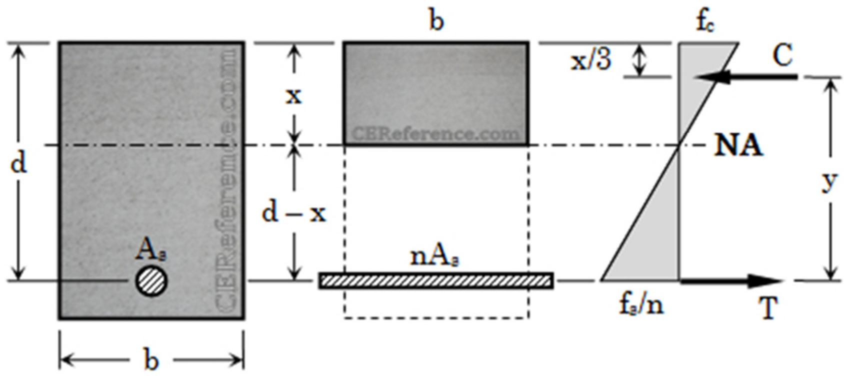
Resin Repair proposals

Drawings

Resin Data Sheet

Transformed Section Method

Convert steel area to equivalent concrete area by multiplying A_S with modular ratio, n.



Location of the neutral axis from extreme compression fiber

Singly reinforced: $\frac{1}{2}bx^2 = nA_s(d-x)$

Doubly reinforced: $\frac{1}{2}bx^2 + (2n-1)A_s'(x-d') = nA_s(d-x)$

Cracked section moment of inertia ($I_{NA} = I_{cr}$)

Singly reinforced: $I_{NA} = \dfrac{bx^3}{3} + nA_s(d-x)^2$

Doubly reinforced: $I_{NA} = \dfrac{bx^3}{3} + (2n-1)A_s'(x-d')^2 + nA_s(d-x)^2$

Actual stresses (calculate using Flexure Formula)

Concrete

$$f_c = \frac{Mx}{I_{NA}}$$

Tension steel

$$\frac{f_s}{n} = \frac{M(d-x)}{I_{NA}}$$

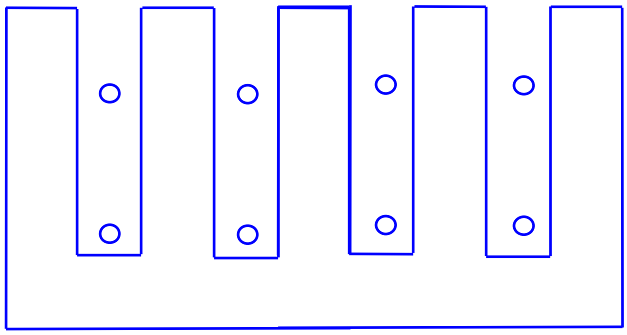
Compression steel for doubly reinforced

$$\frac{f_s'}{2n} = \frac{M(x-d')}{I_{NA}}$$

TRS TYPE E, 8 SHEAR CONNECTORS for each connection

Beam to be made in 3 sections of 500mm - 1800mm - 1700mm

4 SLOTS in both ends of the centre section, holes in one end of the outer sections to join with the centre section



COMPANY - Eradicure (Stratford Upon Avon) Ltd **CONTACT -** Des Parry

SITE - The Old Forge **ENQ/JOB NO:** 5368 **DATE -** 17/09/2020

BEAM REFERENCE NO. 1	**NO. TO REPAIR** 1
DIMENSIONS ***(NOT TO SCALE)***	
WIDTH (mm)	275
DEPTH (mm)	178
OVERALL LENGTH (mm)	4000
BASE THICKNESS (mm)	30
SHEAR CONNECTOR (ROD) CENTRES (mm)	45/134
SHEAR CONNECTORS (RODS)	
LENGTH OVERALL (mm) ***(50:50)***	800
DIAMETER (mm)	20
NUMBER	8 each joint
MATERIAL	HT BZP Steel
SLOTS ***(DO NOT SCALE FROM SKETCH)***	
NUMBER	4
WIDTH (mm) **(MAX. FOR RESIN VOLUME ALLOWED)**	32
DEPTH (mm) **(MAX. FOR RESIN VOLUME ALLOWED)**	138

SCHEMATIC ONLY - NOT TO SCALE
ALL PROPOSALS TO BE VERIFIED BY A STRUCTURAL ENGINEER

REF: THE OLD FORGE

REQUEST FOR STRUCTURAL CALCULATION

UPGRADE

WIDTH OF TIMBER (mm) 215

DEPTH OF TIMBER (mm) 170

LENGTH (excluding bearing) (m) .... 3·7

LENGTH OF BEARING (mm) 150

TIMBER TYPE (softwood or hardwood) .... HARD

FUNCTION OF COMPONENT (supports what?)

CARRIERS FOR FLAG FLOOR

SIZE OF ROOM (m x m) .... 3·6 x 3·3

NUMBER OF CARRIER BEAMS IN ROOM 3

ANY OTHER TIMBERS ON CARRIERS .... NO
(BELOW JOISTS)

SIZE OF JOISTS (mm x mm x m) .... NONE

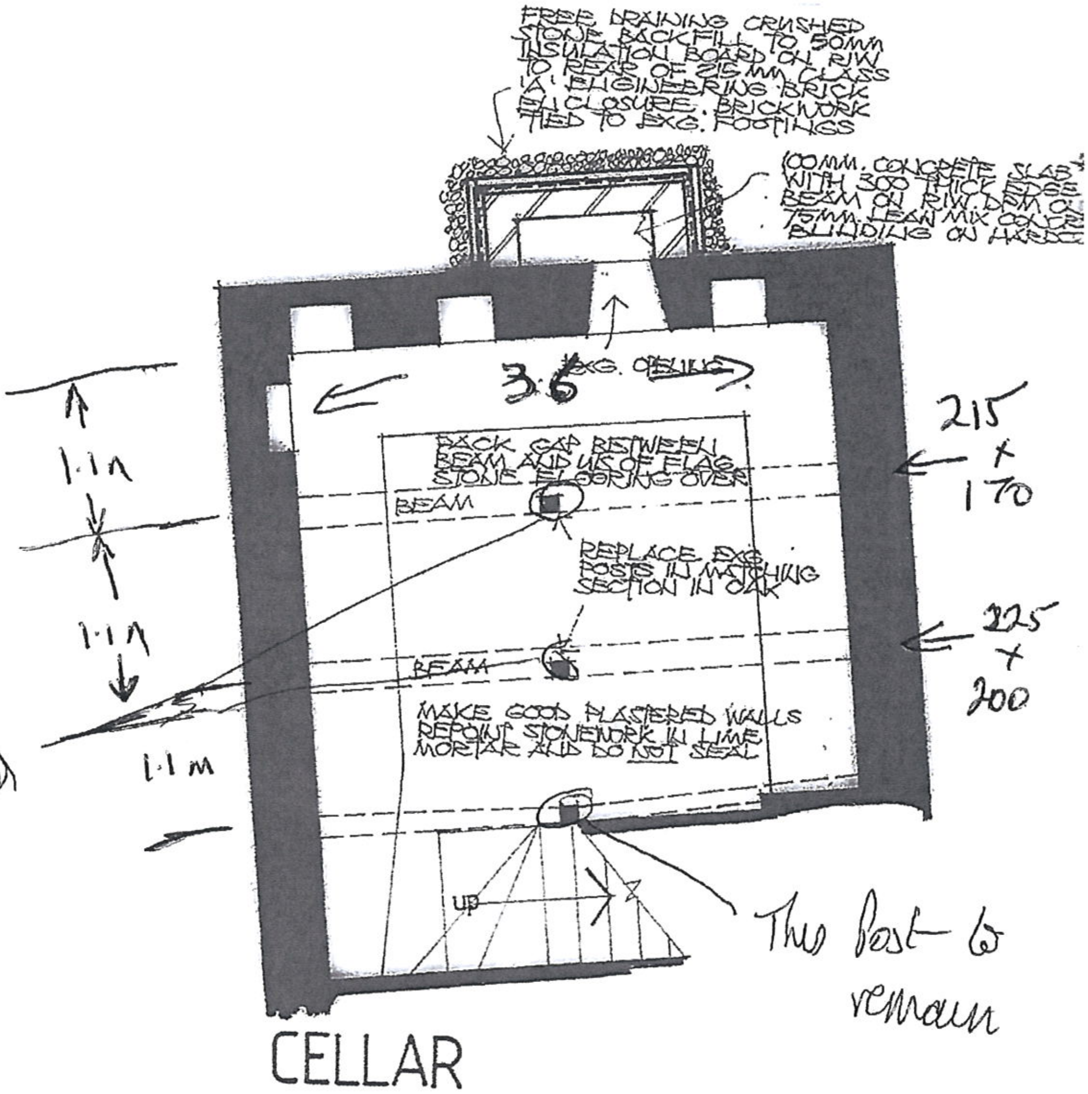
NUMBER OF JOISTS .... NONE

SPACING OF JOISTS (mm) .... N/A.

FLOOR COVERING (Butt edged/T & G) .... FLAG STONES 75mm THICK

LOADING (Domestic/Commercial/Special) .... DOM

Please attach a Sketch or scale drawing of the room and its floor components.



Flagstone Floor above

THIXOTROPIC EPOXY RESIN

An Ultra Low Disturbance Building Solution

Property Repair Systems
01626 331351

DESCRIPTION

THIXOTROPIC EPOXY RESIN is a two part, non-slump gel adhesive, designed to bond materials together or to inject into cracks, fissures and holes. THIXOTROPIC EPOXY RESIN can be injected from a standard 400cc cartridge or applied directly from the mixing pot in a film as thin as 0.2mm. THIXOTROPIC EPOXY RESIN does not contain solvent or water, so can be applied to difficult substrates.

Features

- Adhesion greater than the cohesive strength of timber
- Solvent and water free
- Impermeable to vapour
- Working pot life: 5 – 10 minutes at 15 – 20 C.
- Set time: 1 - 2 hours initial at 15 – 20 degrees C, 5 - 7 days full cure.

TYPICAL USES

For bonding timber, stone and metal and for injecting into cracks and holes in timber and masonry. For bonding dowels into timber and masonry. For laminating timbers and repairing Glulam beams. Suitable for high humidity environments.

PREPARATION & METHOD

Cut out all rotted, loose or flaking material and vacuum to remove dust. Abrade or grind as necessary to provide clean, stable surfaces free of all contaminants.

Mix the two components thoroughly with a stiff, square edged pallet knife until the two colours blend into an even colour.

Approximate spreading 'open' time is 5 - 10 minutes at 15 - 20 degrees centigrade, initial set in 1 - 2 hours. Initial cure minimum 12 hours, full cure 5 -7 days.

Either apply the adhesive to both surfaces to be bonded, or dispense into a cartridge kit for injection.

Ensure that the temperature is above 5 degrees Centigrade, or pre-warm the materials, otherwise curing may be delayed or prevented.

TECHNICAL DATA

Active Substance
Bisphenol A/F epoxy & Aliphatic Amines
Other Components
Glycidyl ether and inert fillers
Mix ratio - Do not vary the mix ratio – 2:1
2 measures of Base to 1 measure of Activator
Bond Strength/Tensile Shear Adhesion -
6 N/mm^2
Compressive Strength - 30 N/mm^2
Tensile Strength - 16 N/mm^2
Flexural Strength - 20 N/mm^2
Flexural Modulus - 503 N/mm^2
Young's Modulus >370 N/mm^2
Aggressivity to other materials
No known aggressivity
Classification
Irritant and corrosive
Packaging
Optional 400cc cartridge, skeleton guns
Colour
Blue/Cream – Mixed = Off White

Property Repair Systems - 01626 331351
Unit 3, Olympus Business Park, TQ12 2SN
DCM – 08/18