Davies Torres Design Ltd
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Project: Claremont Road

Project Ref: 150312

Calculations for: Beam End Repair

Client: Property Repair Systems

Date: March 2015

Building Standards
Approved Certifier
The Scottish Government

Proposals

It is proposed to carry out a timber resin end repair to a bressumer beam at Claremont Road, Newcastle

Calculations carried out in conjunction with Timber Repair Systems proposed connection.

References

BS6399-1: 1996	Loading for Buildings – Code of Practice for dead and imposed loads
BS6399-2:1997	Loadings for buildings – Code of practice for wind loads
BS6399-3:1988	Loadings for Buildings – Code of practice for imposed roof 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	
TRADA	Resin repairs to Timber Structures: Guidance and selection

Calculations prepared by

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MEng PhD CEng MIStructE

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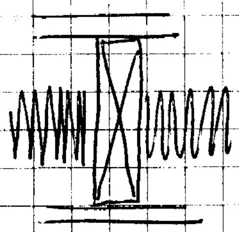
DEAD LOADS.

MASONRY OVER BEAM 345mm THICK. @ 20 kN/m³.
ALLOW 60% DUE TO WINDOW OPENINGS.
HEIGHT OF MASONRY ABOVE BEAM = 3.8m.

DEAD LOAD ON BEAM = 20 x 0.6 x 3.8 x 0.345
= **15.7 kN/m.**

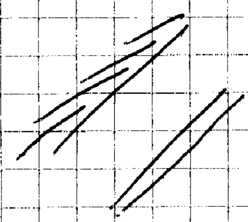
FLOOR JOISTS ONTO BEAM



FLOOR BOARDS	0.20 kN/m²
JOISTS 75x230	0.20 kN/m²
DEADENING	0.25 kN/m²
PLASTER	0.30 kN/m²
Σ	**0.95 kN/m²**

SPAN OF JOISTS = 5.7m.
∴ LOAD ON BEAM = $0.95 \times \frac{5.7}{2}$ = **2.70 kN/m.**

ROOF SUPPORTED ON WALL

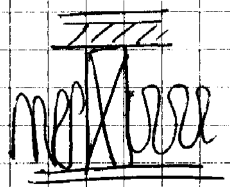


SLATE	0.60 kN/m²
MEMBRANE/FELT	0.10 kN/m²
RAFTERS	0.15 kN/m²
PLASTER	0.20 kN/m²
INSULATION	0.05 kN/m²
Σ	1.10 kN/m².

ALLOW 2.5m WIDTH OF ROOF LOAD.
∴ LOAD ON BEAM = 1.10 x 2.5 = **2.75 kN/m**

DEAD LOADS CONTINUED.

FLAT ROOF AT BAY WINDOW



LEAD	0.20
BOARDS.	0.20
JOISTS	0.15
INSULATION	0.05
PLASTER	0.20
	Σ 0.80 kN/m²

ALLOW 0.5m WIDTH OF LOAD

∴ LOAD ON BEAM = 0.80 x 0.5 = 0.40 kN/m

LIVE LOADS.

DOMESTIC FLOOR 1.5 kN/m².

∴ LOAD ON BEAM = $1.5 \times \frac{5.7}{2}$ = 4.3 kN/m

SNOW LOAD SAY 0.6 kN/m².

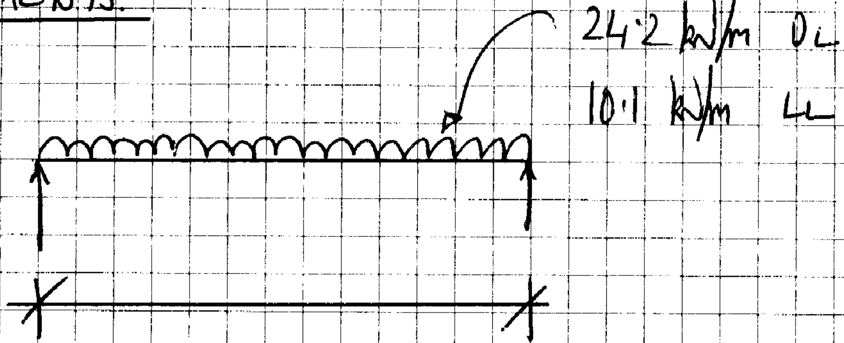
∴ LOAD ON BEAM = 0.6 x 2.5 = 1.5 kN/m.

TOTAL LOAD ON BEAM

DEAD LOAD.	WALL	15.7 kN/m
	FLOORS x2 (1st FLOOR + ATTIC)	5.4 kN/m
	ROOF	2.75 kN/m.
	FLAT ROOF	0.40 kN/m
		Σ 24.2 kN/m.

LIVE LOAD =	FLOORS x 2	8·6 kN/m
	SNOW LOAD	1·5 kN/m
		Σ 10·1 kN/m

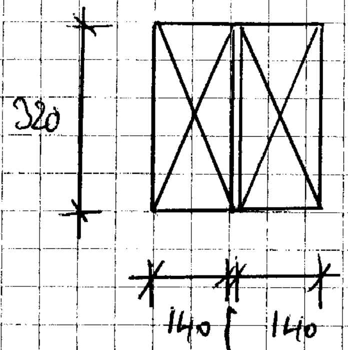
BEAM ANALYSIS



SPAN = 5·0m OVERALL − 2 x 0·2

= 4·6m TO CENTRES OF BEARINGS

ASSUMED BEAM SECTION

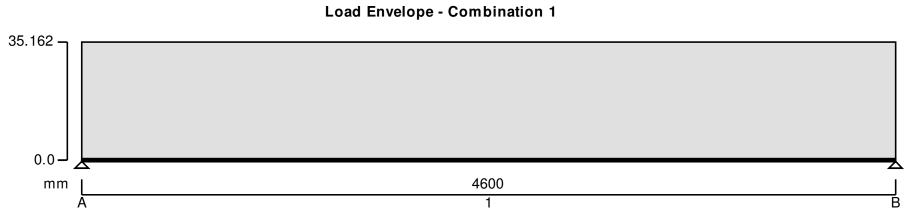


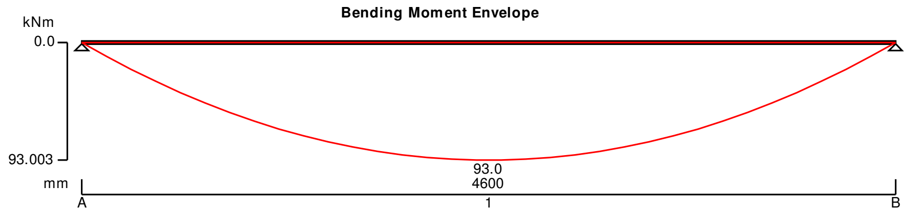
ASSUME 20mm THICK PLATE.

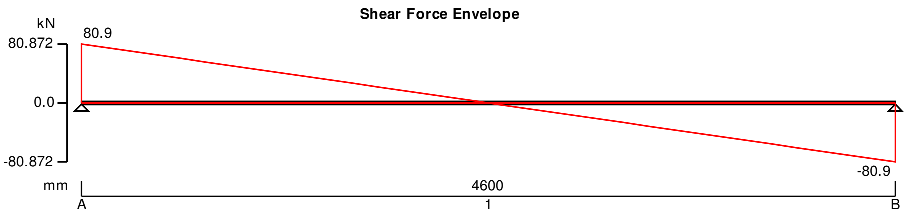
ASSUME EQUIVALENT TO C24 TIMBERS.

FLITCH BEAM ANALYSIS & DESIGN TO BS5268-2:2002

TEDDS calculation version 1.5.07







Applied loading

Beam loads

Live	Imposed full UDL 10.100 kN/m
Dead	Dead full UDL 24.200 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} = 93.003 kNm M_{min} = 0.000 kNm

Design moment M = max(abs(M_{max}),abs(M_{min})) = 93.003 kNm

Maximum shear F_{max} = 80.872 kN F_{min} = -80.872 kN

Design shear F = max(abs(F_{max}),abs(F_{min})) = 80.872 kN

Total load on beam W_{tot} = 161.744 kN

Reactions at support A R_{A_max} = 80.872 kN R_{A_min} = 80.872 kN

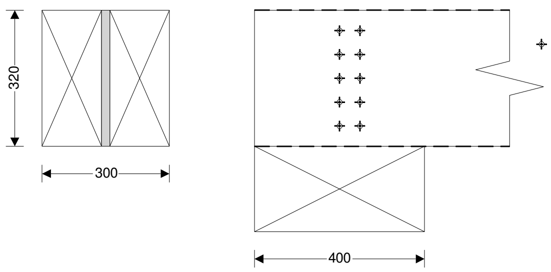
Unfactored dead load reaction at support A R_{A_Dead} = 57.642 kN

Unfactored imposed load reaction at support A $R_{A\_Imposed}$ = 23.230 kN

Reactions at support B R_{B_max} = 80.872 kN R_{B_min} = 80.872 kN

Unfactored dead load reaction at support B R_{B_Dead} = 57.642 kN

Unfactored imposed load reaction at support B $R_{B\_Imposed}$ = 23.230 kN



Timber section details

Breadth of timber sections b = 140 mm

Depth of timber sections h = 320 mm

Number of timber sections in member N = 2

Timber strength class C24

Steel section details

Breadth of steel plate b_s = 20 mm

Depth of steel plate h_s = 320 mm

Number of steel plates in beam N_s = 1

Steel stress p_y = 165 N/mm^2

Bolt diameter ϕ_b = 12 mm

Member details

Service class of timber 1

Load duration Medium term

Length of bearing L_b = 400 mm

Section properties

Cross sectional area of beam $A = N \times b \times h$ = 89600 mm^2

Timber section modulus $Z_{xt} = N \times b \times h^2 / 6$ = 4778667 mm^3

Steel section modulus $Z_{xs} = N_s \times b_s \times h_s^2 / 6$ = 341333 mm^3

Second moment of area of timber $I_{xt} = N \times b \times h^3 / 12$ = 764586667 mm^4

Second moment of area of steel $I_{xs} = N_s \times b_s \times h_s^3 / 12$ = 54613333 mm^4

Load proportions

Instant deflection under permanent actions u_{instG} = 7.511 mm

Instant deflection under principal variable action u_{instQ1} = 3.027 mm

k_{def} = 0.6

ψ_2 = 0.3

Final minimum modulus of elasticity

$E_{min,fin} = E_{min} \times (u_{instG} + u_{instQ1}) / (u_{instG} + u_{instQ1} + k_{def} \times (u_{instG} + \psi_2 \times u_{instQ1}))$ = 4867 N/mm^2

Proportion of applied load in timber $k_t = E_{mean} \times I_{xt} / (E_{mean} \times I_{xt} + E_{S5950} \times I_{xs})$ = 0.424

Proportion of applied load in steel $k_s = 1.1 \times E_{S5950} \times I_{xs} / (E_{min,fin} \times I_{xt} + E_{S5950} \times I_{xs})$ = 0.826

Modification factors

Duration of loading - Table 17 K_3 = 1.25

Bearing stress - Table 18 K_4 = 1.00

Total depth of member - cl.2.10.6 $K_7 = 0.81 \times (h^2 + 92300\ mm^2) / (h^2 + 56800\ mm^2)$ = 0.99

Load sharing - cl.2.9 K_8 = 1.00

Lateral support - cl.2.10.8

No lateral support

Permissible depth-to-breadth ratio - Table 19 2.00

Actual depth-to-breadth ratio $h / (N \times b + N_s \times b_s)$ = 1.07

PASS - Lateral support is adequate

Compression perpendicular to grain

Permissible bearing stress (no wane) $\sigma_{c\_adm} = \sigma_{cp1} \times K_3 \times K_4 \times K_8$ = 3.000 N/mm^2

Applied bearing stress $\sigma_{c\_a} = R_{B\_max} / (N \times b \times L_b)$ = 0.722 N/mm^2

$\sigma_{c\_a} / \sigma_{c\_adm}$ = 0.241

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

Bending parallel to grain

Permissible bending stress $\sigma_{m\_adm} = \sigma_m \times K_3 \times K_7 \times K_8$ = 9.287 N/mm^2

Applied timber bending stress $\sigma_{m\_a} = k_t \times M / Z_{xt}$ = 8.261 N/mm^2

$\sigma_{m\_a} / \sigma_{m\_adm}$ = 0.890

PASS - Timber bending stress is less than permissible timber bending stress

Applied steel bending stress $\sigma_{m\_a\_s} = k_s \times M / Z_{xs}$ = 224.948 N/mm^2

$\sigma_{m\_a\_s} / p_y$ = 1.363

FAIL - Steel bending stress exceeds permissible steel bending stress

Check beam in shear

Permissible shear stress $\tau_{adm} = \tau \times K_{2s} \times K_3 \times K_8$ = 0.888 N/mm^2

Applied shear stress $\tau_a = 3 \times k_t \times F / (2 \times A)$ = 0.575 N/mm^2

τ_a / τ_{adm} = 0.648

PASS - Shear stress within permissible limits

Deflection

Modulus of elasticity for deflection $E = E_{mean}$ = 10800 N/mm^2

Permissible deflection $\delta_{adm} = \min(14\ mm, 0.003 \times L_{s1})$ = 13.800 mm

Bending deflection δ_{b_s1} = 10.538 mm

Shear deflection δ_{v_s1} = 1.845 mm

Total deflection $\delta_a = \delta_{b\_s1} + \delta_{v\_s1} = 12.383$ mm

$\delta_a / \delta_{adm} = 0.897$

PASS - Total deflection is less than permissible deflection

Flitch plate bolting requirements

Total load on beam	$W_{tot} = 161.744$ kN
Total load taken by steel	$W_s = k_s \times W_{tot} = 133.534$ kN
Basic bolt shear load - Table 71	$v_{90} = 3.520$ kN
Number of interfaces	$N_{int} = (N + N_s) - 1 = 2$
Number of bolts required at supports	$N_{be} = \max(k_s \times R_{B\_max} / (N_{int} \times v_{90}), 2) = 9.484$
Limiting bolt spacing	$S_{limit} = \min(2.5 \times h, 600\text{ mm}) = 600$ mm
Maximum bolt spacing	$S_{max} = 475$ mm
Minimum number of bolts along length of beam	$N_{bl} = W_s / (N_{int} \times v_{90}) = 18.968$

- Provide a minimum of 10 No.12 mm diameter bolts at each support
- Provide a minimum of 19 No.12 mm diameter bolts staggered 80 mm alternately above and below the centre line

Minimum bolt spacings

Minimum end spacing	$S_{end} = 4 \times \phi_b = 48$ mm
Minimum edge spacing	$S_{edge} = 4 \times \phi_b = 48$ mm
Minimum bolt spacing	$S_{bolt} = 4 \times \phi_b = 48$ mm
Minimum washer diameter	$\phi_w = 3 \times \phi_b = 36$ mm
Minimum washer thickness	$t_w = 0.25 \times \phi_b = 3$ mm

FROM BEAM ANALYSIS, IT IS CLEAR THAT THE BEAM IS AT OR CLOSE TO CAPACITY

CHECK REIN REPAIR FOR FULL CAPACITY OF TIMBER

BENDING CAPACITY OF TIMBER $M_c = K_3 K_7 K_8 \sigma Z$

$K_3 = 1.0$ LONG TERM LOAD

$K_7 = 0.99$ FOR 320mm DEEP TIMBER

$K_8 = 1.0$ NO LOAD SHARING.

$\sigma = 7.5\ N/mm^2$ C24 TIMBER

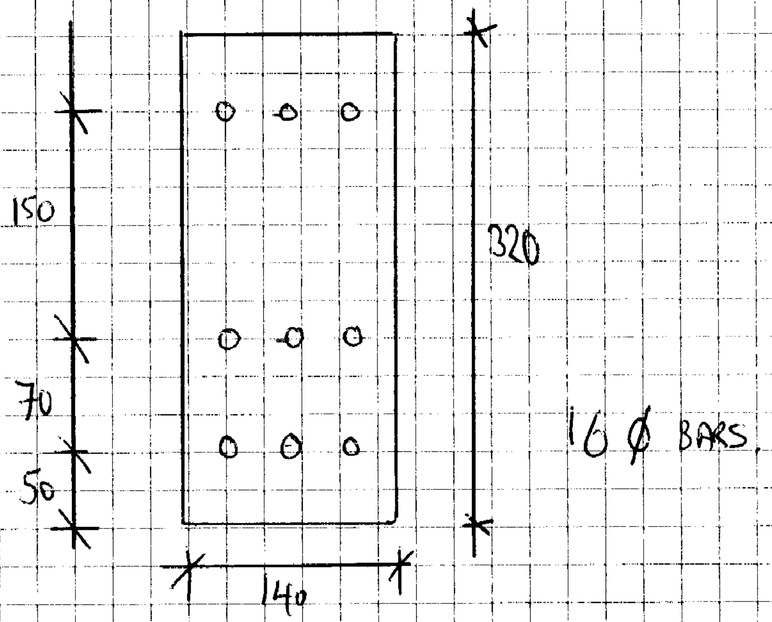
$Z = \frac{bd^2}{6} = \frac{140 \times 320^2}{6}$

$= 2.39 \times 10^6\ mm^3$

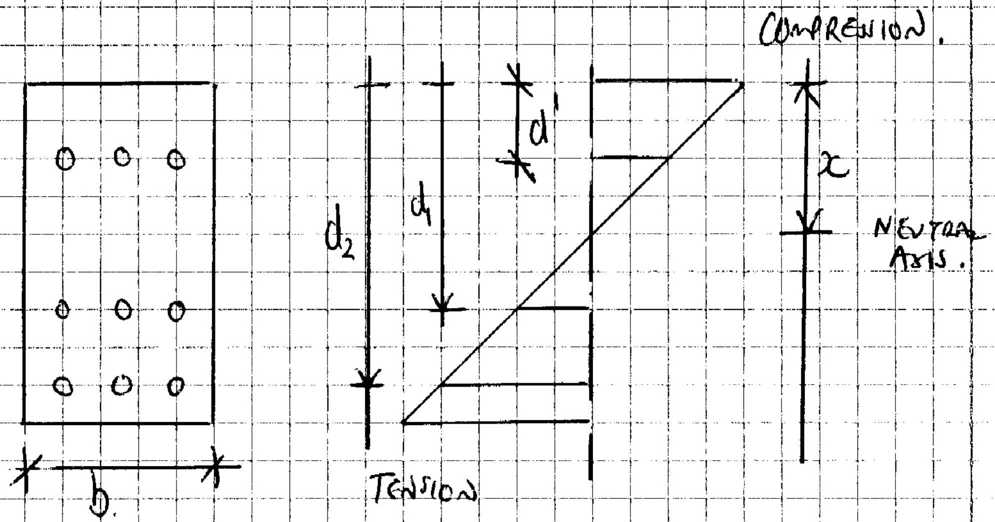
$\therefore M_c = 0.99 \times 7.5 \times (2.39 \times 10^6) \times 10^{-6}$

$= 17.75$ kNm LONG TERM.

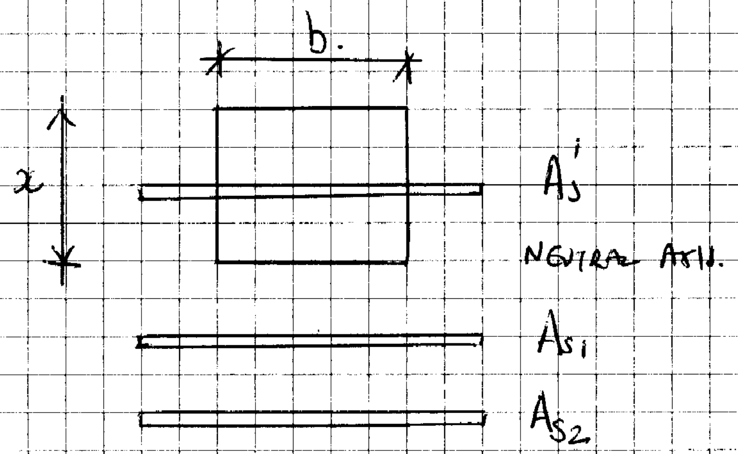
BEAM REPAIR PROPOSAL



ESTABLISH BEAM PROPERTIES FOR DESIGN.



ASSUME TENSION IS SUPPORTED BY BARS ONLY.



TAKE MOMENTS ABOUT NEUTRAL AXIS.

$$\frac{bx^2}{2} - A_s'(x-d') + n_{sc} A_s'(x-d') = n_{sc} A_{s2}(d_2 - x) + n_{sc} A_{s1}(d_1 - x) \times \left(\frac{d_1 - x}{d_2 - x}\right)$$

WHERE $n_{sc} = \frac{E_s}{E_t} = \frac{205000}{10800} = \underline{\underline{19}}$

INSERTING VALUES INTO EQUATION TO SOLVE.

$$A_s' = A_{s1} = A_{s2} = \frac{\pi \times 16^2}{4} \times 3 = 603 \text{ mm}^2.$$

$$\frac{140}{2} \times x^2 - 603(x-50) + 19 \times 603(x-50)$$
$$= 19 \times 603(270-x) + 19 \times 603 \times (200-x) \times \left(\frac{200-x}{270-x}\right)$$

$$70x^2 - 603x + 30150 + 11457x - 572850$$
$$= 3093390 - 11457x + 2291400 - 11457x\left(\frac{200-x}{270-x}\right)$$

$$70x^2 + 10854x - 542700 = 5384790 - 11457x - 11457x\left(\frac{200-x}{270-x}\right)$$

$$70x^2 + 22311x - 5927490 + 11457x\left(\frac{200-x}{270-x}\right) = 0.$$

SOLVE FOR x. $\underline{x = 158\text{mm}}$.

x =	100	120	140	160	150	157	158	157.5
70x^2	700000	1008000	1372000	1792000	1575000	1725430	1747480	1736438
22311x	2231100	2677320	3123540	3569760	3346650	3502827	3525138	3513983
-5927490	-5927490	-5927490	-5927490	-5927490	-5927490	-5927490	-5927490	-5927490
	673941.2	733248	740298.5	666589.1	716062.5	684479.7	678827.3	681691.5
SUM.	-2322449	-1508922	-691652	100859.1	-289778	-14753.3	23955.25	4621.5

SECOND MOMENT OF AREA OF TRANSFORMED SECTION

$$I_c = \frac{bx^3}{3} + (n_{sc}-1)A_s'(x-d')^2 + n_{sc}A_{s1}(d_1 - x)^2 + n_{sc}A_{s2}(d_2 - x)^2$$

$$= \frac{140 \times 158^3}{3} + (19-1)603 \times 108^2 + 19 \times 603(42)^2 + 19 \times 603(112)^2$$

$$= 184 \times 10^6 + 126.6 \times 10^6 + 20.2 \times 10^6 + 143.7 \times 10^6$$

$$= \underline{474.5 \times 10^6 \text{ mm}^4}.$$

CHECK MAXIMUM STRESS IN TIMBER (COMPRESSION).

$$\sigma_c = \frac{Mx}{I_c}$$

$$= \frac{17.75 \times 10^6 \times 158}{474.5 \times 10^6}$$

$$= \underline{5.91\ N/mm^2} < 7.5\ N/mm^2.\ \underline{OK}$$

STRESS IN TENSILE REINFORCEMENT

$$\sigma_t = \frac{\alpha_{sc} M (d_2 - x)}{I}$$

$$= \frac{19 \times 17.75 \times 10^6}{474.5 \times 10^6} \times (270 - 158)$$

$$= \underline{79.6\ N/mm^2} < 270\ N/mm^2 \quad \underline{OK}$$

FORCE IN BAR = $\sigma A = 79.6 \times \left(\frac{\pi \times 16^2}{4}\right) \times 10^{-3}$

$$= \underline{16.0\ kN.}$$

CHECK CAPACITIES OF RESIN CONNECTION

STRESS FROM PULL-OUT OF ROD.

SURFACE AREA OF BAR IN TIMBER = $\pi D L$

$$= \pi \times 16 \times 400$$

$$= \underline{20106\ mm^2.}$$

SHEAR STRESS ON SURFACE OF BAR → RESIN

$$\tau = \frac{F}{A} = \frac{16 \times 10^3}{20106} = \underline{0.80\ N/mm^2.} < 4.0\ N/mm^2.\ \underline{OK}$$

CHECK BOND STRESS OF RESIN INTO TIMBER

HOLE DIAMETER = ROD DIAMETER + 2mm

$\therefore$ SURFACE AREA $= \pi(D+2)L$

$= \pi(18) \times 400$

$= \underline{22619\ mm^2}$

SHEAR STRESS $\tau = \frac{F}{A} = \frac{16 \times 10^3}{22619} = \underline{0.71\ N/mm^2}$

ALLOWABLE SHEAR STRESS IN C24 TIMBER PARALLEL TO GRAIN $= 0.71\ N/mm^2$ OK

BY EXAMINATION, TIMBER SLOTS IN EXISTING TIMBER PROVIDE LARGER SHEAR AREA, THEREFORE WILL BE ACCEPTABLE.

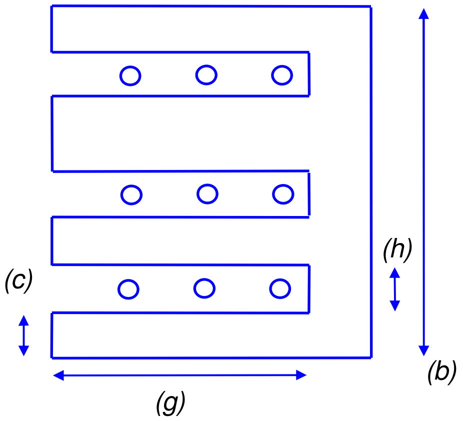
CONCLUSION.

1. PROPOSED BAR POSITIONS AND EMBEDMENT LENGTH ARE ACCEPTABLE.

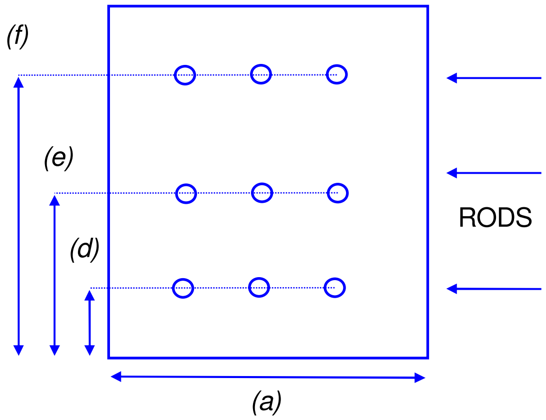
Appendix

Property Repair Systems Beam Proposal
Structural Details/Dimensions
Sketch Plan of Building
Photographs
TG6 Resin Data Sheet

TRS TYPE D, 9 SHEAR CONNECTORS, 3 SLOTS, CATEGORY +/-3mm



EXISTING TIMBER TO BE SLOTTED IN SITU



TRS - RODS FACTORY BONDED

COMPANY - Proten Services **CONTACT -** Ray Stokell

SITE - Claremont Road **ENQ/JOB NO:** 4517 **DATE -** 12/03/2015

BEAM REFERENCE NO. 4	**NO. TO REPAIR** 1
DIMENSIONS ***(NOT TO SCALE)***	
WIDTH (mm) *(a)*	140
DEPTH (mm) *(b)*	320
OVERALL LENGTH (mm)	2200
BASE THICKNESS (mm) *(c)*	37.5
SHEAR CONNECTOR (ROD) CENTRES (mm) *(d/e/f)*	50/120/270
SHEAR CONNECTORS (RODS)	
LENGTH OVERALL (mm) ***(50:50 EXISTING/TRS)***	800
DIAMETER (mm)	16
NUMBER	9
MATERIAL	HT BZP Steel
SLOTS ***(DO NOT SCALE FROM SKETCH)***	
NUMBER	3
WIDTH (mm) *(g)* **(MAX. FOR RESIN VOLUME ALLOWED)**	115
DEPTH (mm) *(h)* **(MAX. FOR RESIN VOLUME ALLOWED)**	25

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

REQUEST FOR STRUCTURAL CALCULATION

BRESSUMER BEAM

WIDTH OF TIMBER (mm) ..140MM

DEPTH OF TIMBER (mm) ..320MM

LENGTH CUT OFF (including bearing) (m) ...2.2M.

LENGTH OF BEARING (mm) ...400MM

TIMBER TYPE (softwood or hardwood) ....

FUNCTION OF COMPONENT (supports what?)

..............SUPPORTS ONE STORY ABOVE..................

SIZE OF ROOM (m x m) ..6.40 X 5.70

NUMBER OF BRESSUMERS/SINGLE BEAM .2. WITH STEEL FLINCH PLATE

TIMBERS RESTING ON BRESSUMER ...10 X 230 X 75 FLOOR JOISTS
(Function/Size/Number)

MASONRY ABOVE BRESSUMER - HEIGHT .8M..APPROX.

- THICKNESS ...345mm

ROOF CARRIED ABOVE BRESSUMER - ....

ROOF COVERINGS ....SLATE...............................

LOADING (Domestic/Commercial/Special) ..DOMESTIC

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

CONTACT RAY STOKELL

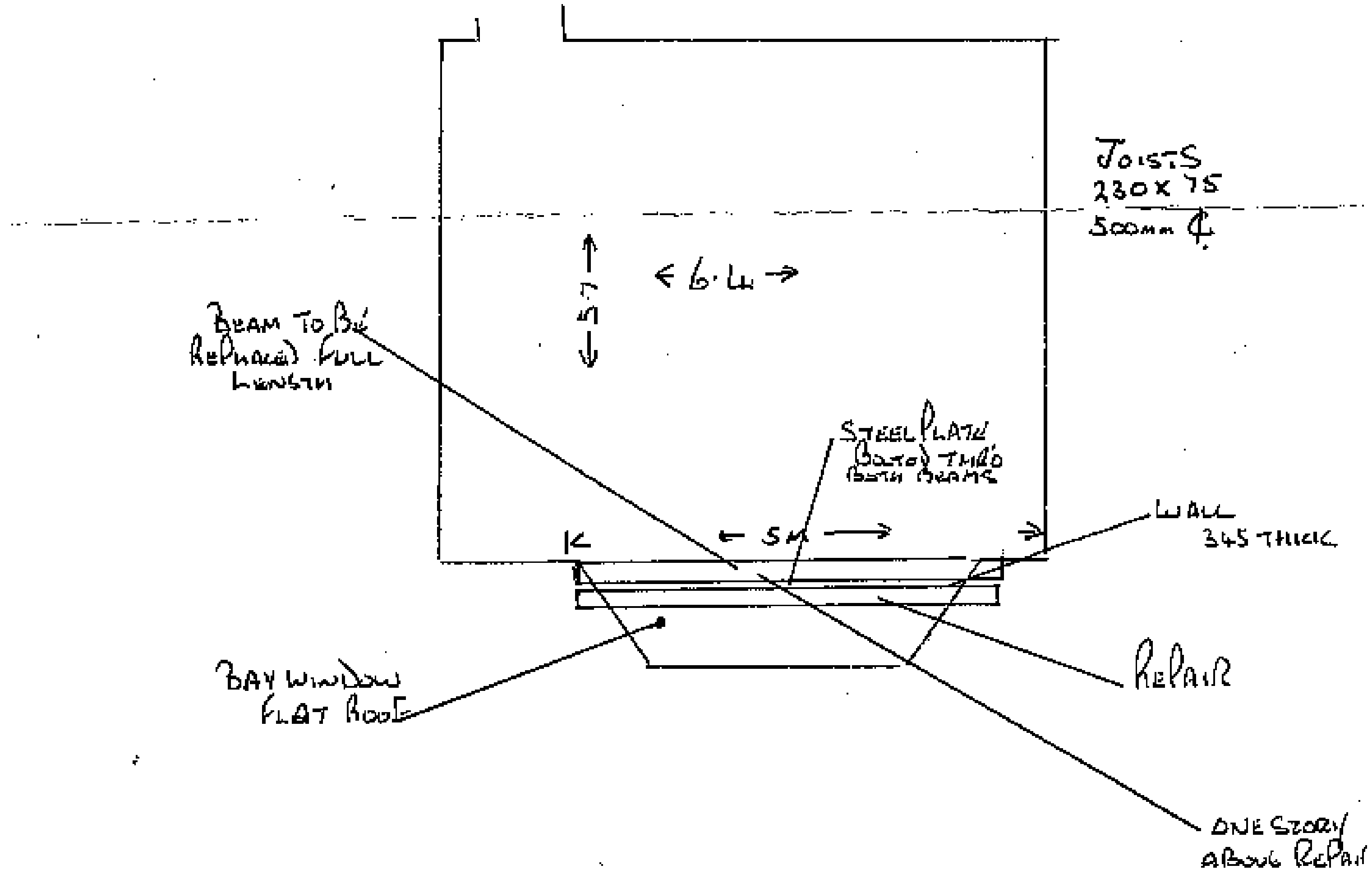
ProTen Services

SKETCH PLAN

CLAREMONT ROAD
NEWCASTLE

REF. NO.

DATE



☐	CHEMICURE D.P.C.	☐	VERTICAL BARRIER	☐		☐	AREA OF PROPOSED DRY ROT TREATMENT
☐	SIPHON D.P.C.	☐	HYGROSCOPIC SALT RESISTANT REPLASTERING	☐	SPECIALIST RENDERING	☐	ROT LOCATED

All heights indicated are in metres. (F.H. indicates to ceiling height)

TRS STRUCTURAL RESIN
POUR or INJECT
1.0, 2.5 & 7.5 Litre

TRS STRUCTURAL RESIN

An Ultra Low Disturbance Building Solution

DESCRIPTION

TRS STRUCTURAL RESIN is a versatile, three part epoxy resin grout which can be applied to all types of timber, masonry, concrete and many metals to bond them together, fill voids and inject into slots. It does not contain solvent or water. The product can be poured or injected

Features

- Adhesion greater than the cohesive strength of timber
- Solvent and water free
- Non shrink
- Working pot life: maximum of 15 minutes at 20 degrees C.
- Cure time: 24 hours initial at 20C, 7 days full cure.

TYPICAL USES

TRS – Timber-Resin Splice installation resin. For pouring or injecting into voids in timber, concrete & masonry and for filling slots. For casting support pads and bearings.

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. Fill any cracks or splits with our Quick Setting Wood Filler Paste, to prevent leakage.
Mix the two liquid components first, then add the powder slowly (wear a dust mask) and mix thoroughly, using a mixing paddle in an electric drill running at low speed.

TRS Structural Resin can be injected using disposable 1 litre cartridge tubes, which require a 1 litre skeleton gun.

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
DGEB A/F Epoxy Resins
Other Components
Cycloaliphatic Polyamine Adduct
Mix ratio - Do not vary the mix ratio
Liquids – Base:Hardener = 2:1
Bond Strength/Tensile Shear Adhesion
12 N/mm^2
Compressive Strength - 81 N/mm^2
Tensile Strength - 22 N/mm^2
Flexural Strength - 42 N/mm^2
Flexural Modulus - 5720 N/mm^2
Specific Gravity - 1.53
Static Modulus of Elasticity
E_t 17.235 KN/mm^2
Young's Modulus >17,000 N/mm^2
Aggressivity to other materials
No known aggressivity
Classification
Irritant & corrosive
Colour
Mid Grey

Property Repair Systems - 01626 331351
Unit 3, Olympus Business Park, TQ12 2SN
DCM – 06/13