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C/08/193

STRUCTURAL CALCULATIONS

FOR

PROPOSED OPENING

AT

THE NATIONAL HOSPITAL

ALBANY WING

THIRD FLOOR

DECEMBER 2008

INDEX

1.00 DESIGN DATA

2.00 LOADINGS

3.00 NEW SUPPORT BEAM

1.00 DESIGN DATA

Steelwork to be grade 43.

Brickwork to be 20N/mm3 in 1. 1. 6. mortar unless noted otherwise.

NOTES

1. All steelwork to be shot blasted and painted.
2. All steels supporting existing walls to be wedged up at 1.0Mc/c to predeflect new beam prior to pinning up with 1-3 dry-pack incorporating 'Combex 100' expanding agent.
3. All beam ends to be built in solid each end.
4. Existing walls and floor over to be properly pinned propped and supported during construction.

2.0 LOADINGS

ROOF (PITCHED)				
Tiles		=	0.65	KN/m2
Battens Felt & Insulation		=	0.05	=
Rafters		=	0.10	=
Ceiling		=	0.20	=
		=	1.00	=
Superimposed.	(40 Degree Pitch)	=	0.60	=
Superimposed on ceiling		=	0.25	=
		=	1.85	KN/m2

UPPER FLOORS ALBANY WING				
Screed		=	1.80	KN/m2
Infill		=	6.00	=
Ceiling		=	0.20	=
		=	8.00	=
Superimposed.		=	5.00	=
		=	13.00	KN/m2

WALLS (ELEVATION AREA)				
105mm Brick		=	2.50	KN/m2
215mm Brick		=	5.00	=

Analysis for a simply-supported single-span beam to BS 5950 (with LTB)

Span length & partial factors for loading

Span (mm)	Factors for moments & forces			Factors for deflection		
	γ_{fd}	γ_{fl}	γ_{fw}	γ_{dd}	γ_{dl}	γ_{dw}
4500	**1.40**	**1.60**	**0.00**	**1.00**	**1.00**	**1.00**

Load descriptions

Loads are applied normal to the major principal axis (x-axis) of the member.

Ref.	Category	Description
1	**"Dead"**	**"ROOF"**
2	**"Imposed"**	**"ROOF"**
3	**"Dead"**	**"WALL"**
4	**"Dead"**	**"FLOORS"**
5	**"Imposed"**	**"FLOORS"**

Loading data (unfactored)

Ref.	Category	Type	Load kN/m	Position mm	Load kN/m	Position mm
1	**"Dead"**	UDL	**5.0**	**0**	-	**4500**
2	**"Imposed"**	UDL	**4.0**	**0**	-	**4500**
3	**"Dead"**	UDL	**18.0**	**0**	-	**4500**
4	**"Dead"**	UDL	**32.0**	**0**	-	**4500**
5	**"Imposed"**	UDL	**23.0**	**0**	-	**4500**

Analysis results - entire span

R_a	R_b	F_{vy}	M_x		Deflection: δEI_x	
kN (fac)	kN (fac)	kN (fac)	kNm (fac)	Sense	kNm^3	Direction
270.5	**270.5**	**270.5**	**304.3**	**"Sagging"**	**437.83**	**"Down"**

Unfactored support reactions

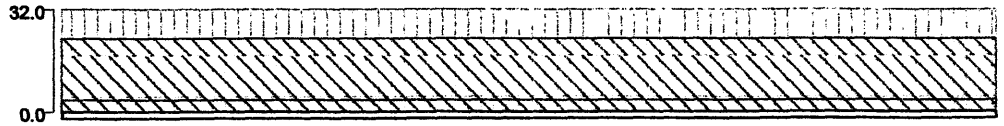
Support A	Dead load	**-123.7 kN**	Live load	**-60.7 kN**	Wind load **0.0 kN**
Support B	Dead load	**-123.7 kN**	Live load	**-60.7 kN**	Wind load **0.0 kN**

LTB segment results

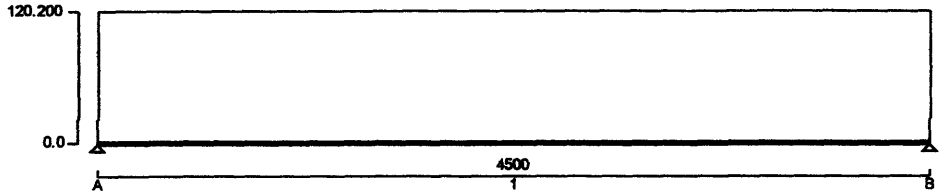
Seg.	x_s mm	x_e mm	L_{LT} mm	M_{LT} kNm (fac)	M_{mLT2} kNm (fac)	M_{mLT3} kNm (fac)	M_{mLT4} kNm (fac)
1	**0**	**4500**	**4500**	**304.3**	**228.2**	**304.3**	**228.2**

CSC TEDDS	Project				Job Ref.	
Robert Austin Associates 57 Fernie Fields High Wycombe HP12 4SN	NAT HOS ALBANY				C/08/193	
	Section				Sheet no./rev.	
	BEAM 1				3/ 2	
	Calc. by	Date	Chk'd by	Date	App'd by	Date
	RA	30/11/2008				

Beam Loads



Load Envelope - Combination 1



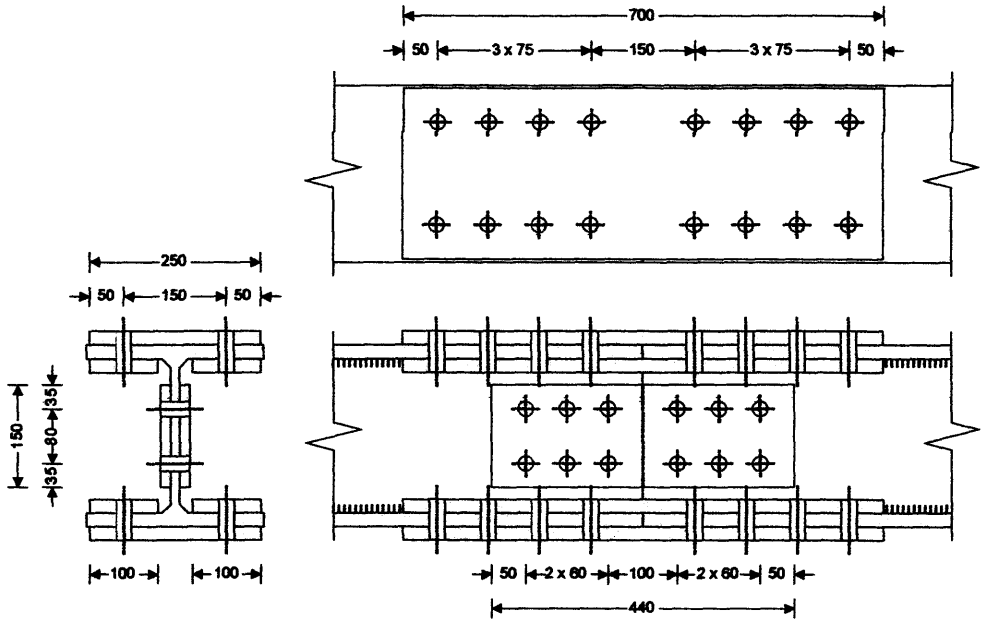
Member design checks for a simply-supported single-span beam to BS 5950 (with LTB)

Summary of results

Material	Grade = "S275"	p_y = 265 N/mm^2	
Section	"UC 254x254x107"	Classification	"Plastic"

Check	*Load*	*Capacity*	*Notes*	*Result*
Deflection	δ_{y_max} = 12.2 mm	δ_{lim} = 12.5 mm	Span / 360 or 13.0 mm	Pass
Shear	F_{vy} = 270.5 kN	P_{vy} = 542.8 kN	Low shear	Pass
Moment	M_x = 304.3 kNm	M_{cx} = 393.4 kNm	Low shear	Pass
LTB	M_{LT} = 304.3 kNm	M_b / m_{LT} = 385.6 kNm	L_{E_LT} = 4.5 m m_{LT} = 0.93	Pass

BOLTED COVER PLATE SPLICE CONNECTION – BS5950-1:2000



Connection loads

Design moment	M = **230** kNm
Axial force in the member (compression +ve)	N = **0** kN
Shear force in the member	V = **140** kN

Steel beam details

Beam section classification	**UC 254x254x107**
Grade of steel section	**S275**
Section bearing strength	p_{bs_s} = **460** N/mm^2

General connection details

Grade of steel plate	**S275**
Plate bearing strength	p_{bs_p} = **460** N/mm^2
Bolt classification	***M20 (Torqued General Grade HSFG)***
Hole diameter	D_h = **22** mm
Bolt slip factor	μ = **0.50**
Hole type factor	K_s = 1.0

Flange plate details – plates bolted to both sides of each flange

Thickness of flange plates	t_{fp} = **20** mm
Width of outer flange plates	b_{fp} = **250** mm
Width of inner flange plates	b_{fp_i} = **100** mm
Length of flange plates	l_{fp} = **700** mm

Flange bolting details

Rows of flange bolts on each side of joint	n_{fb_r} = **4**
Bolts per row	n_{fb_p} = **2**
Total number of flange bolts each side of joint	n_{fb} = n_{fb_r} × n_{fb_p} = **8**
Spacing between rows of bolts	S_f = **75** mm

Spacing between rows of bolts across joint S_{fc} = **150** mm
Spacing at end of flange plates S_{fe} = **50** mm
Lateral spacing between central bolts S_{flc} = **150** mm
Lateral spacing at edge of flange plates S_{fle} = **50** mm

Web plate details - plates bolted to both sides of the web

Thickness of web plates t_{wp} = **15** mm
Width of web plates b_{wp} = **440** mm
Length of web plates l_{wp} = **150** mm

Web bolting details

Rows of web bolts n_{wb_r} = **2**
Bolts per row each side of joint n_{wb_p} = **3**
Total number of web bolts each side of joint $n_{wb} = n_{wb\_r} \times n_{wb\_p}$ = **6**
Spacing between rows of bolts S_w = **80** mm
Spacing at end of web plates S_{we} = **35** mm
Lateral spacing between bolts S_{wl} = **60** mm
Lateral spacing between central bolts S_{wlc} = **100** mm
Lateral spacing at edge of web plates S_{wle} = **50** mm

Step 1 - Distribution of forces in member flanges

Forces in member tension flange $T = [M / (D_b - T_b)] - N / 2$ = **934** kN
Forces in member compression flange $C = [M / (D_b - T_b)] + N / 2$ = **934** kN
Force in the flange $F_f = \max(T, C)$ = **934** kN

Step 2 - Calculate distribution of forces in member flanges

Check area of flange

Design strength of section p_{ys} = **265** N/mm^2
Minimum required effective flange area F_f / p_{ys} = **3525** mm^2
Effective net area coefficient K_e = **1.2**
Effective flange area $A_{ef} = \min(K_e \times [B_b - (n_{fb\_p} \times D_h)] \times T_b, B_b \times T_b)$ = **5284** mm^2

PASS - Effective flange area is adequate

Check area of flange plates

Design strength of plates p_{yp} = **265** N/mm^2
Minimum required effective flange plate area F_f / p_{yp} = **3525** mm^2
Effective flange plate area $A_{ep} = \min(K_e \times [b_{fp} + 2 \times (b_{fp\_i} - (n_{fb\_p} \times D_h))] \times t_{fp}, (b_{fp} + 2 \times b_{fl\_i}) \times t_{fp})$
A_{ep} = **8688** mm^2

PASS - Effective flange plate area is adequate

Step 3 - Design of flange bolts

Slip resistance of the bolt per interface $S_{fb} = 1.1 \times K_s \times \mu \times P_p$ = **79.2** kN
Bearing capacity of the bolt in the flange $P_{bg\_s} = 1.5 \times d \times T_b \times p_{bs\_s}$ = **282.9** kN
Bearing capacity of the bolt in the plate $P_{bg\_p} = 3 \times d \times t_{fp} \times p_{bs\_p}$ = **552.0** kN
Average flange bolt end distance $S_{fe\_ave} = S_{fe} + (n_{fb\_r} - 1) \times S_f / 2$ = **162** mm
Bearing capacity limit of the bolt in the plate $P_{bg\_p\_lim} = S_{fe\_ave} \times t_{fp} \times p_{bs\_p}$ = **1495.0** kN
Bolt capacity $P_s = \min(2 \times S_{fb}, P_{bg\_s}, P_{bg\_p}, P_{bg\_p\_lim})$ = **158.4** kN
Number of bolts required $n_{fb\_req} = F_f / P_s$ = **5.9**
Number of bolts provided n_{fb} = **8**

PASS - Flange plate bolting is adequate

Step 4 - Design of web plates and bolts

Check web plate in shear

Shear force in web plates	V = **140** kN
Gross shear area	$A_v = n_{wp} \times l_{wp} \times t_{wp}$ = **4500** mm²
Net shear area (allowing for bolt holes)	$A_{v\_net} = n_{wp} \times (l_{wp} - n_{wb\_r} \times D_h) \times t_{wp}$ = **3180** mm²
Net shear area limit	$0.85 \times A_v / K_e$ = **3188** mm²
Net shear capacity of web plates	$p_{v\_net} = 0.7 \times K_e \times A_{v\_net} \times p_{yp}$ = **708** kN
Gross shear capacity of web plates	$p_{v\_gross} = 0.6 \times A_v \times p_{yp}$ = **716** kN
Length of block shear face	$L_v = S_{we} + (n_{wb\_r} - 1) \times S_w$ = **115** mm
Length of block tension face	$L_t = S_{wle} + (n_{wb\_p} - 1) \times S_{wl}$ = **170** mm
Block shear coefficient	k = if($n_{wb\_p} > 1$, 2.5, 0.5) = **2.5**
Block shear capacity of web plates	$p_{v\_block} = 0.6 \times p_{yp} \times t_{wp} \times n_{wp} \times [L_v + K_e \times (L_t - k \times D_h)]$ = **1207** kN
Shear capacity of web plates	p_v = min(p_{v_net}, p_{v_gross}, p_{v_block}) = **708** kN

PASS - Effective web plate area is adequate in shear

Check web plate in bending

Second moment of area of web plate	$I = (t_{wp} \times l_{wp}^3 / 12) - (n_{wb\_r} \times t_{wp} \times D_h^3 / 12) - (t_{wp} \times D_h \times K \times S_w^2)$
	I = **3136130** mm⁴
Distance from joint to centroid of bolt group	$a = [((n_{wb\_p} - 1) \times S_{wl}) + S_{wlc}] / 2$ = **110** mm
Moment in web plate	$M_{wp} = V \times a$ = **15.4** kNm
Moment capacity of web plates	$M_{cap} = p_{yp} \times n_{wp} \times I / (l_{wp} / 2)$ = **22.2** kNm

PASS - Effective web plate area is adequate in bending

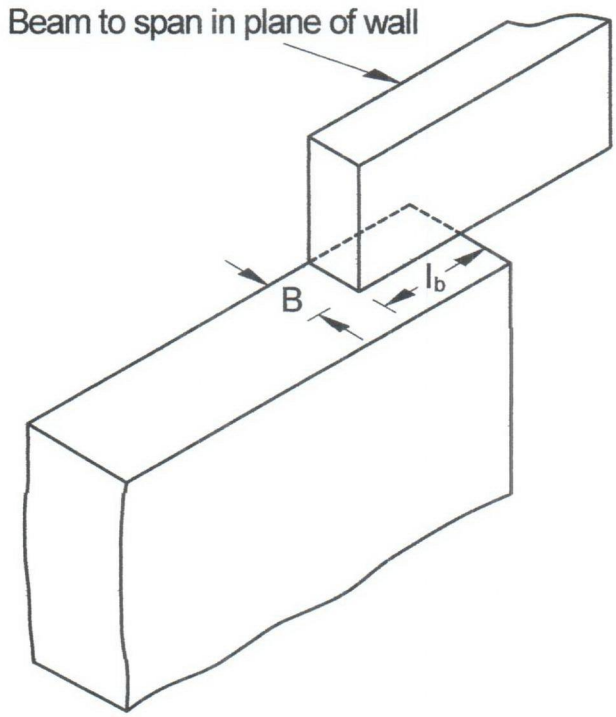
Check web plate bolts

Moment of inertia of bolt group	I_{bg} = **24000** mm²
Force on bolt due to direct shear	$F_v = V / n_{wb}$ = **23.3** kN
Vertical force on bolt due to moment	$F_{mv} = M_{wp} \times x / I_{bg}$ = **38.5** kN
Horizontal force on bolt due to moment	$F_{mh} = M_{wp} \times y / I_{bg}$ = **25.7** kN
Resultant bolt load	$F_r = \sqrt{((F_v + F_{mv})^2 + F_{mh}^2)}$ = **66.9** kN
Angle of the resultant bolt load	θ = atan(F_{mh} / (F_v + F_{mv})) = **22.5** deg
Minimum edge distance	e_r = min(S_{we} / cos(θ), S_{wle} / cos(90 - θ)) = **38** mm
Edge distance factor for web plate bearing	K_{edge} = min(e_r / (3 × d), 1) = **0.6**
Slip resistance of the bolt per interface	$S_{fb} = 1.1 \times K_s \times \mu \times P_p$ = **79.2** kN
Bearing capacity of the bolt in the web	$P_{bg\_s} = 1.5 \times d \times t_b \times p_{bs\_s}$ = **176.6** kN
Bearing capacity of the bolt in the plate	$P_{bg\_p} = 1.5 \times K_{edge} \times d \times t_{wp} \times n_{wp} \times p_{bs\_p}$ = **261.5** kN
Bolt capacity	P_s = min($n_{wp} \times S_{fb}$, P_{bg_s}, P_{bg_p}) = **158.4** kN

PASS - Web plate bolting is adequate

Connection summary

Beam classification	**UC 254x254x107**
Bolt classification	**M20 (Torqued General Grade HSFG)**
Flange plates	**700 mm x 250 mm x 20 mm to the outside of each flange**
	2 No. 700 mm x 100 mm x 20 mm to the inside of each flange
Flange bolting	**16 No. total per flange - 4 No. rows of 2 No. bolts on each side of the joint**
Web plates	**150 mm x 440 mm x 15 mm on each side of the web**
Web bolting	**12 No. total - 2 No. rows of 3 No. bolts on each side of the joint**



MASONRY BEARING DESIGN TO BS5628-1:2005

Masonry details

Masonry type	**Clay or calcium silicate bricks**
Compressive strength of unit	p_{unit} = **50.0** N/mm^2
Mortar designation	**i**
Category of masonry units	**Category I**
Category of construction control	**Normal**
Partial safety factor for material strength	γ_m = **3.1**
Thickness of load bearing leaf	*t* = **220** *mm*
Effective thickness of masonry wall	t_{ef} = **220** mm
Height of masonry wall	h = **3000** mm
Effective height of masonry wall	h_{ef} = **2250** mm

Bearing details

Beam spanning in plane of wall	
Width of bearing	B = **220** mm
Length of bearing	l_b = **450** mm

Compressive strength from Table 2 BS5628:Part 1 - Clay or calcium silicate bricks

Mortar designation	Mortar = **"i"**
Brick compressive strength	p_{unit} = **50.0** N/mm^2
Characteristic compressive strength	f_k = **11.60** N/mm^2

Loading details

Characteristic dead load	G_k = **124** kN

Characteristic imposed load	Q_k = **61** kN
Design load on bearing	$F = (G_k \times 1.4) + (Q_k \times 1.6)$ = **271.2** kN

Masonry bearing type

Bearing type	**Type 1**
Bearing safety factor	γ_{bear} = **1.25**

Check design bearing without a spreader

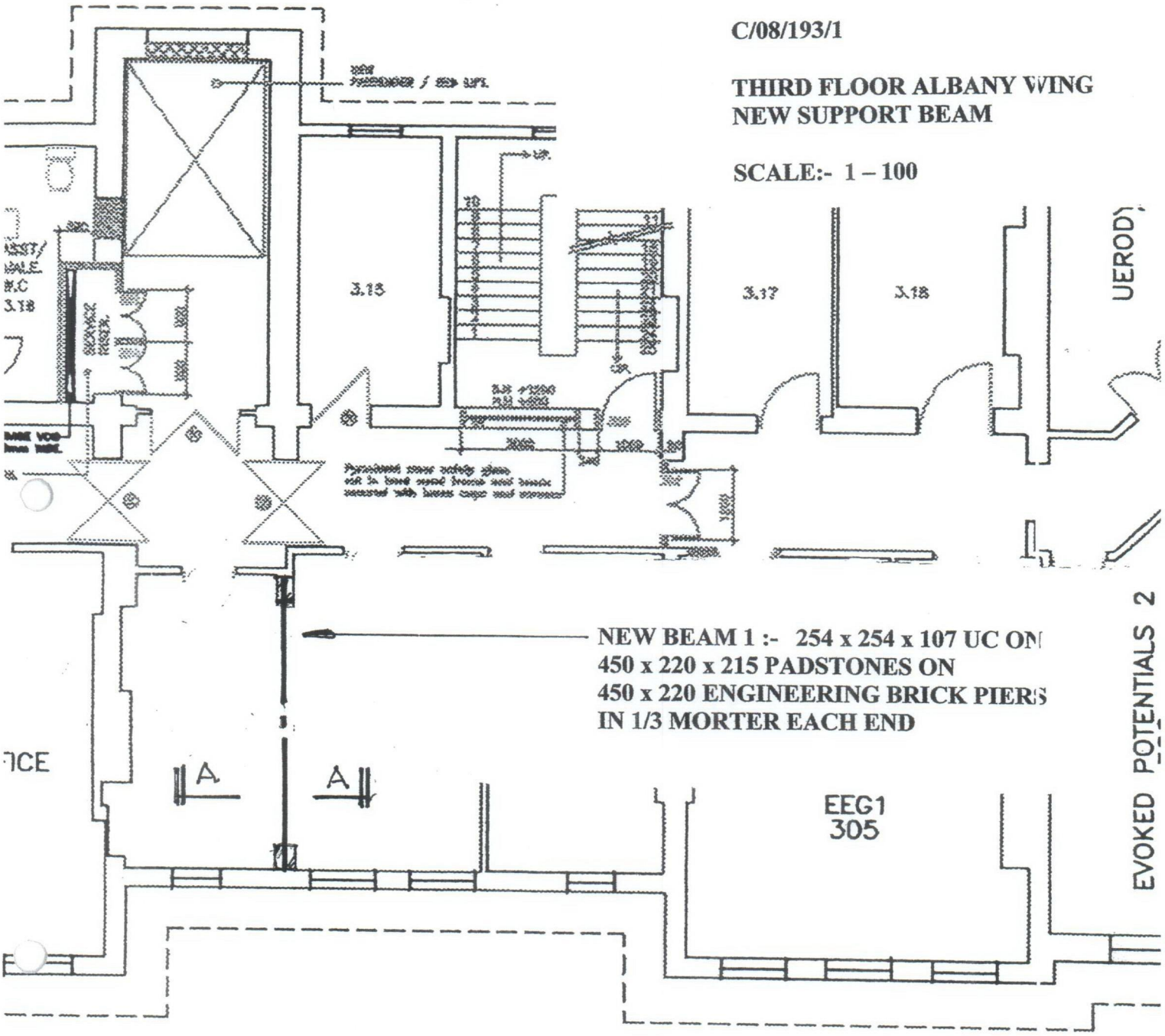
Design bearing stress	$f_{ca} = F / (B \times l_b)$ = **2.739** N/mm^2
Allowable bearing stress	$f_{cp} = \gamma_{bear} \times f_k / \gamma_m$ = **4.677** N/mm^2

PASS - Allowable bearing stress exceeds design bearing stress

Check design bearing at 0.4 × h below the bearing level

Slenderness ratio	h_{ef} / t_{ef} = **10.23**
Eccentricity at top of wall	e_x = **0** mm
From BS5268:1 Table 7	
Capacity reduction factor	β = **0.99**
Length of bearing distributed at 0.4 × h	l_d = **1650** mm
Maximum bearing stress	$f_{ca} = F / (l_d \times t)$ = **0.747** N/mm^2
Allowable bearing stress	$f_{cp} = \beta \times f_k / \gamma_m$ = **3.705** N/mm^2

PASS - Allowable bearing stress at 0.4 × h below bearing level exceeds design bearing stress



ATIONAL HOSPITAL FOR

OLOGY AND NEUROSURGERY

EHABILITATION AND THERAPY SERVICES

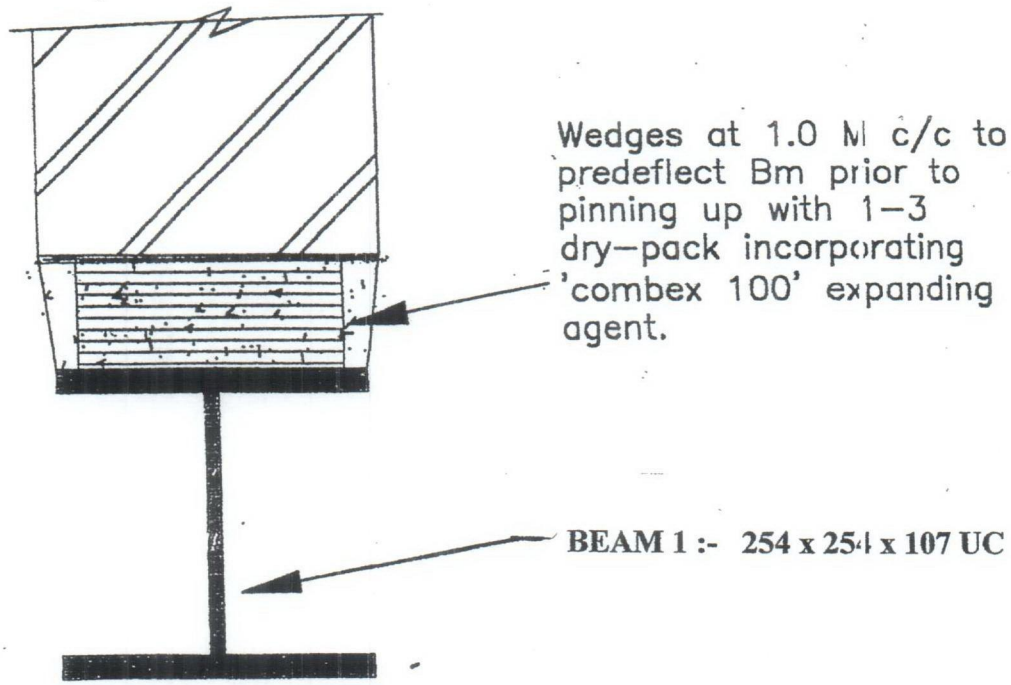
RD FLOOR – ALBANY WING

OPOSED FLOOR PLAN.

C/08/193/2

THIRD FLOOR ALBANY WING
NEW SUPPORT BEAM

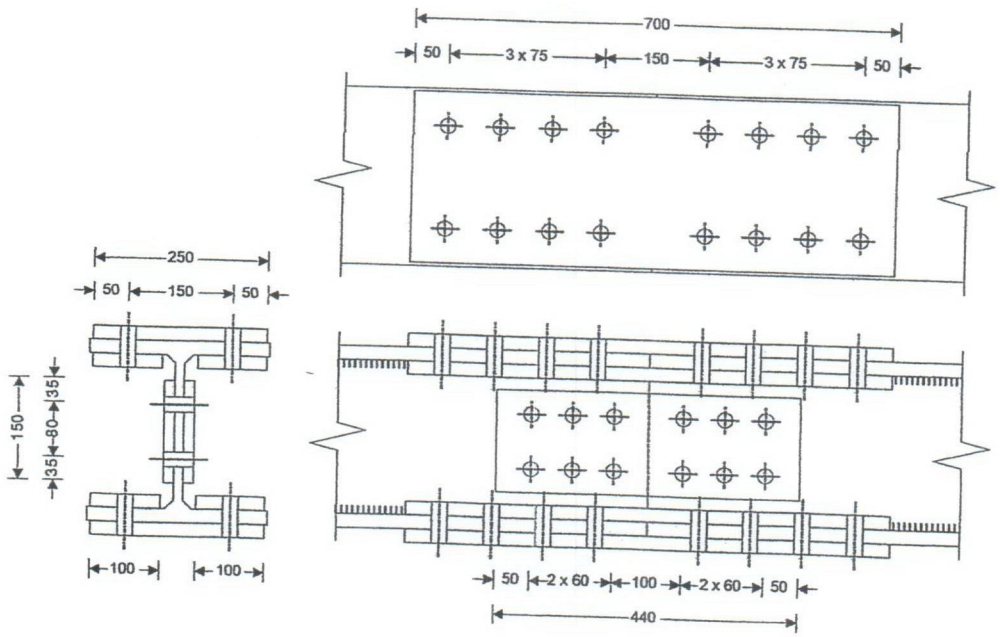
SECTION A - A



SEC TEDDS

Robert Austin Associates 57 Fernie Fields High Wycombe HP12 4SN	Project: NAT HOS ALBANY				Job Ref.: C/08/193
	Section: SPLICE BEAM 1				Sheet no./rev.: 08/103/3
	Calc. by: RA	Date: 30/11/2008	Chk'd by:	Date:	App'd by: / Date:

BOLTED COVER PLATE SPLICE CONNECTION – BS5950-1:2000



SPLICE AT MAXIMUM 1.0M FROM FACE OF PIER EACH END

Connection summary

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