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STRUCTURAL CALCULATIONS FORREMOVAL OF INTERNAL LOADBEARING WALL

AT

33 DERBY LODGE,
BRITANNIA STREET,
LONDON WC1X 9BP

APRIL 2015 - REF: 15013

Index

Introduction

The existing property is a six storey block of flats of traditional construction, concrete ground floor, external solid masonry walls, internal load bearing walls, timber floors at first to roof, a traditional cut timber flat roof.
The proposed alterations are to the flat on the sixth floor, with no properties above. It is proposed to remove the wall between the kitchen and the living room. A section of wall will be left to provide stability to the outside wall as per NHBC guide – 440mm pier.

Site visit revealed the wall to be removed was loading bearing with joists spanning front to back.

Refer to sketches in section B for more information.

Codes of Practice

The following codes have been used in the design of the various structural elements:

BS6399-1	1996 Loading for Buildings
BS8110-1	Structural use of Concrete
BS5628-1	Structural use of Unreinforced Masonry
BS5950:	Structural Steel Design
BS5268-2:	2002 Structural use of Timber
BS8004	Foundations

David Byrne BEng (Hons) CEng MIStructE	Project: 33 Derby Lodge, London			Job Ref.: 15013	
	Section: Introduction			Sheet no./rev.: A	
	Calc. by: DCB	Date: APRIL '15	Chk'd by:	Date:	App'd by:	Date:

LOADING

				DL (kN/m²)	LL (kN/m²)	ULT (kN/m²)
PITCHED ROOF						
CONCRETE TILES				0.75		
INSULATION				0.05		
CEILING				0.30	0.25	
SERVICES				0.10		
TOTAL DEAD				1.20		
DL x SLOPE FACTOR 1/cos(slope)				**1.69**		2.34
SUPERIMPOSED	(reduced for slope)	45	degrees		0.40	
					0.65	1.04
						3.38
FLAT ROOF						
ASPHALT				0.45		
SINGLE PLY MEMBRANE				0.05		
INSULATION				0.05		
18mm PLY DECK				0.10		
TIMBER JOISTS AND FIRRINGS				0.15		
CEILING				0.25		
SERVICES				0.05		
TOTAL DEAD				**1.10**		1.54
SUPERIMPOSED					**0.75**	1.20
						2.74
EXTERNAL WALL						
BRICKWORK &	100mm	mm		4.30		
BLOCKWORK	100mm	THICK				
1 SIDE PLASTER				0.25		
TOTAL DEAD				**4.55**		**6.37**
EXTERNAL STUDWALL						
RENDER				0.50		
2 SIDES PLY				0.20		
STUDS				0.20		
INSULATION				0.05		
1 SIDE PLASTERBOARD				0.20		
TOTAL DEAD				**1.15**		**1.61**

STUD WALL

STUDS	0.20		
INSULATION	0.05		
2 SIDES PLASTERBOARD	0.40		
TOTAL DEAD	**0.65**		**0.91**

INTERNAL WALL 100 mm THICK

BLOCKWORK	1.80		
2 SIDES PLASTER	0.50		
TOTAL DEAD	**2.30**		**3.22**

TIMBER FLOOR

FINISHES	0.10		
PLYWOOD	0.15		
JOISTS	0.20		
CEILING	0.25		
SERVICES	0.10		
			1.12
TOTAL DEAD	**0.80**		
		1.50	2.40
SUPERIMPOSED			
			3.52

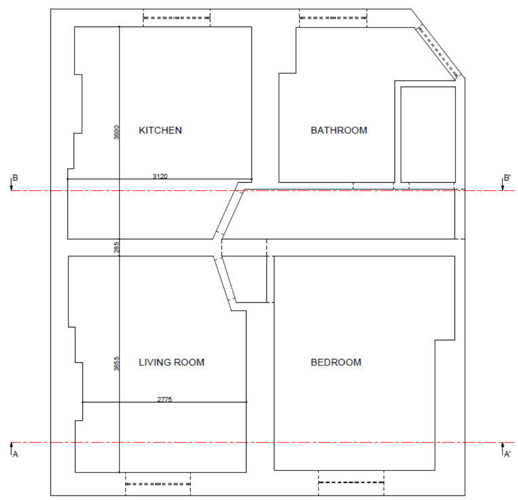
David Byrne BEng (Hons) CEng MIStructE	Project 33 Derby Lodge, London				Job Ref 15013	
	Section Beam Loading				Sheet no. A	
	Calc By	Date	Checked By	Date	Revision	Date
	DCB	APRIL '15				

BUILD UP UDL FOR BEAMS

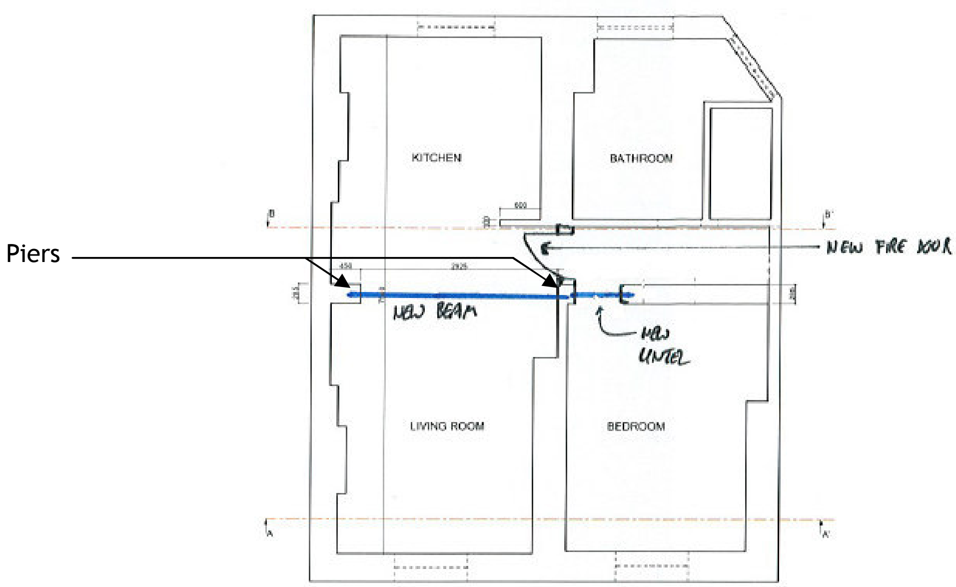
Build up UDL	*BEAM B1 - Ridge Beam*					SPAN (m)	3.3
load element	load rate		w or ht		UDL		
	kN/m^2		m		kN/m		
	DL	LL		**ULT**	**DL only**	**LL only**	**DL+LL**
Wall/Roof Over	0.80	1.50	3.80	*13.38*	3.04	5.70	8.74
Floor over	0.80	1.50	3.80	*13.38*	3.04	5.70	8.74
				26.75	6.08	11.40	17.48
			Reactions (kN)	**44.1**	*10.0*	*18.8*	28.8

Stability

The wall to be removed is of masonry construction and loadbearing, supporting the timber roof over. The wall will be removed to create an opening living space between the kitchen and living room. To maintain stability to the flank wall a pier of 440mm will remain, as per NHBC guide, to prop the span of the existing wall.



Existing layout with central spine wall between kitchen and living room.



Proposed layout with central spine wall removed but 400mm pier left in either end for lateral stability.

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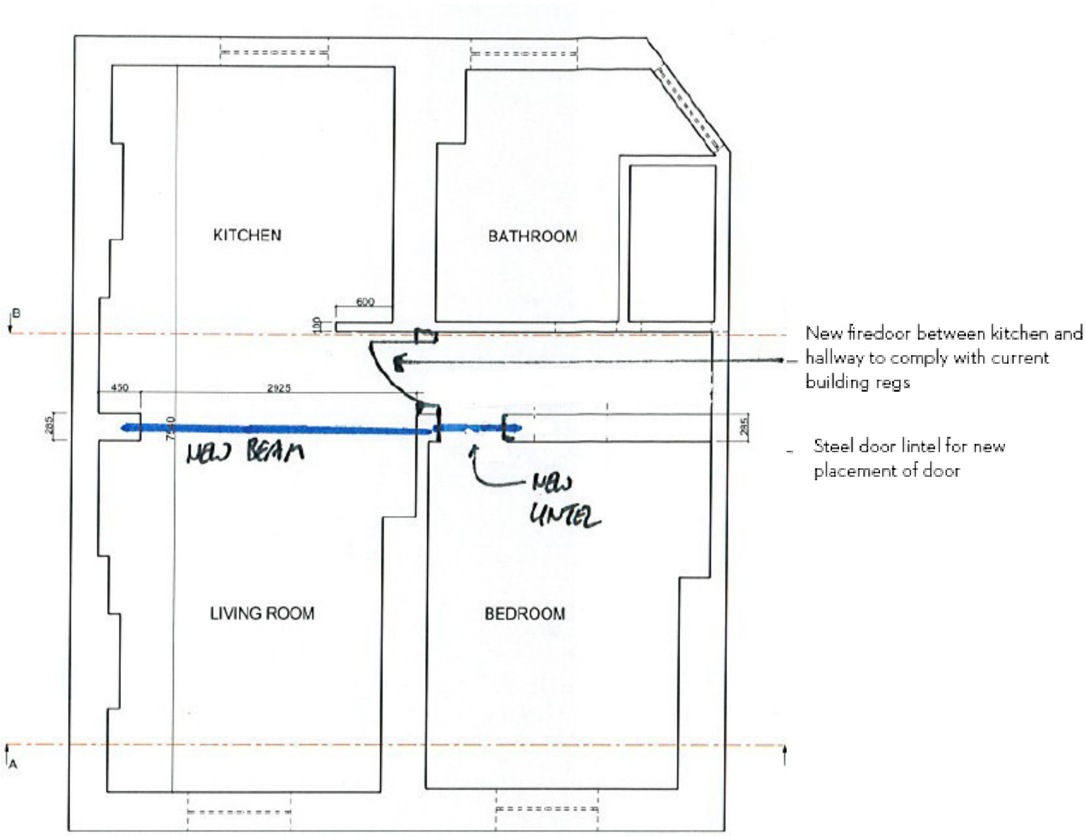
	Section Sketches				Sheet no./rev. B	
	Calc. by DCB	Date APRIL '15	Chk'd by	Date	App'd by	Date

Sketch

Flat No.33 Floor Plan indicating changes



New Steel beam over existing wall to be removed to create open plan living.

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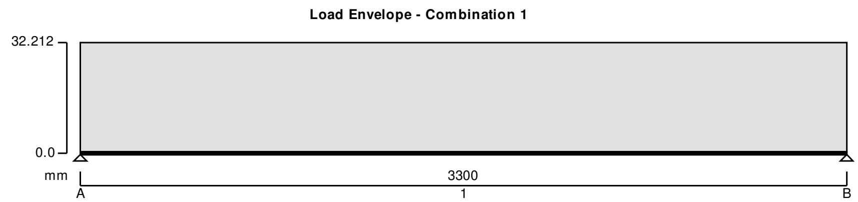
	Section Calculations				Sheet no./rev. D	
	Calc. by DCB	Date APRIL '15	Chk'd by	Date	App'd by	Date

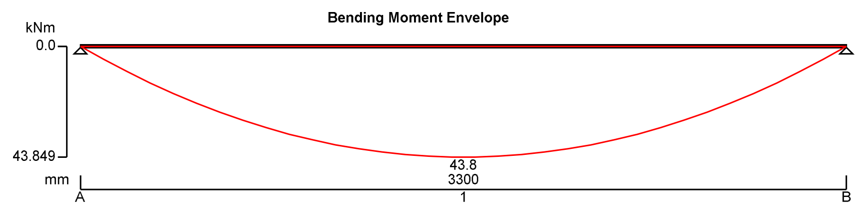
STEEL BEAM ANALYSIS & DESIGN (BS5950)

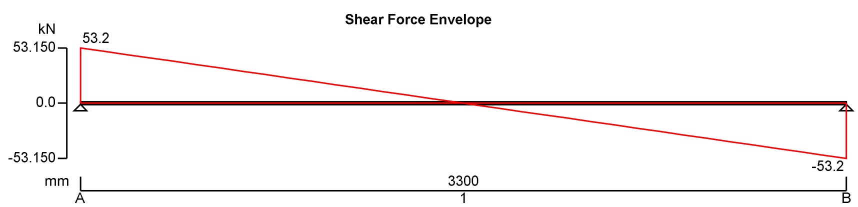
STEEL BEAM ANALYSIS & DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.04







Support conditions

Support A	Vertically restrained
	Rotationally free
Support B	Vertically restrained
	Rotationally free

Applied loading

Beam loads	Dead self weight of beam × 1
	Dead full UDL 9 kN/m
	Imposed full UDL 12 kN/m

Load combinations

Load combination 1	Support A	Dead × 1.40
		Imposed × 1.60
	Span 1	Dead × 1.40
		Imposed × 1.60

	Support B	Dead $\times$ 1.40
		Imposed $\times$ 1.60

Analysis results

Maximum moment	M_{max} = **43.8** kNm	M_{min} = **0** kNm
Maximum shear	V_{max} = **53.2** kN	V_{min} = **-53.2** kN
Deflection	δ_{max} = **5.2** mm	δ_{min} = **0** mm
Maximum reaction at support A	R_{A_max} = **53.2** kN	R_{A_min} = **53.2** kN
Unfactored dead load reaction at support A	R_{A_Dead} = **15.3** kN	
Unfactored imposed load reaction at support A	$R_{A\_Imposed}$ = **19.8** kN	
Maximum reaction at support B	R_{B_max} = **53.2** kN	R_{B_min} = **53.2** kN
Unfactored dead load reaction at support B	R_{B_Dead} = **15.3** kN	
Unfactored imposed load reaction at support B	$R_{B\_Imposed}$ = **19.8** kN	

Section details

Section type — **UKC 152x152x30 (Corus Advance)**

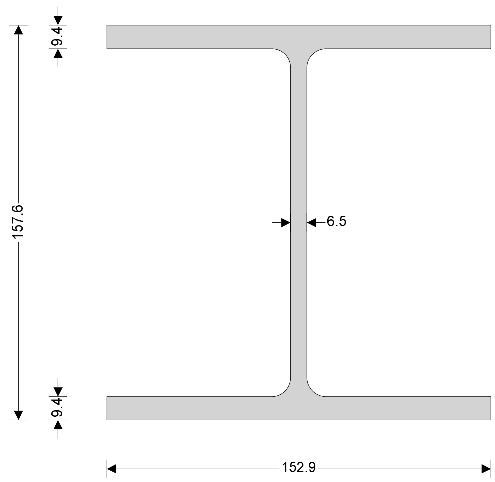
Steel grade — **S355**

From table 9: Design strength p_y

Thickness of element — max(T, t) = **9.4** mm

Design strength — p_y = **355** N/mm^2

Modulus of elasticity — E = **205000** N/mm^2



Lateral restraint

Span 1 has lateral restraint at supports only

Effective length factors

Effective length factor in major axis — K_x = **1.00**

Effective length factor in minor axis — K_y = **1.00**

Effective length factor for lateral-torsional buckling — $K_{LT.A}$ = **1.00**

Classification of cross sections - Section 3.5

$\varepsilon = \sqrt{[275 \text{ N/mm}^2 / p_y]}$ = **0.88**

Internal compression parts - Table 11

Depth of section — d = **123.6** mm

$d / t = 21.6 \times \varepsilon <= 80 \times \varepsilon$ — Class 1 plastic

Outstand flanges - Table 11

Width of section $b = B / 2 = \mathbf{76.5}$ mm

$b / T = 9.2 \times \varepsilon <= 10 \times \varepsilon$ Class 2 compact

Section is class 2 compact

Shear capacity - Section 4.2.3

Design shear force $F_v = \max(\text{abs}(V_{max}), \text{abs}(V_{min})) = \mathbf{53.2}$ kN

$d / t < 70 \times \varepsilon$

Web does not need to be checked for shear buckling

Shear area $A_v = t \times D = \mathbf{1024}$ mm^2

Design shear resistance $P_v = 0.6 \times p_y \times A_v = \mathbf{218.2}$ kN

PASS - Design shear resistance exceeds design shear force

Moment capacity - Section 4.2.5

Design bending moment $M = \max(\text{abs}(M_{s1\_max}), \text{abs}(M_{s1\_min})) = \mathbf{43.8}$ kNm

Moment capacity low shear - cl.4.2.5.2 $M_c = \min(p_y \times S_{xx}, 1.2 \times p_y \times Z_{xx}) = \mathbf{87.9}$ kNm

Effective length for lateral-torsional buckling - Section 4.3.5

Effective length for lateral torsional buckling $L_E = 1.0 \times L_{s1} = \mathbf{3300}$ mm

Slenderness ratio $\lambda = L_E / r_{yy} = \mathbf{86.224}$

Equivalent slenderness - Section 4.3.6.7

Buckling parameter $u = \mathbf{0.849}$

Torsional index $x = \mathbf{15.999}$

Slenderness factor $v = 1 / [1 + 0.05 \times (\lambda / x)^2]^{0.25} = \mathbf{0.799}$

Ratio - cl.4.3.6.9 $\beta_W = \mathbf{1.000}$

Equivalent slenderness - cl.4.3.6.7 $\lambda_{LT} = u \times v \times \lambda \times \sqrt{[\beta_W]} = \mathbf{58.465}$

Limiting slenderness - Annex B.2.2 $\lambda_{L0} = 0.4 \times (\pi^2 \times E / p_y)^{0.5} = \mathbf{30.198}$

$\lambda_{LT} > \lambda_{L0}$ - Allowance should be made for lateral-torsional buckling

Bending strength - Section 4.3.6.5

Robertson constant $\alpha_{LT} = \mathbf{7.0}$

Perry factor $\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{L0}) / 1000, 0) = \mathbf{0.198}$

Euler stress $p_E = \pi^2 \times E / \lambda_{LT}^2 = \mathbf{591.9}$ N/mm^2

$\phi_{LT} = (p_y + (\eta_{LT} + 1) \times p_E) / 2 = \mathbf{532}$ N/mm^2

Bending strength - Annex B.2.1 $p_b = p_E \times p_y / (\phi_{LT} + (\phi_{LT}^2 - p_E \times p_y)^{0.5}) = \mathbf{262}$ N/mm^2

Equivalent uniform moment factor - Section 4.3.6.6

Moment at quarter point of segment $M_2 = \mathbf{32.9}$ kNm

Moment at centre-line of segment $M_3 = \mathbf{43.8}$ kNm

Moment at three quarter point of segment $M_4 = \mathbf{32.9}$ kNm

Maximum moment in segment $M_{abs} = \mathbf{43.8}$ kNm

Maximum moment governing buckling resistance $M_{LT} = M_{abs} = \mathbf{43.8}$ kNm

Equivalent uniform moment factor for lateral-torsional buckling

$m_{LT} = \max(0.2 + (0.15 \times M_2 + 0.5 \times M_3 + 0.15 \times M_4) / M_{abs}, 0.44) = \mathbf{0.925}$

Buckling resistance moment - Section 4.3.6.4

Buckling resistance moment $M_b = p_b \times S_{xx} = \mathbf{64.9}$ kNm

$M_b / m_{LT} = \mathbf{70.1}$ kNm

PASS - Buckling resistance moment exceeds design bending moment

Check vertical deflection - Section 2.5.2

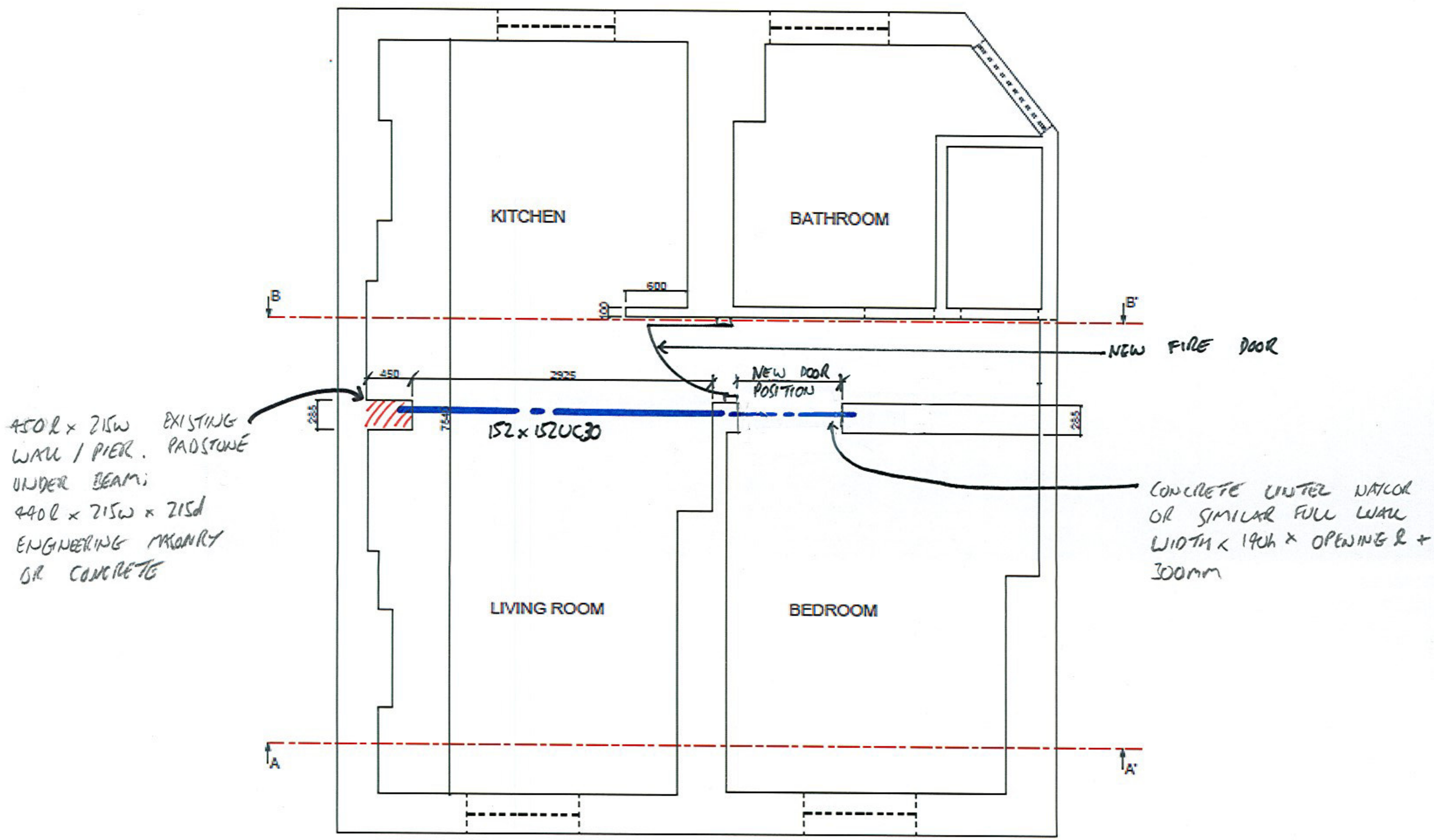
Consider deflection due to imposed loads

Limiting deflection $\delta_{lim} = L_{s1} / 360 =$ **9.167** mm

Maximum deflection span 1 $\delta = max(abs(\delta_{max}), abs(\delta_{min})) =$ **5.171** mm

PASS - Maximum deflection does not exceed deflection limit

Construction Sketches



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33 DERBY LODGE, LONDON	PROPOSED ALTERATIONS	15013	DCB	APRIL '15	TENDER	SK02