ROBERT SMITH ASSOCIATES LTD
CONSULTING STRUCTURAL AND CIVIL ENGINEERS
Spencers Crossing, Mill Lane, Great Alne, Warks. B49 6JA Tel 01789 488402

CALCULATION SHEET

Project	GWR - Broadway	**Made by**	RFS	**Prefix**	**SB**
No.	14 001	**Checked**	RFS	**Sheet**	1
Section	New Signal Box	**Date**	09/09/2014	**Rev**	**B**

REFERENCE DRAWINGS AND SKETCH DETAILS

Engineer's: Robert Smith Associates SK / 1B-4B

Architect's: GWR BW 004 014

DESIGN CODES: British Standards (all relevant and latest parts).

Imposed Loading: BS6399:Part 1 and Part 3.

Wind Loading: BS6399:Part 2

Timber: BS5268:Part 2 and Part 3.

Masonry: BS5628:Part 1, Part 2 and Part 3.

Steelwork: BS5950:Part 1. **All steelwork to be Class S275 JR unless noted otherwise.**

THE USE OF COLD-FORMED HOLLOW SECTIONS IS NOT ACCEPTABLE.

Concrete: BS8110:Part 1, Part 2 and Part 3.

Other Codes:

Building Regulations: All Parts.

Provide solid Eng. brick padstones 215x102x65 deep at all purlin, beam, lintel, and double/triple joist bearings, unless noted otherwise on sketch details.

All foundation depths are for initial guidance only – depths should be agreed on site with the Building Inspector, taking due account of soil type, and proximity of trees.

See General Note regarding the specification of Bi-fold Patio doors and lintels over.

DESIGN PRINCIPLES

The following list summarises the main structural principles used in design;

New signal box of traditional construction, with slated roof and timber first floor.

Provide suspended reinforced concrete ground slab and piled foundations to Signal Box to SBS Consultants / J & S Piling design.

Provide suspended reinforced concrete slab to platform on brick sleeper walls on trench fill foundations. Provide 10mm expansion joint where platform and Signal box construction meet.

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GENERAL CONSTRUCTION NOTES

Sections may be included as follows - General, Alterations to Existing Buildings, Foundations, Concrete, Resin Anchor bolts, Masonry, Lintels and Padstones, Steelwork, and Timber

GENERAL

1. The General Construction Notes are to be read in conjunction with the structural calculations. These notes may be reproduced, and expanded on any structural drawings, which are referred to, and accompany these calculations.

2. Where only structural calculations and sketch details have been produced, and in the absence of full structural drawings, it is essential that the Builder uses his expertise, in conjunction with the Architect's drawings where available, to complete structural details in accordance with usual good building practice.

3. All the dimensions shown in these calculations are for calculation / design purposes and in some cases have been scaled from the Architect's drawings or other information. They are not to be used for setting-out, or for other work on site. These dimensions are to be agreed by the client or architect and/or agreed/checked on site. As a result they may vary slightly from those indicated.

4. All setting out dimensions and levels are to be checked and confirmed on site prior to ordering and/or cutting any materials.

5. All steel beams, and all large timber purlins, trusses, and floor beams, are to be marked with their total weight in kg, prior to delivery to site, to assist in the selection of suitable unloading and lifting equipment.

6. If any information or details vary on site from those shown or assumed, and as a consequence affect or alter these calculations or any details shown, then refer back to the Structural Engineer for re-consideration.

7. These calculations, drawings and sketches are copyright and they must not be modified/altered or reproduced without written permission.

8. NOTE - The Client, in conjunction with the Architect if appropriate, should ensure that the appointed Builder or Fabricator is competent to carry out the works included in these calculations.

9. NOTE - The Client, in conjunction with the Architect if appropriate, should find out whether the Party Wall Act applies in relation to work close to adjoining properties. The local Building Control office may also be able to give guidance on this matter.

10. **Bi-fold Patio doors** – where possible use bottom-supported rather than top-hung doors, as the heavy weight can cause excessive deflection of the lintel over the window opening. Where top-hung doors must be used, please let the Engineer know at design stage, so that a suitable heavy-duty lintel can be specified if necessary.

ALTERATIONS TO EXISTING BUILDINGS

1. Details shown on RSA sketch details and drawings are based on information provided by Architect or Client, and often without the benefit of a site visit to ascertain existing construction. The Builder should study all structural details, and should ensure that existing construction assumed in the structural design is present on site. Any differences should be reported to the Engineer for comment.

2. Alterations to existing buildings may involve the introduction of temporary propping, and the subsequent removal of loadbearing walls. It is essential that a suitably experienced Builder is involved. He should involve a specialist Scaffolding and Shoring specialist if necessary.

3. Loads on various structural elements, both new and existing, are contained in these calculations. To assist the Builder, calculation loads in kN/m may be translated to Tonnes/m thus :

10 kN is 1 Tonne, 25 kN/m is 2.5 Tonnes/m.

3. Working loads, P kN, and w kN/m should be used when assessing Propping loads from these calculations

4. The Builder should seek the advice of the Engineer with regard to Propping loads if he is in doubt.

5. The removal of loadbearing walls, and the introduction of alternative support from steel beams, piers and foundations, will inevitably lead to some minor cracking of structure and finishes above. Correct use of Props and Shores should reduce this cracking to reasonable limits.

FOUNDATIONS

1. If adverse ground conditions are encountered then expensive and complex foundations may be required. Trial holes should be dug at design stage, and prior to appointment of a contractor. This applies to small domestic extensions.

2. The presence of existing trees, and of clay subsoils, can lead to expensive foundations. Deep mass concrete trench fill, piles, suspended ground floors of beam and block or precast concrete, and Void formers to foundations and ground floors may variously be required. Where trees are nearby, or are proposed for planting nearby, the foundations should take account of the trees, particularly where clay soils are present.

3. For trench fill foundations greater than 1.5m deep below finished external ground level, Claymaster Void formers should be provided in accordance with NHBC recommendations. For Low Shrinkage Potential clay soils no Void Former is required. For Medium Shrinkage Potential clay soils a 50mm Void Former is required. For High Shrinkage Potential clay soils a 75mm Void Former is required. The Void Former should be provided on the inside face of the trench fill foundations, starting 500mm above the base of the excavations, and extending up to ground level. The foundation trenches should be widened if necessary, to ensure that the walls and structure above are properly carried on the reduced foundation width at ground level. Claymaster - contact CORDEK on 01403 799600, fax 01403 791718.

4. Where trees are nearby, or are proposed for planting nearby, foundations should be generally in accordance with NHBC or Zurich recommendations as appropriate.

5. It is strongly advised that for all building work involving new foundations, trial holes should be dug and inspected by the Building Inspector, Structural Engineer, or a Geotechnical Engineer, who ideally should then prepare a report giving recommendations on foundation design.

6. The foundation design in these structural calculations is conditional on the ground being found to have an Allowable Net Bearing Pressure of at least 100 kN/m² at foundation level, unless noted otherwise in the calculations. If this is not found, refer to Building Inspector or Structural Engineer for reconsideration.

7. The foundation design calculations will be based on the Net Allowable Bearing Pressure. The Total Allowable Bearing Pressure is the Net Allowable Bearing Pressure + the weight of overburden removed above foundation level. For definitions and diagrams, see "Structural Foundation Designer's Manual", page 186, by Curtins.

8. Foundation depths and the bearing strata are to be agreed on site with the Building Control Officer before the concrete is poured.

9. Unless noted otherwise in the calculations or on details, the foundations are to be central under steel stanchions and walls.

10. Where Underpinning of existing foundations is to be carried out, any structural proposals included in these calculations and sketch details are to be considered as indicative only. Ground conditions and foundation depths may vary considerably from initial assumptions. The Builder should ensure that any suggested Underpinning sequence is feasible, bearing in mind the ground conditions found in his first trial excavations, and the general structural condition of the existing building.

11. Major Underpinning excavations should not be undertaken until a safe and appropriate procedure has been agreed. If the Builder considers that an alternative Underpinning approach is required, he should seek the advice of the Engineer at the earliest possible opportunity, to agree an alternative safe procedure.

Considerable costs can be incurred in underpinning operations, and these should be agreed with the Client or his representative at an early stage. The Party Wall Act may well apply, particularly when underpinning is carried out close to adjacent properties.

CONCRETE

1. All concrete is to be in accordance with BS EN 206-1:2000, BS 8500-1:2002, and BRE Special Digest 1 : 2001 and is to have 20mm nominal maximum size of aggregate, medium workability and 75mm nominal slump.
2. Concrete for foundations is to be Designated Mix FND2, unless chemical conditions in the ground dictate a different mix.
3. Concrete for reinforced foundations, ground floor & suspended slabs, beams etc. is to be Designated mix FND2 for reinforced work, unless specified otherwise in the calculations.
4. Concrete for industrial floor slabs is to be RC40, unless noted otherwise.
5. Where concrete ground floor slabs carry internal loadbearing walls, and where insulation is provided below the floor slab, rigid board insulation such as Celotex Double R FL2000, or Kingspan Thermafloor TF70 should be used. Rockwool Rockfloor is not considered stiff enough to support the load from above.
6. Concrete cavity fill to reinforced cavity retaining walls to be 1:1/4:3:2 cement:lime:sand:10mm aggregate mix, constructed in 450mm maximum lifts and poker-vibrated. Provide vertical movement joints in retaining walls at 6m maximum centres, and within 3m or corners.

RESIN-ANCHOR BOLTS

1. Where chemical or expanding anchor bolts are specified they are to be installed and tightened using a torque wrench in accordance with the manufacturers recommendations/instructions.

2. For information purposes, further guidance on ‘Anchor Installation’ is given in the Construction Fixings Association, CFA Guidance note, a copy of which is attached to these calculations, if applicable.

MASONRY

1. All bricks are to have a characteristic compressive strength of at least 20N/mm², unless specified otherwise in the calculations or on the drawings.

2. All Loadbearing Brick piers should have a characteristic compressive strength of at least 35N/mm², and be topped off with in-situ or precast concrete padstones of the pier size and 150mm deep, or with offcuts of Stressline Hi-Strength precast lintels 100x140 deep to make an equivalent padstone, or with 2 courses of **solid** semi-Eng. bricks.

3. Bricks should be class FL or FN, for frost resistance.

4. All blocks are to be solid and are to have a characteristic compressive strength of at least 3.5N/mm², unless specified otherwise, here or in the calculations.

5. Internal blockwork walls should be of 100 mm solid 3.5 N/mm² medium density blockwork - Tarmac Hemelite, or similar approved.

6. Where blocks are used below dpc level they should be; of block density > 1500 kg/m3 (Tarmac Hemelite or similar); or made with dense aggregate to BS 882 or BS 1047 ; or having a compressive strength > 7 N/mm². Contractor may be asked to provide proof of suitability.

Read with Robert Smith Associates Calculation Sheets, and General Notes & Sketch Details therein.

7. Tarmac Hemelite 3.5 N/mm^2 should be used for the inner leaf of cavity walls and for internal walls below ground. Tarmac Hemelite 7.0 N/mm^2 or Tarmac Topcrete should be used for the outer leaf of cavity walls below ground. Contractor may be asked to provide proof of suitability.

8. All mortar mixes are to be Class(iii)(1:1:6 / cement:lime:sand) above damp proof course, and Class (i)(1:1/4:3 / cement:lime:sand) at and below damp proof course, unless noted otherwise.

9. Wall ties for cavity walls are to be stainless steel throughout and in accordance with BS EN 845-1:2003. Ties are to be embedded a minimum of 50mm in each leaf and spaced horizontally at 900mm crs for cavities up to 75mm, 750mm for cavities over 75mm, vertically at 450crs staggered, and at 225 crs vertically at all ends, openings and discontinuities.

10. Straight vertical tied construction joints ideally should be provided in all blockwork walls at 6 m maximum centres, and at all corners and returns of greater than 550 mm length. Use galvanised double-fishtailed ties 150 mm long, at 450 mm vertical centres in joints.

11. Where new walls butt up to existing walls, provide Expamet stainless steel Multi-Starters, screw-fixed to steelwork with stainless steel M6 bolts or screws at 450 mm vertical centres. Use stainless steel sliding ties at 225 mm vertical centres, to secure wall to Multi Starter.

12. Where internal blockwork abuts steel columns provide Expamet galvanised Multi-Starters, screw-fixed to steelwork with M6 bolts or screws at 450 mm vertical centres. Use galvanised sliding ties at 225 mm vertical centres, to secure blockwork to Multi Starter.

13. Use Marley Aquaguard DPC's throughout at ground floor level, for high bond, and for design flexural continuity of masonry at that level. DPC's must be mortar bedded.

LINTELS AND PADSTONES

1. All lintels and beams should be provided with bearing lengths equal to their structural depth, where possible.

2. For masonry external wall lintels;

Catnic - http://www.corusconstruction.com/en/products_and_services/building_products/

IG - http://www.igltd.co.uk/

or **H S SuperGalv** - http://www.birtley-building.co.uk/

cavity wall lintels are preferred, and usually to suit a standard loading condition.

3. For 100mm thick blockwork internal walls, Stressline prestressed precast concrete lintels are preferred ;

Stressline - Tel:01455 272457 - http://www.stressline.ltd.uk/).

4. Lintel calculations for non-standard, heavy and point load loading situations will usually be provided in the calculations.

5. All padstones are to be central under beam bearings and are to be one of the following;

6. Concrete padstones, made using 1:1:2 cement:sand:10mm aggregate, cast to the specified dimensions.

7. Brickwork padstones, built using Class B engineering solid bricks (no holes or perforations) with a minimum characteristic compressive strength of 48.5N/mm^2 laid in 1:3 (cement:sand) mortar, and built to the specified dimensions or nearest greater brick size.

8. Padstones, using Stressline precast concrete lintels, 100 wide x 145 deep, or 100 wide x 220 deep, as specified on the drawings and sketch details, and cut to specified length.

STEEL

1. All structural steelwork is to be **Design Grade S275 JR**, unless specified otherwise in the calculations. All steelwork should be in accordance with the general requirements of BS 5950, and of the National Structural Steelwork Specification for Building Construction. **THE USE OF COLD-FORMED HOLLOW SECTIONS MAY NOT BE ACCEPTABLE.**

2. All welding is to be in accordance with BS 5135, and all welds are to be butt or fillet, full strength full penetration all round profile. Fillet welds are to be 6mm all round profile, unless specified otherwise in the calculations.

3. All bolts are to be Strength Grade 8.8, 20mm diameter in 22mm clearance holes, and all end plates to be 10mm thick, unless specified otherwise in the calculations. Use torqued HSFG bolts for beam and column splice connections.

4. Use 4 bolts minimum for all UB / UC / PFC connections, and 2 bolts minimum for all CHS / SHS / RHS connections, unless noted otherwise.

5. Where cranked beams are used, with a Full Strength weld specified to maintain full structural continuity of member, such welding should be carried out in the fabrication shop. The use of site welding for any structural members is strongly discouraged, unless absolutely necessary.

6. All steel members should be blast-cleaned to SA 2.5 standard, and be shop-primed with one coat of Zinc Phosphate modified Alkyd High-build primer to 75 microns dry film thickness. This also applies to steel members used in domestic construction.

7. All padstones are to be central under beam bearings, unless noted otherwise, and are to be constructed in accordance with MASONRY Note 6.

TIMBER

1. All new softwood timber is to be Grade C16 (formerly SC3), and all new hardwood timber is to be Oak, of equivalent Grade C24 or D30, unless specified otherwise in the calculations. All new or reclaimed timber is to be of the type and strength grade specified, well seasoned, and dry with a moisture content not exceeding 20% in individual pieces at time of construction. It is to be sound and free from any strength weakening defects or decay.

2. All new and existing timber may shrink laterally and/vertically upon drying out in its final construction position. The exact amount of shrinkage movement is dependent upon the moisture content of the timber at the time of construction and the rate of drying out during initial and/or continuing heating of the new construction/building. Timber should be kept covered wherever possible and ideally, internally exposed timbers should be kiln-dried.

3. Rafters are to be birdsmouthed on to wallplates & purlins, and are to be fixed down using 'BAT' truss clips nailed through every hole with 9 SWG x 32mm long, square twisted sherardised nails.

4. Where new Ridges run into existing roofs, and if appropriate, the new Reducing Gable Frames may be constructed on Layboards fixed to the top face of the existing Jack Rafters. The Layboards should be 25x150 unless noted otherwise, double-skew-nailed to the top of all existing Jack Rafters crossed.

5. The Reducing Gable Frames should be constructed with standard Jack Rafters, 50x75 Ceiling ties, and 50x75 vertical struts as appropriate. All joints should be bolted using single M10 bolts. The Jack Rafter sloping span should be limited to 2.0 m maximum. Additional vertical struts should be introduced if necessary to restrict the span of the Jack Rafters to 2.0 m. Rafter centres should ideally be 400 mm or 450 mm, But 600 mm centres is acceptable if this matches the centres of adjacent Trussed Rafters.

6. Steel beam purlins are to have a continuous 100mm or 150mm wide x 50mm deep timber plate firmly fixed to the top flange of the steel beam purlin with M10 bolts 6mm self drill screws at 500mm centres. Fixings

may be staggered each side of the web. Fixings must be adequately tightened to prevent movement between the timber plate and beam.

7. Where bolts are used to connect timber members, the bolts should be Grade 4.6 or Grade 8.8, and standard washers should be used on each face.

8. 50mm wide joists at 400 mm centres are generally recommended for rafters, ceiling joists and floor joists, as they give an increased width for nailing compared to 38mm wide members, and suit plasterboard and plywood widths.

9. Standard 19x38mm tiling battens may be used for rafters at 400 or 450 mm centres, but 600 mm centres dictates the use of 25x38mm battens.

10. All trussed rafter roofs should be braced and strapped in accordance with the Building Regulations, and with BS 5268 Part 3.

11. All roofs, ceilings and floors should be strapped to walls, in accordance with the Building Regulations, using suitable horizontal or vertical restraint straps. **See page extracts from Building Regulations Part A.**

12. Timber purlins should be connected at combined bearings on supporting walls, using traditional splices and jointing methods, or using vertical halving joints, min. 150 mm long, and bolted with at least 2 M12 Grade 4.6 bolts. See RSA sketch details where appropriate for typical details

13. Where timber purlins connect at right angles, one onto another, use suitably sized Heavy-duty joist hangers.

14. Provide **Herringbone strutting or full-depth noggins** between joists for all spans over 2.5m. For spans 2.5 m to 4.5 m use one row at midspan, and for spans above 4.5 m use two rows at 1/3 spans, as NHBC Design clause 6.4 - D. Noggins may be kept 50mm low locally, to allow services to pass over.

15. **Double up** all floor joists in **Bathroom areas**, and based on arrangement shown in RSA sketch details where appropriate, to cater for weight of bath and water.

16. **Notches** should only be formed in the top surface of joists at 1/10 to 1/4 span from support (e.g. 4.0m span joist – 4.0m/10 and 4.0m/4 is notch 0.4m to 1.0m from support), and should be no more than 1/8 of the joist depth (e.g. 200mm joist / 8 is 25mm notch depth).

17. **Holes** should only be formed in joists at mid-depth 1/4 to 4/10 from support (e.g. 4.0m span joist – 4.0m/4 and 4.0mx4/10 is notch 1.0m to 1.6m from support), and should be no more than 1/4 of the joist depth in diameter (e.g. 200mm joist/4 is 50mm diameter) and be spaced no closer than 3xdiameter of hole centre to centre.

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STRUCTURE LOADINGS - DEAD AND IMPOSED

Assume for C16 timber ; E_{min} = 5800 N/mm^2; E_{mean} = 8800 N/mm^2;

Assume for steelwork ; E_{S5950} = **205.×10^3** N/mm^2

ROOFS

PITCHED

Pitched Roof - Slates ;;

Slates, battens, felt, jack rafters, all at ;**p_{roof} = 30**; degrees pitch

G_{r1} = ((.50 + .04 + .02 + .06) kN/m^2) / cos(p_{roof}) = **0.72** kN/m^2

Q_{r1} = 0.60 kN/m^2 × (60 - p_{roof}) / 30 = **0.60** kN/m^2

CEILING

Ceiling - Flat - storage Imposed load over

Joists, insulation, 12mm plasterboard, skim,

G_{c1} = ((.06 + .03 + .12 + .03) kN/m^2) = **0.24** kN/m^2

Q_{c1} = 0.25 kN/m^2

Ceiling - Sloping on underside of rafters - no Imposed and no additional allowance for joists ;;

Insulation, 12mm plasterboard, skim, all at ; **p_{clg} = 30**; degrees pitch

G_{c2} = ((.03 + .12 + .03) kN/m^2) / cos(p_{clg}) = **0.21** kN/m^2

Q_{c2} = 0.00 kN/m^2

FLOORS

First Floor - Timber

22mm chipboard, timber joists, quilt, 12 mm plasterboard, skim

G_{f1} = (.16 + .20 + .03 + .10 + .03) kN/m^2 = **0.52** kN/m^2

Q_{f1} = 2.00 kN/m^2

WALLS

SOLID

Existing External 229mm Solid Brick Wall

Brickwork 229mm thick, plaster one side

G_{w4} = (4.60 + .24) kN/m^2 = **4.84** kN/m^2

Internal 100mm Blockwork Wall

100mm medium density blocks (1450 kg/m^3), plaster both sides

G_{w5} = (1.45 + .12 + .12) kN/m^2 = **1.69** kN/m^2

Internal 112mm Brickwork Wall

Bricks, plaster both sides

G_{w51} = (2.25 + .12 + .12) kN/m^2 = **2.49** kN/m^2

R1 RAFTERS

Common or Jack rafters for roofs having a pitch more than 22.5° but not more than 30° with access only for purposes of maintenance or repair. Imposed loading 0.75kN/m^2.

Table A9 - C16 and C24 (Formerly SC3 and SC4) grades

;;;Span on plan; L = **1.60** m; ;Span on slope; L_s = L / cos (p_{roof}) = **1.85** m;

Total dead load; gk = G_{r1} – 0.05 kN/m^2 = **0.67** kN/m^2; (excluding rafter) ;

Imposed load; qk = 0.75 kN/m^2

;; Span of timber rafter; L_s = **1.8** m

; **From Building Regulations Safe Load Table A9, Timber Grade C16**

TRY ;**"50 x 100"** ;**grade** ;;**"C16"**; **timber section @** ;**450** ;**mm centres, maximum span** ;**2.36 m**

Use ; 50 x 100; at ; s = 450 mm ; crs.

R2 HIP RAFTER

Point/Total load from roof ; ;

	Item	Load	Span.Ht	Width	Pt load	Factor	Ult Pt load
1	;Roof d;	G_{r1} ;	;;**1.60** m;	;;**0.80** m;	P_1 = **0.92** kN;	F_d = 1.4;	P_{1u} = **1.28** kN;
2	;Roof i;	Q_{r1} ;	;;**1.60** m;	;;**0.80** m;	P_2 = **0.77** kN;	F_i = 1.6;	P_{2u} = **1.23** kN;
11	;S.Wt;	;; **0.10** kN/m;	;;**2.20** m;		P_{11} = **0.22** kN;	F_d = 1.4;	P_{11u} = **0.31** kN;

Point imposed ; P_i = (P_2) = **0.77** kN

Point total ; P = ($P_1 + P_2 + P_{11}$) = **1.90** kN

Ult Point total ; P_{ult} = ($P_{1u} + P_{2u} + P_{11u}$) = **2.82** kN

Hip rafter pitch;; $\mathbf{p_{rafter}}$ **= 22**; degrees pitch ;

;Span on plan; L_{plan} = **2.2** m; Span on Slope; L_{slope} = (L_{plan} / cos(p_{rafter})) = **2.4** m;

E_{min} = 5800 N/mm^2;

M_x = (P × cos(p_{rafter}) × L_{slope}) × .128 = **0.54** kNm

I_{min} = (0.01304 × P × cos(p_{rafter}) × L_{slope}^3) / (E_{min} × L_{slope} × .003) = **7.45×10⁶** mm⁴

R_{min} = (P / 3) = **0.63** kN ; R_{max} = (2 × P / 3) = **1.27** kN

Try Sawn Softwood - Basic Size 50x125

A = $\mathbf{6.25 \times 10^3}$ mm^2 ; I_{xx} = $\mathbf{8.14 \times 10^6}$ mm^4 ; Z_{xx} = $\mathbf{130. \times 10^3}$ mm^3 ;

Use C16 timber (Table 8 BS5268:Pt 2:2002)

;Modification factor for duration of load (Table 14); K_3 = **1.25**

;Load sharing factor (Clause 2.9); K_8 = **1.00**

;Grade stress (Table 7); σ_m = **5.30** N/mm^2

M_{all} = ($K_3 \times K_8 \times \sigma_m \times Z_{xx}$) = **0.86** kNm

Use ;50(125); Hip/Valley Rafter

R3 RIDGE PURLIN

UDL from roof, sloping ceiling and Self-weight ; ;

	Item	Load	Span.Ht	UDL	Factor	Ult UDL
1	;Roof d;	G_{r1} ;	;;**1.60** m;	w_1 = **1.15** kN/m;	F_d = 1.4;	w_{1u} = **1.60** kN/m;
2	;Roof i;	Q_{r1} ;	;;**1.60** m;	w_2 = **0.96** kN/m;	F_i = 1.6;	w_{2u} = **1.54** kN/m;
3	;Clg d;	G_{c2} ;	;;**1.60** m;	w_3 = **0.33** kN/m;	F_d = 1.4;	w_{3u} = **0.47** kN/m;
4	;Clg i;	Q_{c2} ;	;;**1.60** m;	w_4 = **0.00** kN/m;	F_i = 1.6;	w_{4u} = **0.00** kN/m;
11	;S.wt;			;; w_{11} = **0.20** kN/m;	F_d = 1.4;	w_{11u} = **0.28** kN/m;

UDL total ; w = ($w_1 + w_2 + w_3 + w_4 + w_{11}$) = **2.6** kN/m

Ult UDL total ; w_{ult} = ($w_{1u} + w_{2u} + w_{3u} + w_{4u} + w_{11u}$) = **3.9** kN/m

;Span; L = **3.85** m; E_{min} = 5800 N/mm^2;

M_x = (w × L^2 / 8) = **4.09** kNm

I_{min} = (5 × w × L^4) / (384 × E_{min} × L × .003) = $\mathbf{94.2 \times 10^6}$ mm^4

R = (w × L / 2) = **4.25** kN

R_{ult} = (w_{ult} × L / 2) = **6.31** kN

Try Sawn Softwood - Basic Size 2x50x225

A = $\mathbf{22.5 \times 10^3}$ mm^2 ; I_{xx} = $\mathbf{94.9 \times 10^6}$ mm^4 ; Z_{xx} = $\mathbf{844. \times 10^3}$ mm^3 ;

Use C16 timber (Table 8 BS5268:Pt 2:2002)

;Modification factor for duration of load (Table 14); K_3 = **1.25**

;Load sharing factor (Clause 2.9); K_8 = **1.00**

;Grade stress (Table 7); σ_m = **5.30** N/mm^2

$M_{all} = (K_3 \times K_8 \times \sigma_m \times Z_{xx})$ = **5.59** kNm

Use ;2x50(225); Purlin

C2 SIMPLE TRUSS

Point / Total load from roof, sloping ceiling, and Self-weight ; ;

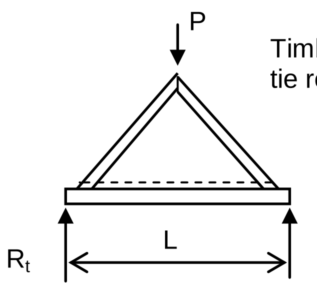
	Item	Load	Span.Ht	Width	Pt load	Factor	Ult Pt load
1	;Roof d;	G_{r1} ;	;;**1.60** m;	;;**2.50** m;	P_1 = **2.86** kN;	F_d = 1.4;	P_{1u} = **4.01** kN;
2	;Roof i;	Q_{r1} ;	;;**1.60** m;	;;**2.50** m;	P_2 = **2.40** kN;	F_i = 1.6;	P_{2u} = **3.84** kN;
3	;Clg d;	G_{c2} ;	;;**1.60** m;	;;**2.50** m;	P_3 = **0.83** kN;	F_d = 1.4;	P_{3u} = **1.16** kN;
4	;Clg i;	Q_{c2} ;	;;**1.60** m;	;;**2.50** m;	P_4 = **0.00** kN;	F_i = 1.6;	P_{4u} = **0.00** kN;
11	;S.Wt;	;; **0.10** kN/m;	;;**2.50** m;		P_{11} = **0.25** kN;	F_d = 1.4;	P_{11u} = **0.35** kN;

Point Imposed ; P_i = (P_2 + P_4) = **2.4** kN

Point total ; P = (P_1 + P_2 + P_3 + P_4 + P_{11}) = **6.3** kN

Ult Point total ; P_{ult} = (P_{1u} + P_{2u} + P_{3u} + P_{4u} + P_{11u}) = **9.4** kN

Simple triangular truss



Angle of roof truss is; p_{roof} = **30** ; degrees. Assume ridge purlins contribute to forces within truss. Assume C16 Timber members.

; Span of Truss; L = **3.20** m ;

Length of Rafter ; L_r = (L / 2) / cos(p_{roof}) = **1.85**m

; Rafter breadth; b_r = **50** mm; ; Rafter depth; h_r = **150** mm;

; Tie breadth; b_t = **50** mm; ; Tie depth; h_t = **150** mm;

Truss reaction; R_t = (P / 2) = **3.17** kN

Tension in bottom tie; T_b = (R_t / tan(p_{roof})) = **5.49** kN

Compression in rafter; C_r = (T_b / cos(p_{roof})) = **6.35** kN

Rafter - **b_r x h_r**

comp_stress = (C_r / ($b_r \times h_r$)) = **0.85** N/mm^2

all_comp_stress = (6.8 N/mm^2 × 1.25) = **8.50** N/mm^2

Bottom Tie - $b_t \times h_t$

tens_stress = $(T_b / (b_t \times h_t))$ = **0.73** N/mm^2

all_tens_stress = $(3.2 \text{ N/mm}^2 \times 1.25)$ = **4.00** N/mm^2

Truss Members OK

Rafter ; b_r = 50 mm ; h_r = 150 mm ; Rafter ; b_t = 50 mm ; h_t = 150 mm ;

Provide bolted steel plates at ridge and eaves.

Eaves purlin reaction is 6.3 kN or 3.15 kN each side

Tie tension is 5.49 kN

Use steel plates in centre of section and M12 bolts

Assume M12 bolts in shear – medium term load is 1.85 kN x 1.25 – say 2 kN per bolt

C4 EAVES BEAM

;;Incoming Reaction; **"C2"** ; ;P = **3.10** kN ; ;P_{ult} = **4.65** kN

UDL from roof, ceiling and Self-weight ; ;

	Item	Load	Span.Ht	UDL	Factor	Ult UDL
1	;Roof d;	G_{r1} ;	;;**0.90** m;	w_1 = **0.64** kN/m;	F_d = 1.4;	w_{1u} = **0.90** kN/m;
2	;Roof i;	Q_{r1} ;	;;**0.90** m;	w_2 = **0.54** kN/m;	F_i = 1.6;	w_{2u} = **0.86** kN/m;
3	;Clg d;	G_{c2} ;	;;**0.90** m;	w_3 = **0.19** kN/m;	F_d = 1.4;	w_{3u} = **0.26** kN/m;
4	;Clg i;	Q_{c2} ;	;;**0.90** m;	w_4 = **0.00** kN/m;	F_i = 1.6;	w_{4u} = **0.00** kN/m;
11	;S.wt;			;; w_{11} = **0.20** kN/m;	F_d = 1.4;	w_{11u} = **0.28** kN/m;

UDL total ; w = $(w_1 + w_2 + w_3 + w_4 + w_{11})$ = **1.6** kN/m

Ult UDL total ; w_{ult} = $(w_{1u} + w_{2u} + w_{3u} + w_{4u} + w_{11u})$ = **2.3** kN/m

;Span; L = **2.40** m; E_{min} = 5800 N/mm^2;

;a = **0.6** m; ;Point load at a from lhs; P = **3.100** kN;

M_x = $(w \times L^2 / 8) + (P \times a \times (L - a) / L)$ = **2.96** kNm

R_L = $(w \times L / 2) + (P \times (L - a) / L)$ = **4.93** kN

R_R = $(w \times L / 2) + (P \times a / L)$ = **3.38** kN

I_{min} = ((5 × w × L^4 / 384) + (P × L^3) × (3 × a / L - 4 × (a / L)^3) / (48)) / (E_{min} × L × .003)
= **37.1×10^6** mm^4

Try Sawn Softwood - Basic Size 2x50x150

A = **15.0×10^3** mm^2 ; I_{xx} = **28.1×10^6** mm^4 ; Z_{xx} = **375.×10^3** mm^3 ;

Use C16 timber (Table 8 BS5268:Pt 2:2002)

;Modification factor for duration of load (Table 17); K_3 = **1.25**

;Load sharing factor (Clause 13); K_8 = **1.00**

;Grade stress (Table 9,10,11,12 or 13); σ_m = **5.30** N/mm^2

M_{all} = (K_3 × K_8 × σ_m × Z_{xx}) = **2.48** kNm

Use 4 / 50x150 min.

P2 P2A TIMBER POSTS

Consider as sway frame resisting sidesway from wind load.

Wind load from wind on end along front eaves line on each of say five posts 150x175

say ; P = (0.50 kN/m^2 × (3.0m / 2) × (3.6m / 2)) / 4 = **0.3** kN

Try Rectangular section ;; Width; B = **175.0** mm; ;Depth; D = **150.0** mm;

A = (B × D) = **26.3×10^3** mm^2 ; Z_{xx} = (B × D^2) / 6 = **656.×10^3** mm^3; I_{xx} = (B × D^3) / 12 = **49.2×10^6** mm^4

Cantilever - Point load P at end

;;Span; L = **1.00** m; ;;Deflection ratio ; Dr = **180**;

; Modulus of Elasticity; E = 8800 N/mm^2;

M = (P × L) = **0.3** kNm ;

I_{min} = ((P × L^3) / (3 × E × L / Dr)) = **2.30×10^6** mm^4

R = P = **0.3** kN ; R_{ult} = P_{ult} = **0.5** kN ;

150x175 posts by inspection

FF1 FLOOR JOISTS

UDL from floor, and Self-weight ; ;

	Item	Load	Span.Ht	UDL	Factor	Ult UDL
5	;Floor d;	G_{f1} ;	;;**0.45** m;	w_5 = **0.23** kN/m;	F_d = 1.4;	w_{5u} = **0.33** kN/m;
6	;Floor i;	Q_{f1} ;	;;**0.45** m;	w_6 = **0.90** kN/m;	F_i = 1.6;	w_{6u} = **1.44** kN/m;
11	;S.wt;			;; w_{11} = **0.00** kN/m;	F_d = 1.4;	w_{11u} = **0.00** kN/m;

Imposed ; w_i = (w_6) = **0.9** kN/m

UDL total ; w = ($w_5 + w_6 + w_{11}$) = **1.1** kN/m

Ult UDL total ; w_{ult} = ($w_{5u} + w_{6u} + w_{11u}$) = **1.8** kN/m

Dead plus Imposed - main design case

;Span; L = **3.2** m; ;Width carried; wc = **450** mm; E_{mean} = 8800 N/mm^2;

M_{x1} = (w × L^2 / 8) = **1.45** kNm

I_{min1} = (5 × w × L^4) / (384 × E_{mean} × L × .003) = **18.3×10^6** mm^4

Also consider dead only plus (1.4 kN / 3) Point load, at midspan for moment, and at end for reaction. Assume point load is spread over at least three members.

M_{x2} = ((w - w_i) × L^2 / 8) + (1.4 kN × L / (3 × 4)) = **0.67** kNm

I_{min2} = (5 × (w - w_i) × L^4) / (384 × E_{mean} × L × .003) + (1.4 kN × L^3) / (3 × 48 × E_{mean} × L × .003) = **7.55×10^6** mm^4

Max reaction with point load at lhs ; R_L = (1.4 kN / 3 + (w - w_i) × L / 2) = **0.84** kN

Reaction at rhs ; R_R = ((w - w_i) × L / 2) = **0.37** kN

Limit maximum deflection to 14mm for floor joists ;

I_{min3} = (5 × w × L^4) / (384 × E_{mean} × 14mm) = **12.6×10^6** mm^4

M_x = max (M_{x1}, M_{x2}) = **1.45** kNm ; I_{min} = max (I_{min1}, I_{min2} , I_{min3}) = **18.3×10^6** mm^4;

Try Sawn Softwood - Basic Size 44x225

A = **9.90×10^3** mm^2 ; I_{xx} = **41.8×10^6** mm^4 ; Z_{xx} = **371.×10^3** mm^3 ;

Use C16 timber (Table 8 BS5268:Pt 2:2002)

;Modification factor for duration of load (Table 14); K_3 = **1.00**

;Load sharing factor (Clause 2.9); K_8 = **1.10**

;Grade stress (Table 7); σ_m = **5.30** N/mm^2

M_{all} = ($K_3 \times K_8 \times \sigma_m \times Z_{xx}$) = **2.16** kNm

Use ;44(225); Joists at; wc = 450 mm; crs.

FF3 STEEL BEAM LINTEL

UDL from roof, ceiling, floor, wall and self-weight ; ;

	Item	Load	Span.Ht	UDL	Factor	Ult UDL
1	;Roof d;	G_{r1} ;	;;**1.90** m;	w_1 = **1.36** kN/m;	F_d = 1.4;	w_{1u} = **1.90** kN/m;

2	;Roof i;	Q_{r1} ;	;;**1.90** m;	w_2 = **1.14** kN/m;	F_i = 1.6;	w_{2u} = **1.82** kN/m;
3	;Clg d;	G_{c1} ;	;;**1.60** m;	w_3 = **0.38** kN/m;	F_d = 1.4;	w_{3u} = **0.54** kN/m;
4	;Clg i;	Q_{c1} ;	;;**1.60** m;	w_4 = **0.40** kN/m;	F_i = 1.6;	w_{4u} = **0.64** kN/m;
5	;Floor d;	G_{f1} ;	;;**1.60** m;	w_5 = **0.83** kN/m;	F_d = 1.4;	w_{5u} = **1.16** kN/m;
6	;Floor i;	Q_{f1} ;	;;**1.60** m;	w_6 = **3.20** kN/m;	F_i = 1.6;	w_{6u} = **5.12** kN/m;
7	;Wall d;	G_{w4} ;	;;**3.50** m;	w_7 = **16.94** kN/m;	F_d = 1.4;	w_{7u} = **23.72** kN/m;
11	;S.wt;			;; w_{11} = **1.00** kN/m;	F_d = 1.4;	w_{11u} = **1.40** kN/m;

Provide two beams – load per beam

UDL total ; w $= (w_1 + w_2 + w_3 + w_4 + w_5 + w_6 + w_7 + w_{11}) / 2$ = **12.6** kN/m

Ult UDL total ; w_{ult} $= (w_{1u} + w_{2u} + w_{3u} + w_{4u} + w_{5u} + w_{6u} + w_{7u} + w_{11u}) / 2$ = **18.2** kN/m

<u>UDL w throughout</u>

;;Span; L = **2.90** m; ;;Deflection ratio ; Dr = **360**;

; Modulus of Elasticity; E = **205.×10³** N/mm²;

$M = (w \times L^2 / 8)$ = **13.3** kNm

$M_{ult} = (w_{ult} \times L^2 / 8)$ = **19.1** kNm

$I_{min} = (5 \times w \times L^4) / (384 \times E \times L / Dr)$ = **704** cm⁴

$R_L = (w \times L / 2)$ = **18.3** kN ; $R_R = (w \times L / 2)$ = **18.3** kN

$R_{Lult} = (w_{ult} \times L / 2)$ = **26.3** kN ; $R_{Rult} = (w_{ult} \times L / 2)$ = **26.3** kN

<u>BS 5950-1:2000 4.3.7 Equal flanged rolled UC sections - Class 1 Plastic, or Class 2 Compact cross-section. Simple conservative approach.</u>

Try UC 152 x 152 x 23;

;; Steel grade; **"S275"** ; p_y = **275** N/mm² ;

; $\varepsilon = \sqrt{(275 \text{ N/mm}^2 / p_y)}$ = **1.000** ; K_e = **1.2**

S_{xx} = **182** cm³ ; I_{xx} = **1250** cm⁴ ; r_{yy} = **3.70** cm ;x = **20.7** ; D/T = **22**

;Lateral restraint provided by floor or roof.; **"No"**

;Segment Length between restraints; L_{LT} = **2.90** m

;Effective length factor; f1 = **1.00** ; ;Bearing factor; f2 = **2** ;

Effective length ; $L_E = (L_{LT} \times f1 + f2 \times D)$ = **3.20** m ;

Ratio ; β_W = 1.00 ; $\lambda_{mod1} = (\beta_W)^{0.5} \times (L_E / r_{yy})$ = **87** ; λ_{mod2} = 30 ; $\lambda_{mod} = \max(\lambda_{mod1} , \lambda_{mod2})$ = **87**

Table = "BS 5950-1: 2000 ..... Table 20"

From BS 5950-1: 2000 ..... Table 20; p_b = **194** N/mm^2

; Equivalent uniform moment factor - .925 for UDL, .85 for central point; m_{LT} = **0.925** ;

Net Buckling resistance moment ; M_{b_net} = ($p_b \times S_{xx}$) / m_{LT} = **38.2** kNm

Deflection and Ultimate moment - Use ;UC 152x152x23;

For simply supported beams and cantilevers - Ultimate Moment, M_{ult}, should be less than M_c and M_{c1}

M_{ult} = **19.1** kNm ; M_c = ($p_y \times S_{xx}$) = **50.05** kNm ; M_{c1} = ($1.2 \times p_y \times Z_{xx}$) = **54.13** kNm ;

Moment capacity ;OK;

For Low Shear considerations

; Ultimate shear force; F_v = **26.32** kN;

60% of Ultimate shear capacity; P_{v_60} = ($0.6 \times p_y \times t \times D$) $\times$ 60 / 100 = **87.51** kN

;OK - Low shear;

FF4 KINGSPAN MULTIDECK

Assume Imposed 5 kN/m^2 , asphalt 0.50 kN/m^2 , and 150mm to 200mm reinforced concrete slab for fall

Use Kingspan Multideck, 2 span continuous, unpropped, 1.2 gauge

1.2g with A193 fabric OK for 200 slab and 6.0 kN/m^2 applied load

FF6 TRIMMER BEAM

UDL from floor, and Self-weight ; ;

	Item	Load	Span.Ht	UDL	Factor	Ult UDL
5	;Floor d;	G_{f1} ;	;;**0.90** m;	w_5 = **0.47** kN/m;	F_d = 1.4;	w_{5u} = **0.66** kN/m;
6	;Floor i;	Q_{f1} ;	;;**0.90** m;	w_6 = **1.80** kN/m;	F_i = 1.6;	w_{6u} = **2.88** kN/m;
11	;S.wt;			;; w_{11} = **0.20** kN/m;	F_d = 1.4;	w_{11u} = **0.28** kN/m;

Imposed ; w_i = (w_6) = **1.8** kN/m

UDL total ; w = ($w_5 + w_6 + w_{11}$) = **2.5** kN/m

Ult UDL total ; w_{ult} = ($w_{5u} + w_{6u} + w_{11u}$) = **3.8** kN/m

;Span; L = **5.0** m; E_{min} = 5800 N/mm^2; for C16

M_x = ($w \times L^2 / 8$) = **7.71** kNm

I_{min} = (5 × w × L^4) / (384 × E_{min} × L × .003) = **231.×10^6** mm^4

R = (w × L / 2) = **6.17** kN

Try Sawn Softwood - Basic Size 2x50x300

A = **30.0×10³** mm^2 ; I_{xx} = **225.×10⁶** mm^4 ; Z_{xx} = **1.50×10⁶** mm^3 ;

Use C16 timber (Table 8 BS5268:Pt 2:2002)

;Modification factor for duration of load (Table 14); K_3 = **1.00**

;Load sharing factor (Clause 2.9); K_8 = **1.00**

;Grade stress (Table 7); σ_m = **5.30** N/mm²

M_{all} = ($K_3 \times K_8 \times \sigma_m \times Z_{xx}$) = **7.95** kNm

Use 2 / 50x300

UDL w throughout

;;Span; L = **5.00** m; ;;Deflection ratio ; Dr = **360**;

; Modulus of Elasticity; E = **205.×10³** N/mm²;

M = (w × L^2 / 8) = **7.7** kNm

M_{ult} = (w_{ult} × L^2 / 8) = **11.9** kNm

I_{min} = (5 × w × L^4) / (384 × E × L / Dr) = **705** cm^4

R_L = (w × L / 2) = **6.2** kN ; R_R = (w × L / 2) = **6.2** kN

R_{Lult} = (w_{ult} × L / 2) = **9.5** kN ; R_{Rult} = (w_{ult} × L / 2) = **9.5** kN

or 152x152x23 UC

FF7 STEEL BEAM

UDL from platform, and Self-weight ; ;

	Item	Load	Span.Ht	UDL	Factor	Ult UDL
5	;Floor d;	G_{f2} ;	;;**2.90** m;	w_5 = **15.81** kN/m;	F_d = 1.4;	w_{5u} = **22.13** kN/m;
6	;Floor i;	Q_{f2} ;	;;**2.90** m;	w_6 = **14.50** kN/m;	F_i = 1.6;	w_{6u} = **23.20** kN/m;
11	;S.wt;			;; w_{11} = **1.00** kN/m;	F_d = 1.4;	w_{11u} = **1.40** kN/m;

Imposed ; w_i = (w_6) = **14.5** kN/m

UDL total ; w = ($w_5 + w_6 + w_{11}$) = **31.3** kN/m

Ult UDL total ; w_{ult} = ($w_{5u} + w_{6u} + w_{11u}$) = **46.7** kN/m

UDL w throughout

;;Span; L = **2.50** m; ;;Deflection ratio ; Dr = **360**;

; Modulus of Elasticity; E = **205.×10^3** N/mm^2;

M = (w × L^2 / 8) = **24.5** kNm

M_{ult} = (w_{ult} × L^2 / 8) = **36.5** kNm

I_{min} = (5 × w × L^4) / (384 × E × L / Dr) = **1118** cm^4

R_L = (w × L / 2) = **39.1** kN ; R_R = (w × L / 2) = **39.1** kN

R_{Lult} = (w_{ult} × L / 2) = **58.4** kN ; R_{Rult} = (w_{ult} × L / 2) = **58.4** kN

BS 5950-1:2000 4.3.7 Equal flanged rolled UC sections - Class 1 Plastic, or Class 2 Compact cross-section. Simple conservative approach.

Try UC 152 x 152 x 23;

;; Steel grade; **"S275"** ; p_y = **275** N/mm^2 ;

; ε = √(275 N/mm^2 / p_y) = **1.000** ; K_e = **1.2**

S_{xx} = **182** cm^3 ; I_{xx} = **1250** cm^4 ; r_{yy} = **3.70** cm ;x = **20.7** ; D/T = **22**

;Lateral restraint provided by floor or roof.; **"No"**

;Segment Length between restraints; L_{LT} = **2.50** m

;Effective length factor; f1 = **1.00** ; ;Bearing factor; f2 = **0** ;

Effective length ; L_E = (L_{LT} × f1 + f2 × D) = **2.50** m ;

Ratio ; β_W = 1.00 ; λ_{mod1} = $(\beta_W)^{0.5}$ × (L_E / r_{yy}) = **68** ; λ_{mod2} = 30 ; λ_{mod} =max(λ_{mod1} , λ_{mod2}) = **68**

Table = "BS 5950-1: 2000 ..... Table 20"

From BS 5950-1: 2000 ..... Table 20; p_b = **225** N/mm^2

; Equivalent uniform moment factor - .925 for UDL, .85 for central point; m_{LT} = **0.925** ;

Net Buckling resistance moment ; M_{b_net} = (p_b × S_{xx}) / m_{LT} = **44.2** kNm

Deflection and Ultimate moment - Use ;UC 152x152x23;

For simply supported beams and cantilevers - Ultimate Moment, M_{ult}, should be less than M_c and M_{c1}

M_{ult} = **36.5** kNm ; M_c = (p_y × S_{xx}) = **50.05** kNm ; M_{c1} = (1.2 × p_y × Z_{xx}) = **54.13** kNm ;

Moment capacity ;OK;

For Low Shear considerations

; Ultimate shear force; F_v = **58.41** kN;

60% of Ultimate shear capacity; P_{v_60} = (0.6 × p_y × t × D) × 60 / 100 = **87.51** kN

;OK - Low shear;