

7 ABERDARE ROAD,
GLYNNEATH,
NEATH.

STRUCTURAL CALCULATIONS.

PROPOSED GARAGE :

FLAT SLAB RAFT FOUNDATION DESIGN.

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1. INTRODUCTION:

THE PROPOSAL INVOLVES THE CONSTRUCTION OF A REINFORCED CONCRETE FLAT SLAB RAFT FOUNDATION TO SUPPORT A SINGLE STOREY GARAGE WITH FLAT ROOF AT THE ABOVE PROPERTY.

THE RAFT WILL BE DESIGNED FOR A MAX. GROUND BEARING PRESSURE OF 50 kn/m^2 , AND SUITABLE TO SPAN A 3m VOID.

THE RAFT IS TO BE CONSTRUCTED WITH A 150mm PROJECTION FROM THE FACE OF THE GARAGE WALLS, WHERE POSSIBLE.

NO ACCOUNT IS TAKEN OF ANY PUBLIC SEWERS IN THE VICINITY OF THE EXTENSION OR ANY SIGNIFICANT CHANGES IN GROUND LEVEL.

2. LOADING DATA:

FLAT ROOF (POLYROOF):

DEAD LOAD:	COVERING	0.35 kn/m^2
	BATTENS	0.05 kn/m^2
	INSULATION	0.05 kn/m^2
	PLASTERBOARD & SKIM	0.15 kn/m^2
	JOISTS	<u>0.05 kn/m^2</u>
		0.65 kn/m^2

LIVE LOAD: 0.75 kn/m^2 TOTAL S.L.S LOAD = 1.4 kn/m^2

U.L.S. LOAD = $(0.65 \text{ kn/m^2 x 1.4) + (0.75 \text{ kn/m^2 x 1.6) = 2.11 $\text{kn/m}^2$$

CAVITY WALL:

DEAD LOAD :	WALL	4.2 kn/m^2	
	FINISHES	<u>0.15 kn/m^2</u>	
		4.35 kn/m^2	TOTAL S.L.S LOAD = 4.35 kn/m^2

U.L.S. LOAD = $(4.35 \text{ kn/m^2 x 1.4) = 6.09 $\text{kn/m}^2$$

RAFT FOUNDATION:

DEAD LOAD :	175mm THICK SLAB	$(23.6 \text{ \text{kn/m}^3 x 0.25m) =$	5.9 kn/m^2
	50mm SCREED	$(23.6 \text{ \text{kn/m}^3 x 0.05m) =$	<u>1.18 kn/m^2</u>
			7.08 kn/m^2

IMPOSED LOAD: 2.5 kn/m^2 TOTAL S.L.S LOAD = 9.58 kn/m^2

U.L.S. LOAD = $(7.08 \text{ kn/m^2 x 1.4) + (2.5 \text{ kn/m^2 x 1.6) = 13.91 $\text{kn/m}^2$$

3. AVERAGE GLOBAL BEARING PRESSURE

RAFT SIZE: = (6.3m x 5.9) = 37.17 m²

LOADING:

ROOF =

1.40 kn/m²

RAFT SLAB =

9.58 kn/m²

WALLS = $\frac{(23.2\text{m} \times 2.5\text{m}) \times 4.35 \text{ kn/m}^2}{37.17\text{m}^2} =$

6.79 kn/m²

NETT BEARING PRESSURE = 17.76 kn/m² < 50 kn/m² SO ACCEPTABLE.

4. U.L.S. DESIGN:

BENDING IN THE SLAB IS CAUSED BY CONCENTRATED LOADING FROM ABOVE, AS UNIFORMLY DISTRIBUTED LOADING IS BALANCED BY AN EQUAL AND OPPOSITE REACTION FROM THE GROUND BELOW.

CALCULATE U.L.S. LOAD CAUSING BENDING:

ROOF LOAD: $2.11 \text{ kn/m}^2 \times 5.0\text{m} / 2 = 5.275 \text{ kn/m}$

CAVITY WALL: $6.09 \text{ kn/m}^2 \times 2.5\text{m} = 15.22 \text{ kn/m}$

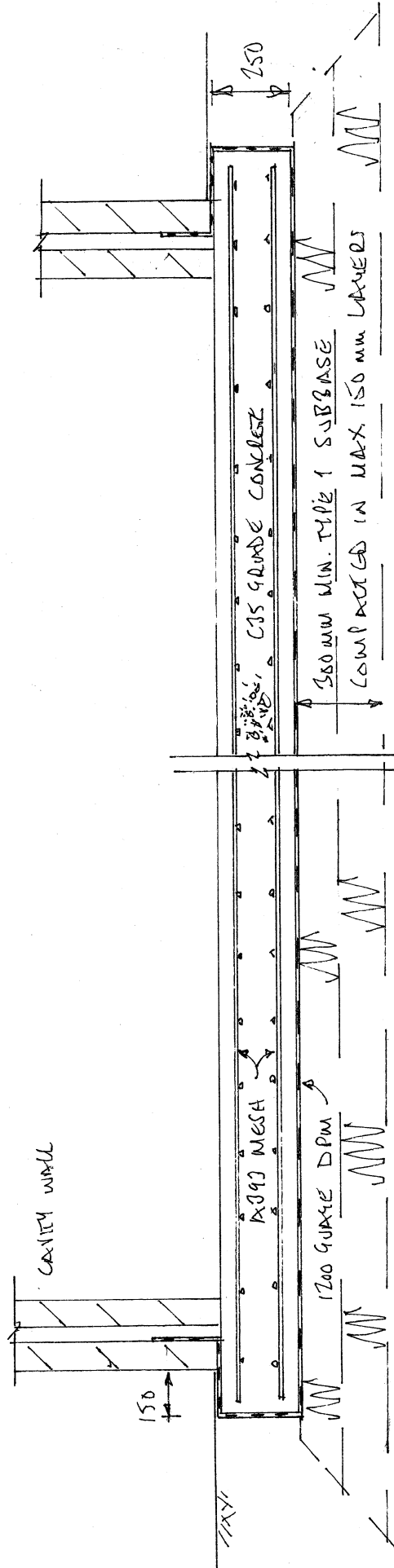
TOTAL = 5.275 + 15.22 = 20.5 kn/m

FOR THE DESIGN CONSIDER SLAB AS ONE-WAY SPANNING WITH A DESIGN SPAN OF 3m
(CONSERVATIVE)

DESIGN BENDING MOMENT = $\frac{20.5 \text{ kn/m} \times 3\text{m} \times 3\text{m}}{8} = 23 \text{ knm}$

FROM THE COMPUTER PRINTOUT: PROVIDE A 250mm THICK CONCRETE SLAB WITH 1 LAYER
OF A393 MESH TOP AND BOTTOM.

1. Concrete grade to be C35, maximum aggregate size 20mm, minimum cement content 300kg/m³, maximum free water / cement ratio 0.6.
2. Reinforcement to be grade 460 deformed type 2 high yield bars to BS 4449.
3. Cover to reinforcement to top of slab 40mm, bottom of slab 40mm, edge beams 50mm.
4. Min. reinforcement lap lengths: 760mm for T16, 500mm for T12. Mesh reinforcement 400mm. Provide patented chairs and spacer blocks at 1m centres.
5. Construction joints to be scabbled to provide a suitable key.
6. Raft foundation constructed on 1200 gauge D.P.M. on 50mm concrete or sand/dust blinding on Type 1 granular sub-base compacted in layers of maximum 150mm thick.



COMPACTION SPECIFICATION - EXTENSION.

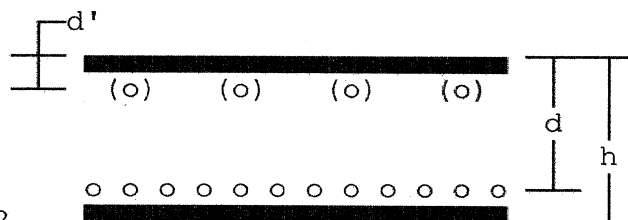
Excavate existing ground to formation level. Proof roll formation with 8 passes of a Bomag 55 / 65 single or double drum rollers or 16 passes with a Bomag 10/35 or 25/40 heavy duty vibratory compactor plate.. 300mm thickness of imported sub-base to be compacted in max. 150mm layers up to underside of raft with 8 passes of a Bomag 55 / 65 single or double drum roller or 16 passes with a Bomag 10/35 or 25/40 heavy duty vibratory compactor plate.

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Location: FLAT SLAB RAFT FOUNDATION

Bending in solid slabs (with comp.steel if reqd.), designed per metre width, with checks on minimum steel and span/effective-depth ratio

Calculations are based on formulae in Clause 3.4.4.4 of BS8110: Part 1 and thus assume the use of a simplified rectangular concrete stress-block, and that the depth to the neutral axis is restricted to $d/2$.



Design to BS8110(1997) with partial safety factor for steel $\gamma_s=1.15$
Moment before redistribution $M_{bef}=23$ kNm per metre width
Slab containing section being analysed is considered as continuous.
Design moment (after redistrib.) $M=23$ kNm per metre width
Characteristic concrete strength $f_{cu}=35$ N/mm²
Characteristic steel strength $f_y=500$ N/mm²
Longitudinal reinforcement is high-yield steel.
Diameter of tension bars $\text{dia}=10$ mm

Minimum nominal cover to all steel is 20 mm

Nominal concrete cover $\text{cover}=50$ mm

Overall thickness of slab $h=250$ mm

Maximum effective depth $d_{max}=h-\text{cover}-\text{dia}/2=250-50-10/2=195$ mm

Effective depth of section $d=195$ mm

Longitudinal reinforcement

As $M_{bef}=M$, no redistribution has occurred.

Thus redistribution factor β_b $\text{betab}=1$

and resistance-moment factor $K'=0.156$ [Cl.3.2.2.1, Condition (b)].

As applied-moment factor $K=M \cdot 10^6 / (1000 \cdot d^2 \cdot f_{cu})$
 $=23 \cdot 10^6 / (1000 \cdot 195^2 \cdot 35)$
 $=0.017282$

does not exceed resistance-moment factor K' , no comp.steel is needed.
and lever arm $z=d \cdot (0.5 + \text{SQR}(0.25 - K/0.9))$
 $=195 \cdot (0.5 + \text{SQR}(0.25 - 0.017282/0.9))$
 $=191.18$ mm

but must not exceed $0.95 \cdot d = 0.95 \cdot 195 = 185.25$ mm

i.e. take $z=185.25$ mm

Area of tension steel required $A_s = M \cdot 10^6 / (z \cdot f_y / \gamma_s)$
 $=23 \cdot 10^6 / (185.25 \cdot 500 / 1.15)$
 $=285.56$ mm²/metre width.

Minimum permissible area of tension steel $A_{smin}=0.0013 \cdot 1000 \cdot h$
 $=0.0013 \cdot 1000 \cdot 250$
 $=325$ mm²/m;

see Table 3.25. As this exceeds calculated area, make $A_s=325$ mm²/m.

As $3 \cdot d < 750$ mm, maximum clear distance between bars

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for tension steel $\max c_1 = 3 \cdot d = 3 \cdot 195 = 585 \text{ mm}$, and
maximum spacing (c.to c.of bars) $p_{chmx} = 3 \cdot d + d_{ia} = 595 \text{ mm}$
Calculated c.to c.spacing for tension bars $p_{ch} = 1000 \cdot \pi / 4 \cdot d_{ia}^2 / A_s$
 $= 1000 \cdot 3.1416 / 4 \cdot 10^2 / 325$
 $= 241.66 \text{ mm}$

As this does not exceed maximum permissible spacing of 595 mm,
employ this value.

Round spacing (c.to c.of bars) to 240 mm (rounded).

Chosen spacing of tension bars $p_{ch} = 200 \text{ mm}$

Area of tension steel provided $A_{spr} = 1000 / p_{ch} \cdot \pi \cdot d_{ia}^2 / 4$
 $= 1000 / 200 \cdot 3.1416 \cdot 10^2 / 4$
 $= 392.7 \text{ mm}^2/\text{m}$

Spacing and proportion of tension steel (see Clause 3.12.11.2.7)

Tension steel provided $per = A_{spr} / (10 \cdot h) = 392 / (10 \cdot 250)$
 $= 0.1568 \%$ of gross section.

As this falls within Code limits of 0.13% and 4%, this is satisfactory.
As the area of tension steel provided does not exceed 0.3% of A_{spr}/bd ,
no check on the spacing of bars is needed [see Clause 3.12.11.2.7(a3)].

TENSION (AND
DISTRIBUTION)
REINFORCEMENT
SUMMARY

Characteristic strength	500 N/mm ²
Diameter of bars	10 mm
Spacing of bars	200 mm
Effective depth	195 mm
Area of steel required	325 mm ² /m
Area of steel provided	392 mm ² /m
Percentage provided	0.1568 %
Weight of steel provided	3.08 kg/m ²

Check on span/effective-depth ratio

Calculate redistribution ratio $b_{tab} = M/M_{bef} = 23/23 = 1$
Basic ratio for slab
continuous at one edge $bs \cdot d = 23$
(interpolated from Table 3.9)
Area of tension steel provided $A_{spr} = 392 \text{ mm}^2$
Service stress in this steel $f_s = 2 \cdot f_y \cdot A_s / (3 \cdot A_{spr} \cdot b_{tab})$
 $= 2 \cdot 500 \cdot 325 / (3 \cdot 392 \cdot 1)$
 $= 276.36 \text{ N/mm}^2$
As applied-moment factor $M'bd_2 = M \cdot 10^6 / (1000 \cdot d^2)$
 $= 23 \cdot 10^6 / (1000 \cdot 195^2)$
 $= 0.60487$
From equation 7 $modf_1 = 0.55 + (477 - f_s) / (120 \cdot (0.9 + M'bd_2))$
 $= 0.55 + (477 - 276.36) / (120 \cdot (0.9$
 $+ 0.60487))$
 $= 1.6611$
Mod.factor for tension steel $modf_1 = 1.6611$
Mod.factor for no comp.steel $modf_2 = 1.0$
Maximum permissible
span/effective-depth ratio $ps \cdot d = bs \cdot d \cdot modf_1 \cdot modf_2 = 23 \cdot 1.6611 \cdot 1$
 $= 38.204$
Effective span of slab $span = 3 \text{ m}$

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Page: 6
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True span/effective-depth ratio as $d=1000 \times \text{span} / d=1000 \times 3 / 195$
 $=15.385$
As this does not exceed 38.204, this is Acceptable.
No 81