

**12 TRAM RD SIDE,**  
**QUAKERS YARD,**  
**TREHARRIS.**

**STRUCTURAL CALCULATIONS.**

PROPOSED EXTENSION :

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 REAR EXTENSION WITH PITCHED ROOF AT THE ABOVE PROPERTY.

THE RAFT WILL BE DESIGNED FOR A MAX. GROUND BEARING PRESSURE OF 50 kn/m<sup>2</sup>, AND SUITABLE TO SPAN A 2.5m VOID.

THE RAFT IS TO BE CONSTRUCTED WITH A 150mm PROJECTION FROM THE FACE OF THE EXTENSION WALLS, WHERE POSSIBLE, AND DOWELLED INTO THE EXISTING SUBSTRUCTURE WALL.

THE LEVEL DIFFERENCE FROM D.P.C. TO EXISTING GROUND LEVEL, MAY REQUIRE A BEAM AND BLOCK FLOOR SOLUTION ABOVE THE RAFT. THE APPROPRIATE LOADS ARE ACCOUNTED FOR.

NO ACCOUNT IS TAKEN OF ANY PUBLIC SEWERS IN THE VICINITY OF THE EXTENSION.

## 2. LOADING DATA:

### ROOF:

|             |                     |                              |
|-------------|---------------------|------------------------------|
| DEAD LOAD : | SLATES / TILES      | 0.48 kn/m <sup>2</sup>       |
|             | INSULATION          | 0.06 kn/m <sup>2</sup>       |
|             | BATTENS & FELT      | 0.04 kn/m <sup>2</sup>       |
|             | CEILING             | 0.25 kn/m <sup>2</sup>       |
|             | PLASTERBOARD & SKIM | 0.15 kn/m <sup>2</sup>       |
|             | JOISTS & RAFTERS    | <u>0.12 kn/m<sup>2</sup></u> |
|             |                     | 1.10 kn/m <sup>2</sup>       |

IMPOSED LOAD : 0.75 kn/m<sup>2</sup> TOTAL S.L.S LOAD = 1.85 kn/m<sup>2</sup>

U.L.S. LOAD = (1.10 kn/m<sup>2</sup> x 1.4) + (0.75 kn/m<sup>2</sup> x 1.6) = 2.74 kn/m<sup>2</sup>

### GROUND:

|             |                |                              |
|-------------|----------------|------------------------------|
| DEAD LOAD : | BEAM AND BLOCK | 2.25 kn/m <sup>2</sup>       |
|             | SCREED         | <u>1.20 kn/m<sup>2</sup></u> |
|             |                | 3.45 kn/m <sup>2</sup>       |

IMPOSED LOAD : 1.5 kn/m<sup>2</sup> TOTAL S.L.S LOAD = 4.95 kn/m<sup>2</sup>

U.L.S. LOAD = (3.45 kn/m<sup>2</sup> x 1.4) + (1.5 kn/m<sup>2</sup> x 1.6) = 7.23 kn/m<sup>2</sup>

### CAVITY WALL:

|             |                    |                                           |
|-------------|--------------------|-------------------------------------------|
| DEAD LOAD : | OUTER SKIN (BLOCK) | 2.00 kn/m <sup>2</sup>                    |
|             | INNER SKIN (BLOCK) | 2.00 kn/m <sup>2</sup>                    |
|             | FINISHES           | <u>0.30 kn/m<sup>2</sup></u>              |
|             |                    | 4.30 kn/m <sup>2</sup>                    |
|             |                    | TOTAL S.L.S LOAD = 4.30 kn/m <sup>2</sup> |

U.L.S. LOAD = (4.30 kn/m<sup>2</sup> x 1.4) = 6.02 kn/m<sup>2</sup>

### RAFT FOUNDATION:

|             |                  |                                    |                              |
|-------------|------------------|------------------------------------|------------------------------|
| DEAD LOAD : | 250mm THICK SLAB | (23.6 kn/m <sup>3</sup> x 0.25m) = | 5.90 kn/m <sup>2</sup>       |
|             | 50mm SCREED      | (23.6 kn/m <sup>3</sup> x 0.05m) = | <u>1.18 kn/m<sup>2</sup></u> |
|             |                  |                                    | 7.08 kn/m <sup>2</sup>       |

IMPOSED LOAD: 1.5 kn/m<sup>2</sup> TOTAL S.L.S LOAD = 8.58 kn/m<sup>2</sup>

U.L.S. LOAD = (7.08 kn/m<sup>2</sup> x 1.4) + (1.5 kn/m<sup>2</sup> x 1.6) = 12.31 kn/m<sup>2</sup>

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### **3. AVERAGE GLOBAL BEARING PRESSURE (REAR EXTENSION)**

RAFT SIZE: =  $(15.3\text{m} \times 5.1) = 78.03 \text{ m}^2$

LOADING:

ROOF = 1.85 kn/m<sup>2</sup>

FLOOR = 4.95 kn/m<sup>2</sup>

RAFT SLAB = 8.58 kn/m<sup>2</sup>

WALLS =  $\frac{(27.8\text{m} \times 3.6\text{m}) \times 4.30 \text{ kn/m}^2}{78.03\text{m}^2} = 5.51 \text{ kn/m}^2$

NETT BEARING PRESSURE =  $20.9 \text{ kn/m}^2 < 50 \text{ kn/m}^2$  SO ACCEPTABLE.

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### **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:  $2.74 \text{ kn/m}^2 \times 4.0\text{m} / 2 = 5.48 \text{ kn/m}$

FLOOR LOAD:  $7.23 \text{ kn/m}^2 \times 4.0\text{m} / 2 = 14.46 \text{ kn/m}$

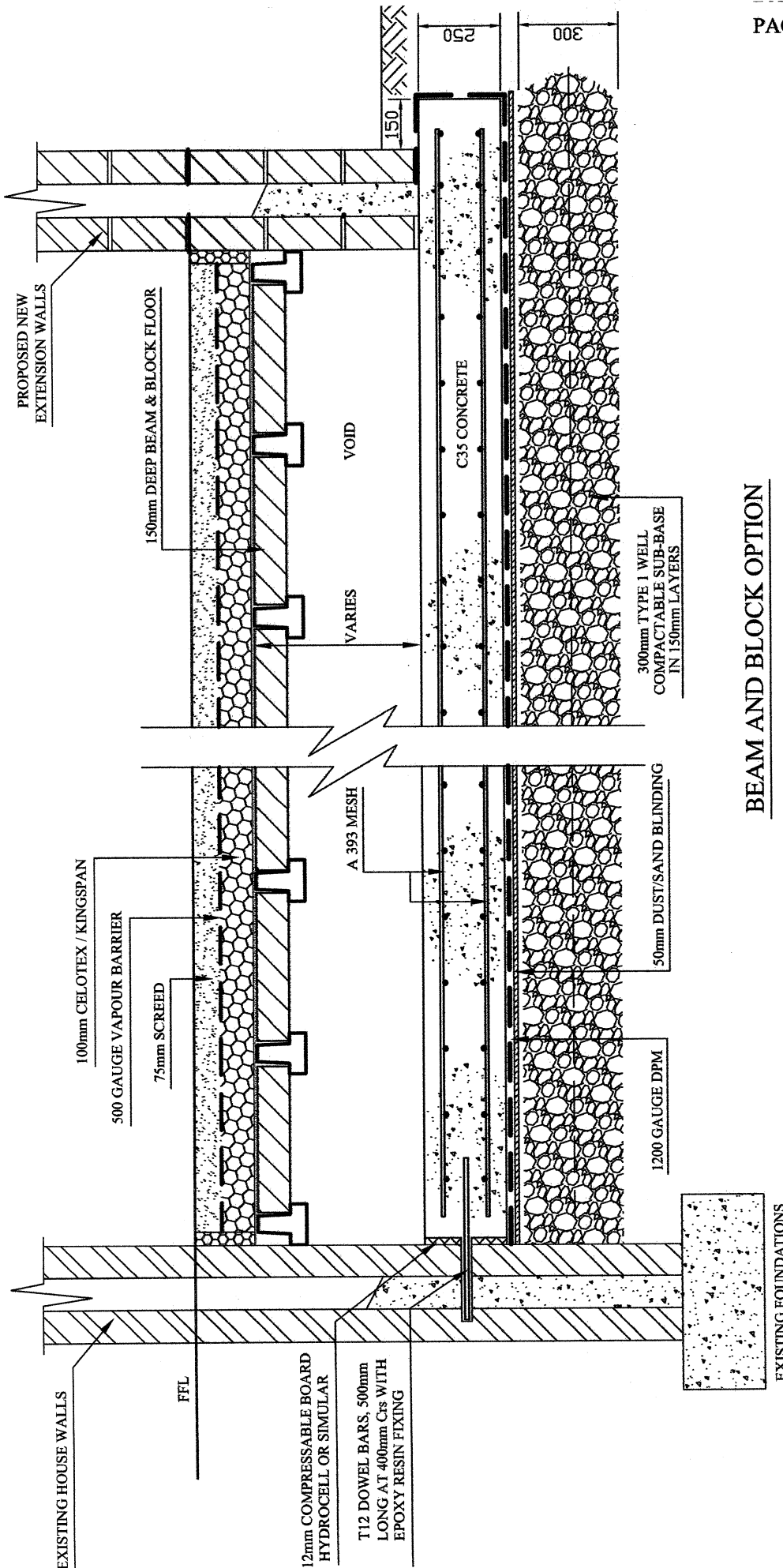
CAVITY WALL:  $6.02 \text{ kn/m}^2 \times 3.6\text{m} = 21.67 \text{ kn/m}$

TOTAL =  $5.48 + 14.46 + 21.67 = 41.6 \text{ kn/m}$

FOR THE DESIGN CONSIDER SLAB AS ONE-WAY SPANNING WITH A DESIGN SPAN OF 2.5m (CONSERVATIVE)

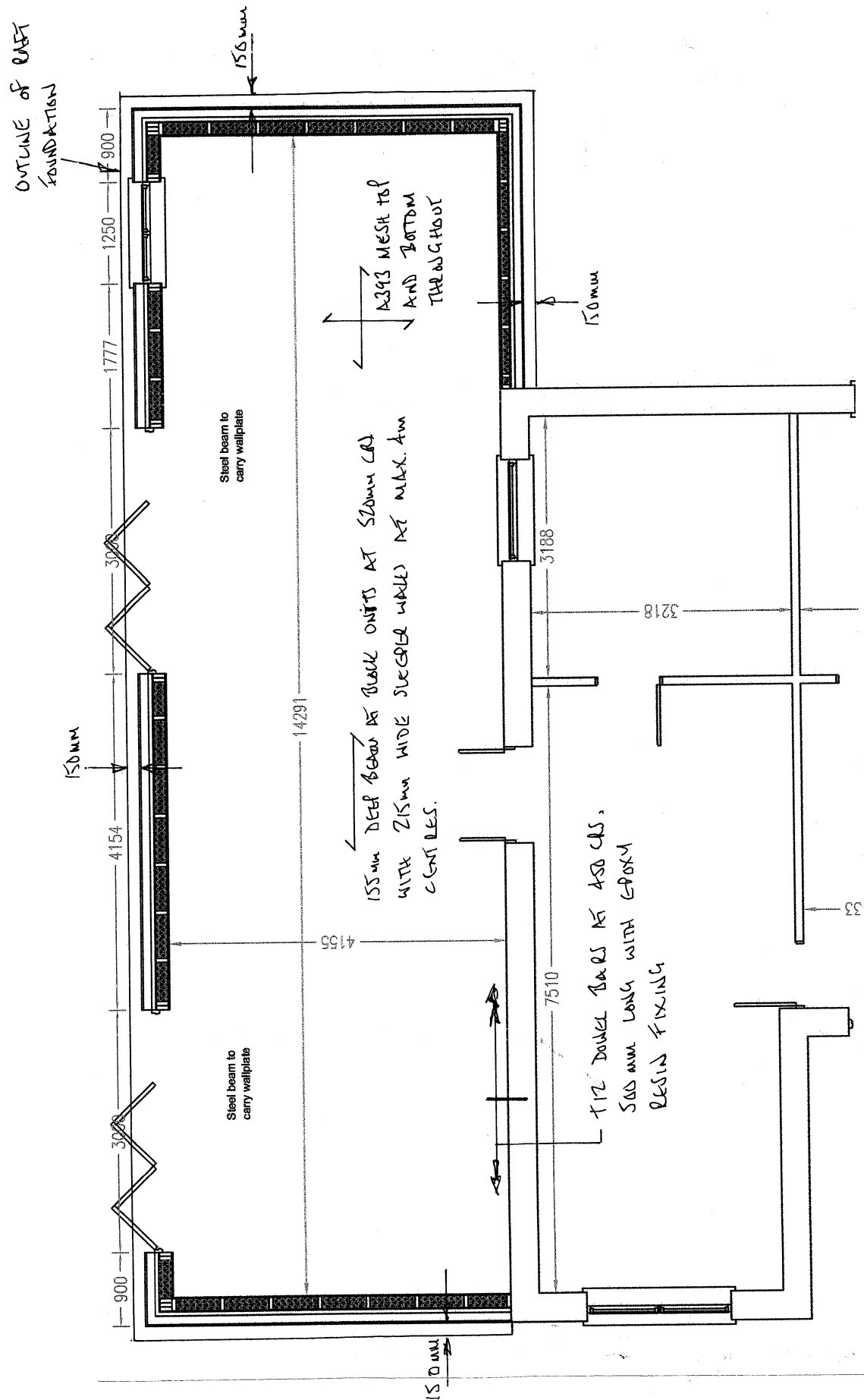
DESIGN BENDING MOMENT =  $\frac{41.6 \text{ kn/m} \times 2.5\text{m} \times 2.5\text{m}}{8} = 32.5 \text{ knm}$

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



PAGE:-

- 1) CONCRETE GRADE TO BE C35, MAXIMUM AGGREGATE SIZE 20mm, MINIMUM CEMENT CONTENT 300 kg/m<sup>3</sup>, 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 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 & SPACER BLOCKS AT 1 Mtr. C/s.
  - 5) CONSTRUCTION JOINTS TO BE SCABBLED TO PROVIDE A SUITABLE KEY.
  - 6) RAFT FOUNDATION CONSTRUCTION ON 1200 GAUGE DPM ON 50mm CONCRETE / STONE DUST BLINDING ON TYPE 1 GRANULAR SUB-BASE COMPACTED IN LAYERS OF MAX. 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 ROLLERS OR 16 PASSES WITH A BOMAG 10/35 OR 25/40 HEAVY DUTY VIBRATORY COMPACTOR PLATE.

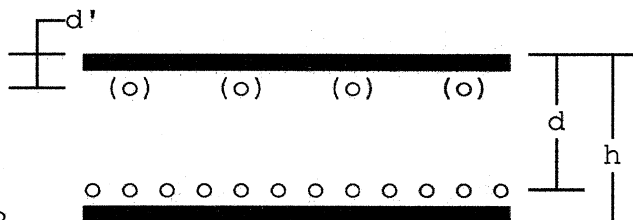


Office:

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  $\gamma_{sS}=1.15$   
Moment before redistribution  $M_{bef}=32.5$  kNm per metre width  
Slab containing section being analysed is considered as continuous.  
Design moment (after redistrib.)  $M=32.5$  kNm per metre width  
Characteristic concrete strength  $f_{cu}=35$  N/mm<sup>2</sup>  
Characteristic steel strength  $f_y=500$  N/mm<sup>2</sup>  
Longitudinal reinforcement is high-yield steel.  
Diameter of tension bars  $dia=10$  mm

Minimum nominal cover to all steel is 20 mm  
Nominal concrete cover  $cover=50$  mm  
Overall thickness of slab  $h=250$  mm

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

Effective depth of section  $d=195$  mm

#### Longitudinal reinforcement

As  $M_{bef}=M$ , no redistribution has occurred.  
Thus redistribution factor  $\beta_b$   $\beta_{tab}=1$   
and resistance-moment factor  $K'=0.156$  [Cl.3.2.2.1, Condition (b)].

As applied-moment factor  $K=M*10^6/(1000*d^2*f_{cu})$   
 $=32.5*10^6/(1000*195^2*35)$   
 $=0.02442$

does not exceed resistance-moment factor  $K'$ , no comp.steel is needed.  
and lever arm  $z=d*(0.5+SQR(0.25-K/0.9))$   
 $=195*(0.5+SQR(0.25-0.02442/0.9))$   
 $=189.56$  mm

but must not exceed  $0.95*d=0.95*195=185.25$  mm

i.e. take  $z=185.25$  mm

Area of tension steel required  $A_s=M*10^6/(z*f_y/\gamma_{sS})$   
 $=32.5*10^6/(185.25*500/1.15)$   
 $=403.51$  mm<sup>2</sup>/metre width.

As  $3*d<750$  mm, maximum clear distance between bars  
for tension steel  $maxcl=3*d=3*195=585$  mm, and  
maximum spacing (c.to c.of bars)  $p_{chmx}=3*d+dia=595$  mm

Calculated c.to c.spacing for tension bars  $p_{ch}=1000*PI/4*dia^2/A_s$   
 $=1000*3.1416/4*10^2/403.51$   
 $=194.64$  mm

Office:

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

Round spacing (c.to c.of bars) to 190 mm (rounded).

Chosen spacing of tension bars pch=190 mm

Area of tension steel provided  $Aspr = 1000 / pch * \pi * dia^2 / 4$   
 $= 1000 / 190 * 3.1416 * 10^2 / 4$   
 $= 413.37 \text{ mm}^2/\text{m}$

Spacing and proportion of tension steel (see Clause 3.12.11.2.7)

Tension steel provided  $per = Aspr / (10 * h) = 413 / (10 * 250)$   
 $= 0.1652 \%$  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  $Aspr/bd$ , no check on the spacing of bars is needed [see Clause 3.12.11.2.7(a3)].

Minimum distribution steel required

Min.permiss.steel area (Table 3.25)  $Asmin = 0.0013 * 1000 * h = 0.0013 * 1000 * 250$   
 $= 325 \text{ mm}^2/\text{m width.}$

Diameter of distribution bars  $diamn = 10 \text{ mm}$

As  $3 * d$  does not exceed 750, max.permiss.clear spacing of bars is  $3 * d$  and thus maximum permiss.pitch  $pchmx = 3 * d + diamn = 3 * 195 + 10$

$= 595 \text{ mm}$

Max.pitch for distribution steel  $pchmn = 1000 * \pi / 4 * diamn^2 / Asmin$   
 $= 1000 * 3.1416 / 4 * 10^2 / 325$   
 $= 241.66 \text{ mm,}$

which is O.K. as it does not exceed the limit  $pchmx$  (i.e. 595. mm)  
 $= 240 \text{ mm (rounded)}$

Spacing of distribution bars  $pchDA = 200 \text{ mm}$

Area of dist.steel provided  $Asmpr = 1000 * \pi / 4 * diamn^2 / pchDA$   
 $= 1000 * 3.1416 / 4 * 10^2 / 200$   
 $= 392.7 \text{ mm}^2/\text{m}$

TENSION  
REINFORCEMENT  
SUMMARY

|                          |                           |
|--------------------------|---------------------------|
| Characteristic strength  | 500 N/mm <sup>2</sup>     |
| Diameter of bars         | 10 mm                     |
| Spacing of bars          | 190 mm                    |
| Effective depth          | 195 mm                    |
| Area of steel required   | 403.51 mm <sup>2</sup> /m |
| Area of steel provided   | 413 mm <sup>2</sup> /m    |
| Percentage provided      | 0.1652 %                  |
| Weight of steel provided | 3.24 kg/m <sup>2</sup>    |

DISTRIBUTION  
REINFORCEMENT  
SUMMARY

|                          |                        |
|--------------------------|------------------------|
| Characteristic strength  | 500 N/mm <sup>2</sup>  |
| Diameter of bars         | 10 mm                  |
| Spacing of bars          | 200 mm                 |
| Depth to bar centres     | 185 mm                 |
| Area of steel required   | 325 mm <sup>2</sup> /m |
| Area of steel provided   | 392 mm <sup>2</sup> /m |
| Percentage provided      | 0.1568 %               |
| Weight of steel provided | 3.08 kg/m <sup>2</sup> |

Office:

Check on span/effective-depth ratio

|                                 |                                                                                                                                                      |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Calculate redistribution ratio  | $b_{tab} = M/M_{bef} = 32.5/32.5 = 1$                                                                                                                |
| Basic ratio for slab            |                                                                                                                                                      |
| continuous at one edge          | $b_{s'd} = 23$<br>(interpolated from Table 3.9)                                                                                                      |
| Area of tension steel provided  | $A_{spr} = 413 \text{ mm}^2$                                                                                                                         |
| Service stress in this steel    | $f_s = 2 \cdot f_y \cdot A_s / (3 \cdot A_{spr} \cdot b_{tab})$<br>$= 2 \cdot 500 \cdot 403.51 / (3 \cdot 413 \cdot 1)$<br>$= 325.67 \text{ N/mm}^2$ |
| As applied-moment factor        | $M'_{bd2} = M \cdot 10^6 / (1000 \cdot d^2)$<br>$= 32.5 \cdot 10^6 / (1000 \cdot 195^2)$<br>$= 0.8547$                                               |
| From equation 7                 | $modf1 = 0.55 + (477 - f_s) / (120 \cdot (0.9 + M'_{bd2}))$<br>$= 0.55 + (477 - 325.67) / (120 \cdot (0.9 + 0.8547))$<br>$= 1.2687$                  |
| Mod.factor for tension steel    | $modf1 = 1.2687$                                                                                                                                     |
| Mod.factor for no comp.steel    | $modf2 = 1.0$                                                                                                                                        |
| Maximum permissible             |                                                                                                                                                      |
| span/effective-depth ratio      | $p_{s'd} = b_{s'd} \cdot modf1 \cdot modf2 = 23 \cdot 1.2687 \cdot 1$<br>$= 29.18$                                                                   |
| Effective span of slab          | $span = 2.5 \text{ m}$                                                                                                                               |
| True span/effective-depth ratio | $a_{s'd} = 1000 \cdot span / d = 1000 \cdot 2.5 / 195$<br>$= 12.821$                                                                                 |
| As this does not exceed         | 29.18, this is Acceptable.                                                                                                                           |

No 81