19-21 THE CORSO MANLY
DESIGN CALCULATIONS
SECTION 1.0

- REVIEW OF EXISTING DESIGN LOADS

- REVIEW OF DESIGN LOADS DURING CONSTRUCTION

- COMPARE OVERALL PRESSURES ON SOIL OVER SEWER CULVERT

- SEE ADDITIONAL ATTACHMENTS WITH PRINTOUT OF REPORT FROM MICROSTRAN

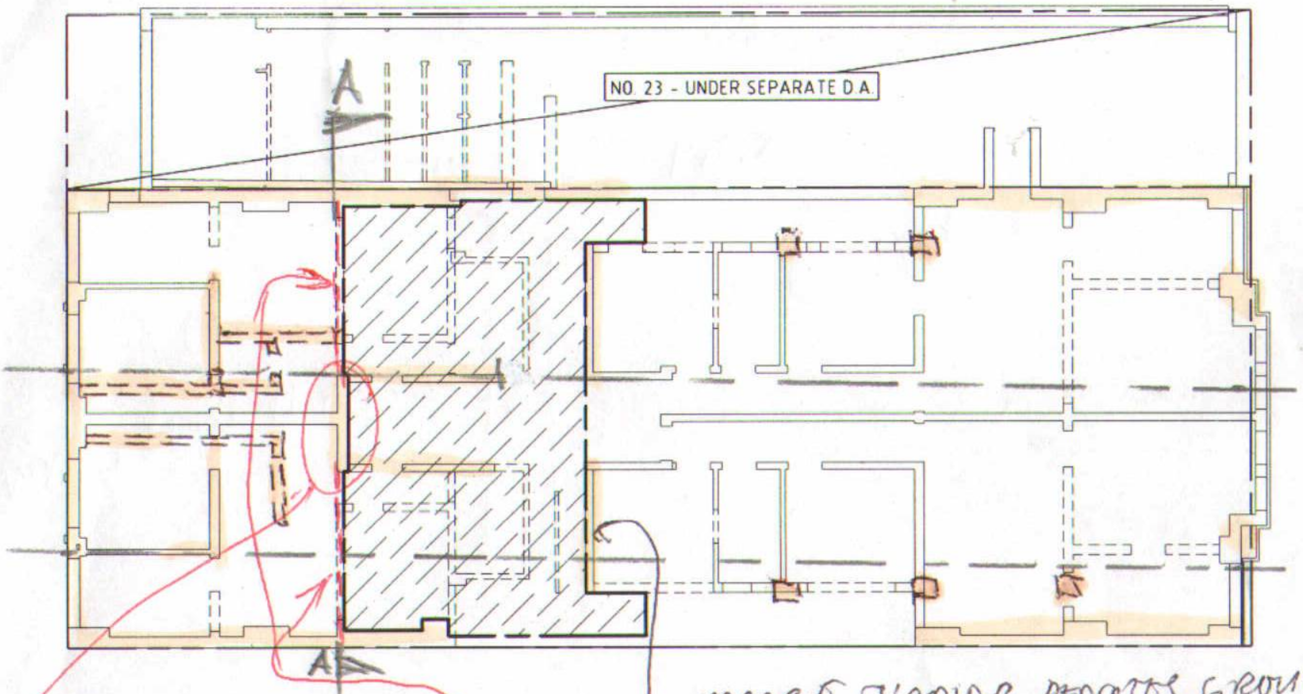
SECTION 2.0

ANALYSIS & DESIGN OF FOOTINGS & LOADS ON PILES.

BY SIMON WADDINGTON
WADDINGTON CONSULTING PTY LTD

28/02/2020

Swaddington.



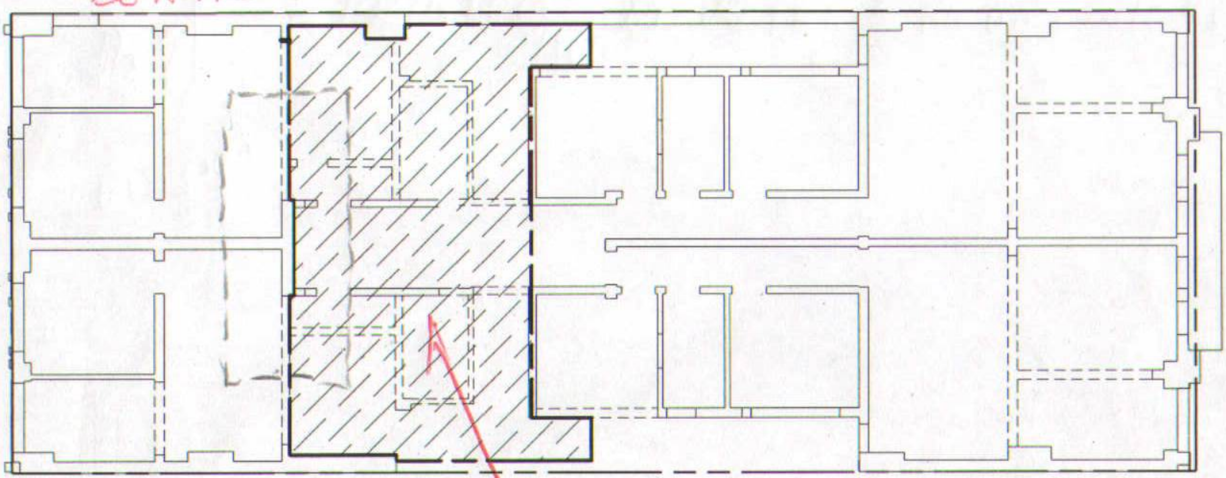

## FIRST FLOOR PLAN

SCALE 1:200

CRITICAL WALL OVER SEWER WITH NEW BEAMS

NEW BEAMS

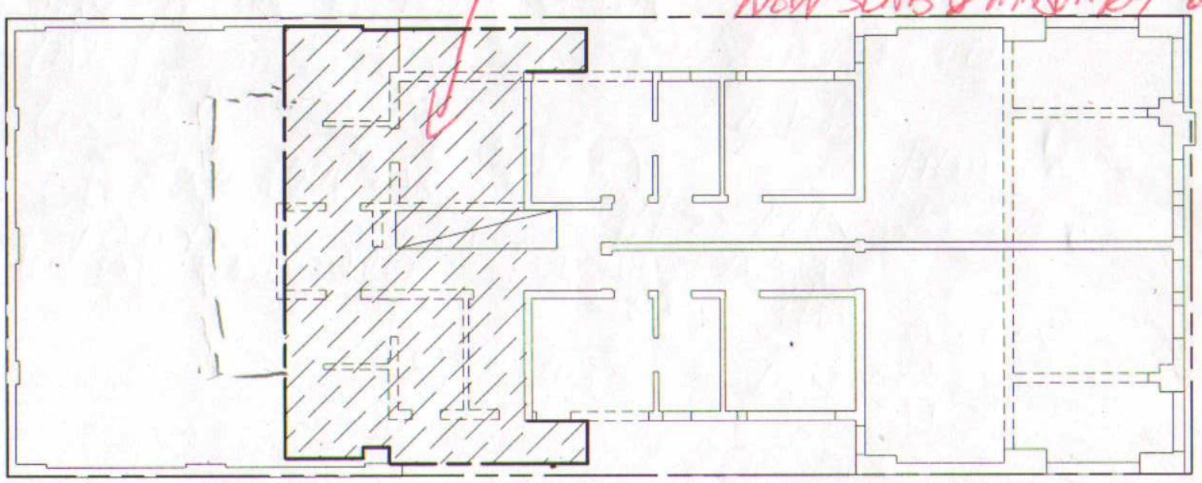
ORANGE SHADING DENOTES GROUND FLOOR WALLS & COLUMNS TO REMAIN



## SECOND FLOOR PLAN

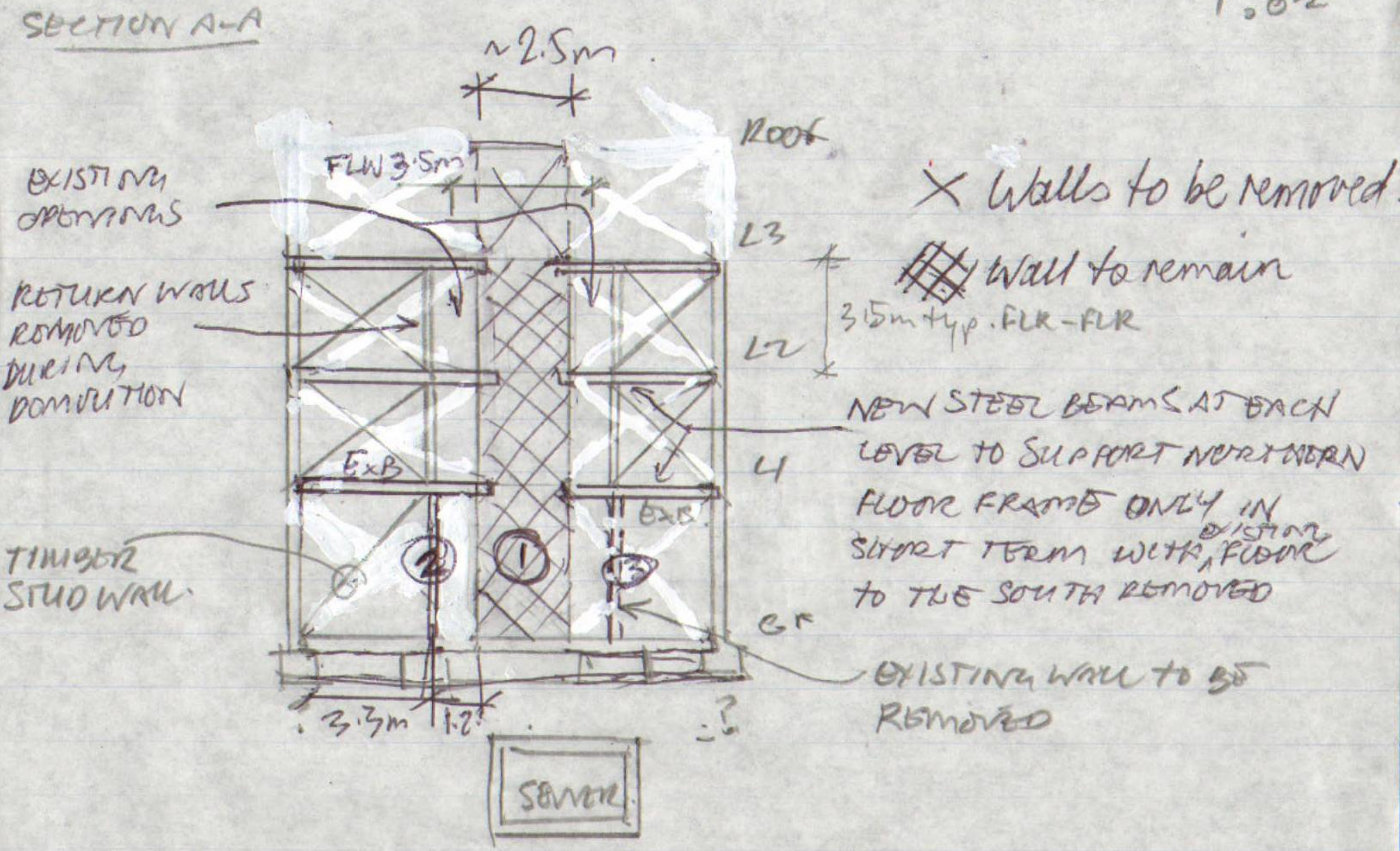
SCALE 1:200

SHADED AREAS GENERALLY ALL MASONRY WALLS & SLABS REMOVED & REPLACED WITH TIMBER FRAMING NEW SLAB & MASONRY ON NEW PILED FTGS



## THIRD FLOOR PLAN

SCALE 1:200




## SECTION A-A – NORTH END WALL OF MAIN INTERNAL STAIR

① Determine design loads over the 2.5m length of wall that remains at north end of stair well/landing

| | | |
|---|---|---|
| ROOF – 0.4kPa × 1m × 2.5m | = 1.5kN | = 208.8kN |
| WALL OVER L3 – 0.23m × 22kN/m³ × 2.5m × 3.5m | = 44.3kN | |
| L3 – Trafficable roof, timber frame, pebbles = 1.2kPa × 1.8m (FLW) × 3.5m | = 7.6kN | |
| L3 – Ignore roof live loads as negligible | | |
| L2-L3 – walls – brick 230 thick = 0.23m × 22kN/m³ × 2.5m × 3.5m | = 38kN | |
| L2 Floor = 0.6kPa × 3.5m × 1.8m FLW | = 3.8kN | |
| " " Live = 1.5kPa × 3.5m × 1.8m | = 9.4kN | |
| L1-L2 walls – as above | = 38kN | |
| L1 floor – as L2 – dead | = 3.8kN | |
| live | = 9.4kN | |
| GF to L1 wall – 0.23m × 22kN/m³ × 2.5 × 4.2m | = 53kN | |

Total load on footing carried over = 208.8kN.

Plus party wall load that separates the units L1 to u/s L3

= 0.7m × 0.23m thk × 7m × 22kN/m³ = 24.8kN

234kN

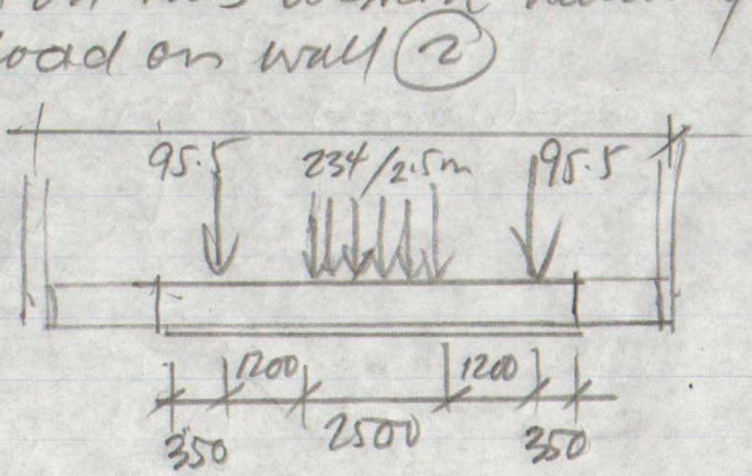
(2) Determine load on ground floor hallway wall that will remain

Floor load width above existing beam 8×8 = 3m (L1, L2, L3)

| | | |
|---|---|---|
| Level 3 roof | 3m × 1.2kPa × 4.5m | = 8.1kN |
| L2 to L3 wall | 2.25m × .11 × 22kN/m² × 3.5m | = 19 kN |
| L2 floor dead | 0.6kPa × 3m × 2.25m | = 4 kN |
| " " live | 1.5kPa × 3m × 2.25m | = 10.1kN |
| L1 to L2 wall - as L2-L3 | | = 19kN |
| L1 floor dead | | = 4kN |
| " " live | | = 10.1kN |
| Ground to L1 wall | 4.2m × 1m × .23 × 22kN/m³ | = 21.2kN |
| | | 95.5kN |

(3) Load on this western hallway wall same as load on wall (2)

= 95.5kN




Conservatively assume boundary walls independent to internal strip.

Beam on elastic springs to determine bearing pressures

Assume existing strip footing 400×400 RC.

Loose sand modulus of subgrade reaction

4800 to 16000 kPa per mm deflection
(from J.E. Bowles, Foundation Analysis & Design Table 9.1)

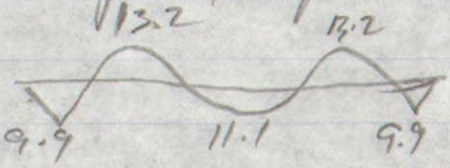
For modelling purposes try springs supports @ 400 cts.

Spring restraints 0.4×0.4×4800 = 768 kN/m
Say 750 kN/m lower bound

& 0.4×0.4×16000 = 2560
Say 2500 kN/m upper bound.

— Use Microstran model.
FILE → 11401 – EXFTG – 1.msw

Lower bound spring → uniform deflection ≈ 38mm
k = 750 kN/m →



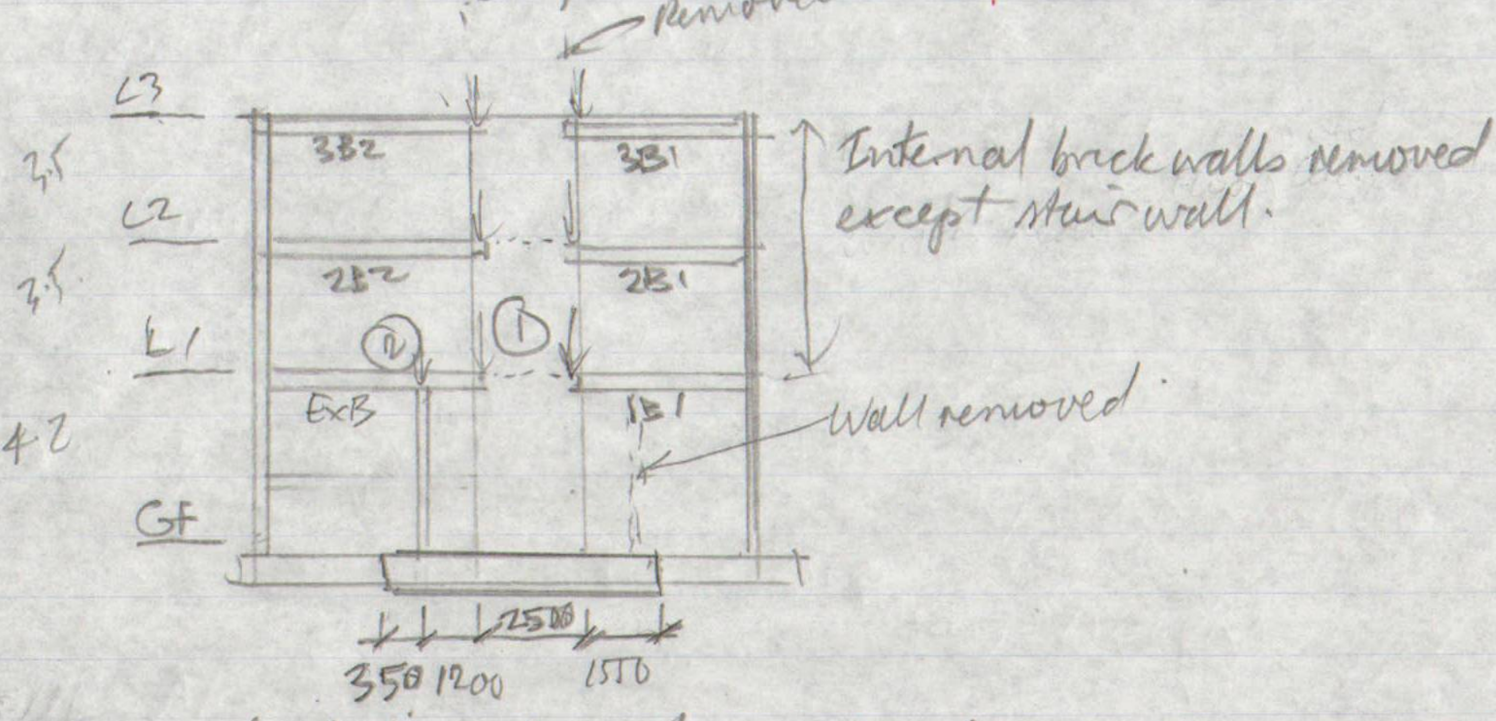

BMD

→ Support reactions fairly uniform 28.3 & 28.4 kN

→ Equivalent to $28.4 / (0.4 \times 0.4)$ ≈ 178 kPa

Upper bound soil spring k = 2500 kN/m

Deflection fairly uniform ≈ 11mm.
Bending moment fairly similar to above.
Support reactions very slight change 28.29 to 28.53 kN
178.3 kPa → negligible change




Using full design working loads.

(1) TOTAL LOAD ON 2.5m WALL

Level 2 & Level 3 loads entirely on centre 230x2500 wall

Floor removed south of this wall.

Use full residential live load although likely less.

L3 floor - 1.8m x 7m x 1.2kPa (pebbles) = 15.1kN
 - " " x 1.5kPa. live) = 18.9kN

L2 floor - 1.8 x 7m x 0.6kPa (dead) = 7.6kN
 - 1.8 x 7m x 1.5kPa (live) = 18.9kN

L1 floor - 1.8 x 5.3 x 0.6 (dead) = 5.7kN
 " " 1.5 (live) = 14.3kN

Wall GF to L3 - 0.23m x 22kN/m³ x 2.5 x 11.2m = 142kN

222kN

TOTAL UDL UNDER WALL /2.5m 89kN/m.

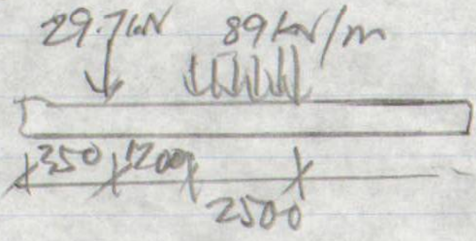
(2)

L1 floor 2.25m x 1.8m x (0.6+1.5) kPa = 8.5kN
GF to L1 wall 0.23m x 22kN/m³ x 4.2 x 1m = 21.2kN

29.7kN

Microstran model footing on springs -

LOAD CASE 2 - Post demolition & beams installed.




→ Firstly with lower bound springs k=750kN/m

Deflection varies 27mm to 14mm. 

BMD 

77.6kNm

400 x 400 cracking moment $M_{cr} \simeq 0.6 \times \sqrt{25 MPa} \times .4 \times .4^2 / 6$

$= 32 kNm$.

Support reactions - more significant variation due to assymetric loading

Max. 19.7kN = 123kPa

Upper bound soil spring

Deflection varies 3mm to 8mm

Max. bending moment 67.2kNm

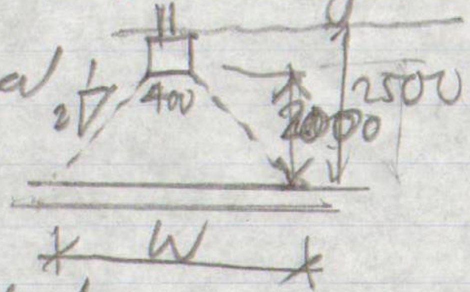
Max reaction 20.4kN = 128 kPa bearing pressure

Therefore removal of upper walls & part of floor has reduction in bearing pressure ~ 50kPa assume 400 wide footing.

At top of sewer culvert 2500mm below ground.

Conservatively distribute vertical load at 2V to 1H.

Width W at sewer = 2400

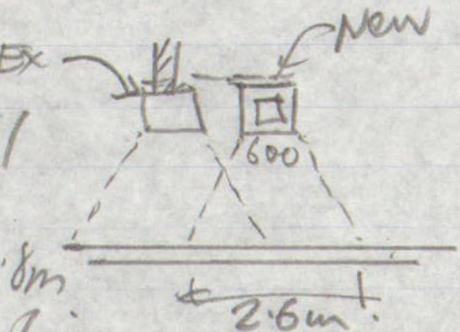



∴ Pressure on culvert estimated

| | | |
|---|---|---|
| Soil weight | $2.5m \times 15 kN/m^3$ | 37.5 kPa. |
| Footing existing | $178 kPa \times \frac{0.4}{2.4}$ | 29.7 kPa. |
| Footing after demo. | $128 \times \frac{0.4}{2.4}$ | 21.3 kPa. |

Dig out trench for new concrete footing beam adjacent to the footing for the stair end wall

Additional weight of concrete compared with soil




$P = (24.5 kN/m^3 - 15 kN/m^3) \times .6m \times .8m$

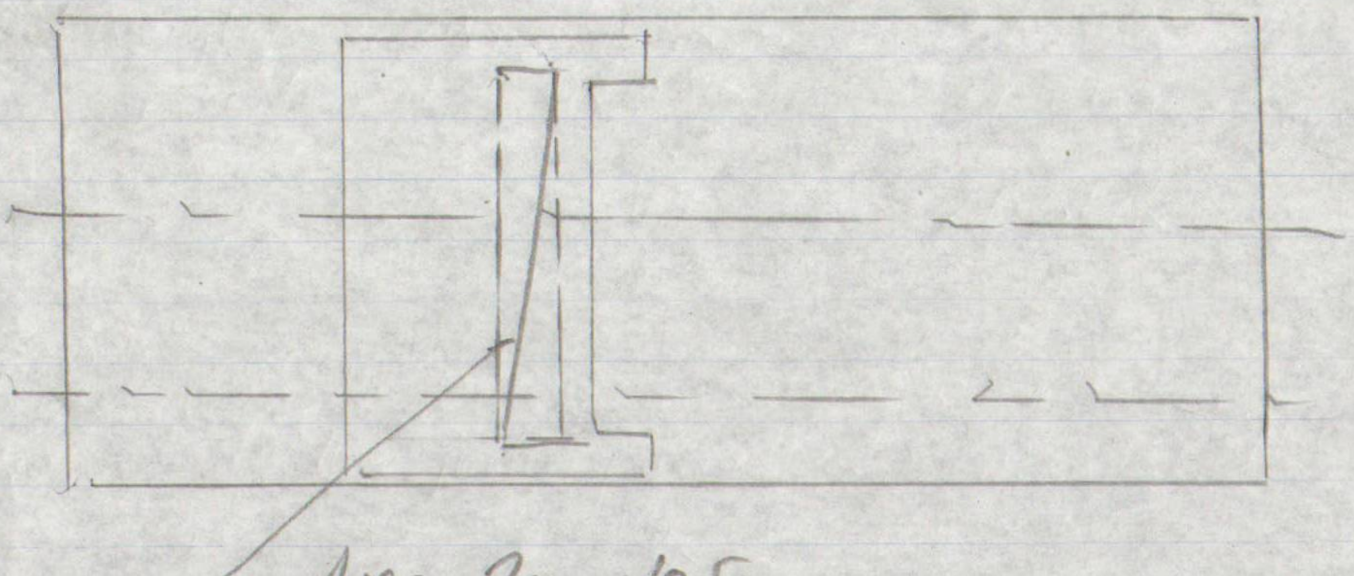
$= 4.6 kN/m$ length of footing

Additional pressure on sewer < 2kPa

- Consider area south of existing stair well.
- Demolish from top down & remove all walls & floor in level 1, 2, 3 & roof.

Consider total loads removed over floor area shown below that are above new concrete beam.

→



Area 2m x 10.5m.

Compare construction loads with current full design load.

| | | |
|---|---|---|
| Roof sheeting & frame | 0.4 kPa | 10.7 kPa |
| Level 3 floor frame + live | 2.1 kPa | |
| Level 2 " " " | 2.1 kPa | |
| Level 1 " " " | 2.1 kPa | |
| GF slab 100 thick + live | 4 kPa | |

Total walls removed in this area from level 1 to roof

$8m \times (3.5+3.5+3.5) \times 0.13 \times 22 kN/m^3 = 240 kN$

Equivalent pressure of walls over this area

$240 / 2 \times 10.5 = 11.4 kPa$.

Total equivalent pressure at ground level of existing structure to be removed.

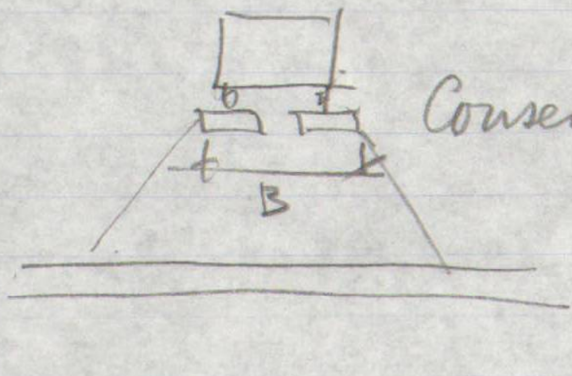
$10.7 \times 11.4 = 22.1$ kPa

Cut out soil for new concrete footing

Additional load of wet concrete (24.5 kN/m³) compared to soil (15 kN/m³) 800mm deep.

$(24.5-15) \times 0.8\,m = 7.7$ kPa. $\ll 22.1$ kPa.

Installation of screw piles – 5T excavator. ≙ 50kN




Conservatively 1.8m×1.8m area.

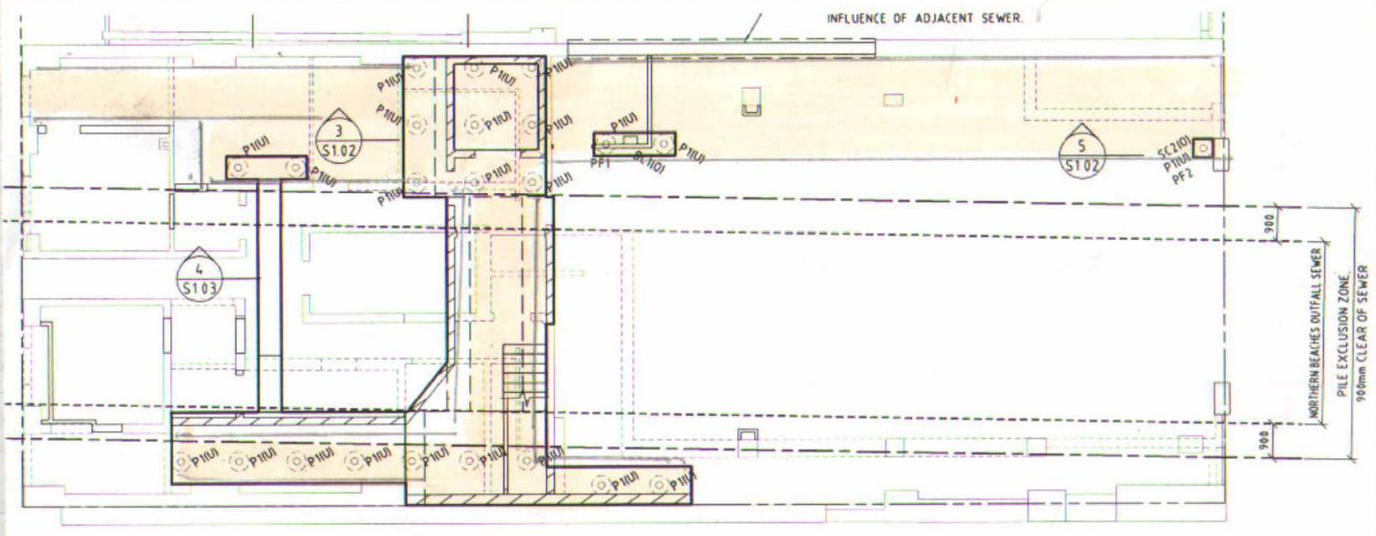
$50/1.8^2 = 15.4$ kPa at ground level.

$< 22.1$ kPa.

Limit area for screw pile installation as shown below, where upper floors & walls demolished or not over sewer.

After screw piles & concrete beams installed all new additional masonry walls & slab supported by piled footings below line of influence.

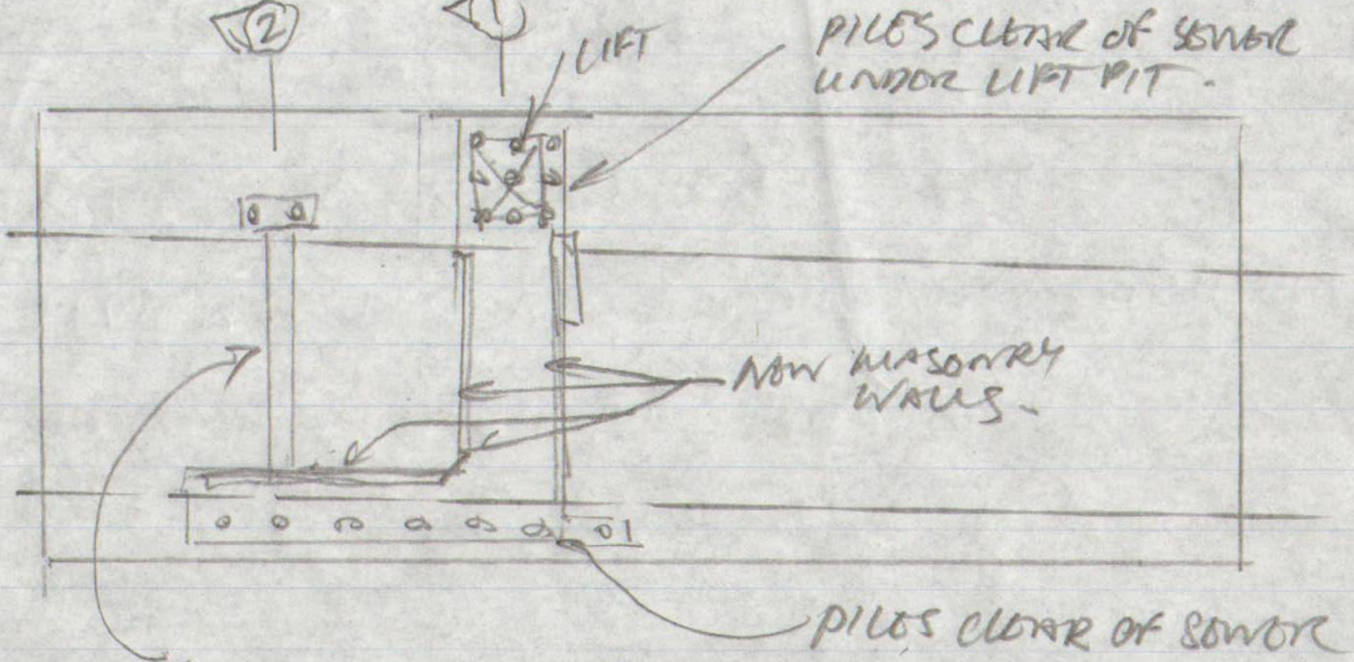
1.10




GROUND FLOOR & FOOTING PLAN
SCALE 1:100

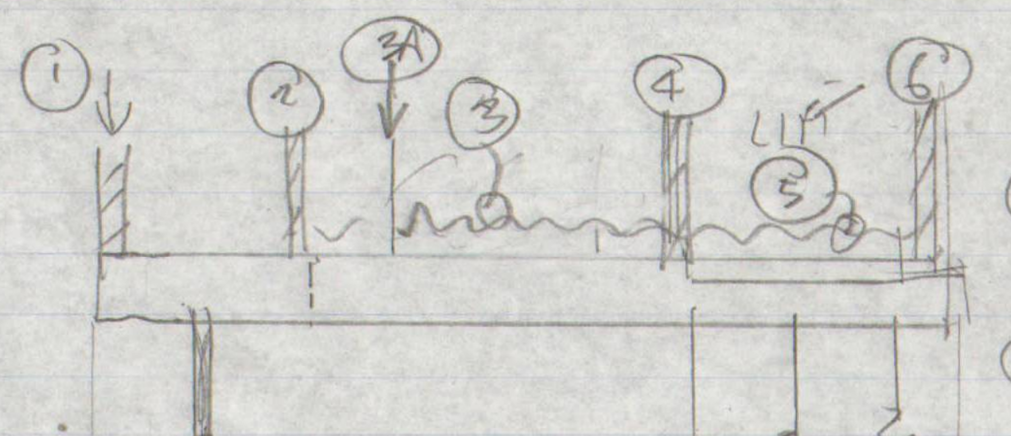
DENOTES AREAS TRAVELLED BY 5T EXCAVATOR

DESIGN NEW RC FOOTING ON PILES.

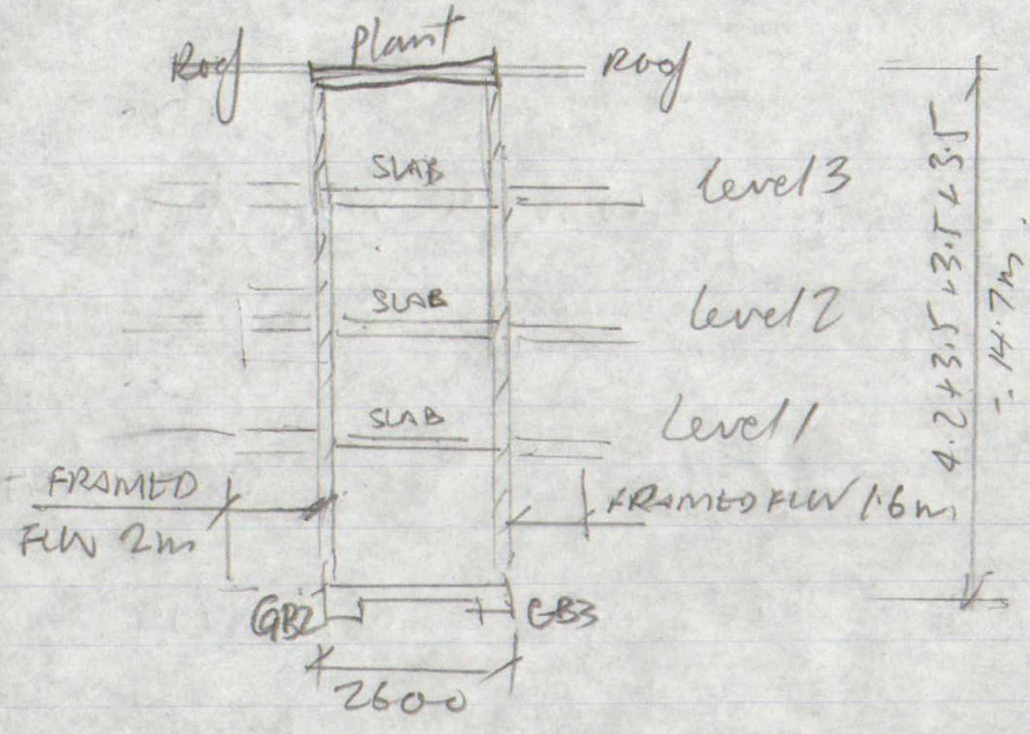



BEAM TO RECTIFY
ECCENTRICITY OF NEW WALLS
TO PILES UNDER THAT NEED TO BE CLEAR OF THE SEWER

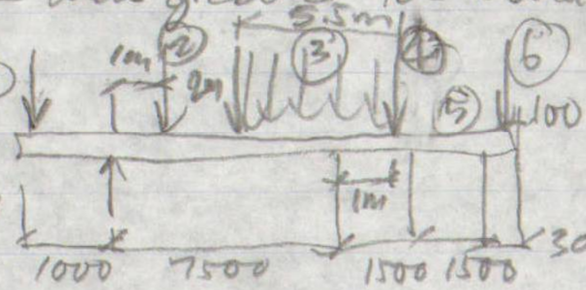
SECTION (1) — LIFT & STAIR WELL BEAM.




(1) Blockwall + stair
(2) Ground floor wall only
(3) Blockwall full height + landing slabs + timber floor
(3A) Concentrated load from stairs on edge of landing
(4) – (6) Lift walls
(5) Wall inc + timber floor




Design as a raft slab in two with two edge beams. Northern edge beam has greater load width




Determine loads.

(1) Blockwall 2.5m × 14.7 × .2 × 22 kN/m³
= 162 kN

Stair slab (3 levels)
3 × 2m × 1m × 6kPa. = 36kN

Stair live 3 × 2m × 1m × 2kPa = 12kN

Stair wth wall spanning over hallway on GF
3.4m/2 × 12.5 × .2 × 22 = 94 kN

Floor load over hallway
Dead. 3 floors × 0.6kPa × 1.7m × 2m = 6kN
Live " 1.5kPa × " × " = 15.3kN

(1) = 334 kN

(2). Wall over hallway 94kN
Floor load Dead 6kN
Live 15kN
GF hallway wall
2.5m × 4.2 × .2 × 22kN/m³ = 46kN

(2) 161kN

(3A) Stair slab load @ top landing over 3 floors
dead 36kN
live 12kN
} 48kN

(3) UDL

Wall 14.7m × .2 × 22 kN/m³ × = 64.7kN/m
Floor dead (2m × .6 + 1.3 × 4 kPa) × 3
" + 1.3m × 5 kPa. = 26.2kN
Floor live (2m × 1.5 + 1.3m × 2 kPa) × 3 + 1.3 × 5 = 23.3kN/m
} 114.2kN/m

(4) Lift wall 1m × 14.7 × .2 × 22kN/m³ 65kN

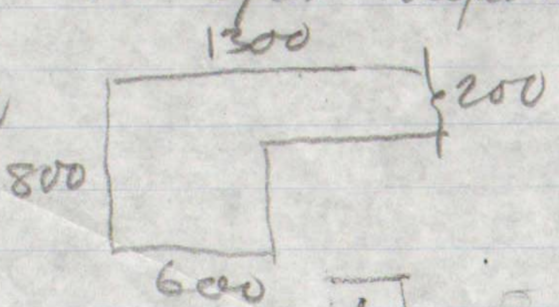
(5) Timber frame floor + wall.
UDL Wall = 64.7
Floor dead. 2m × .6 × 3 + 1.3 × 5kPa 11.1
" live 2m × 1.5 × 3 + 1.3m × 5kPa 15.5
} 91.3kN/m

(6) Wall only 64.7 kN/m × 1.3m 84.1 kN

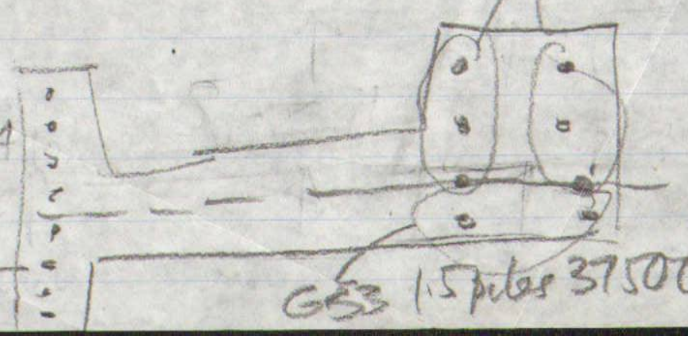
→ Use microstran model to assess deflections and influence of pile deflection on pile loads and bending moments.

Pile spring 150 kN / 6mm deflection = 25000 kN/m per pile

Try section

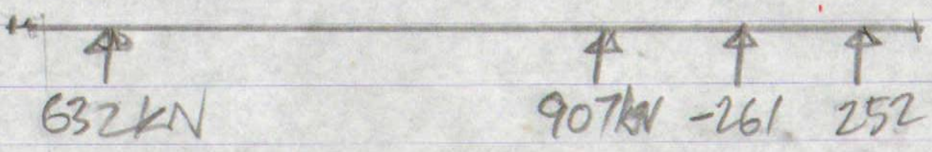



SPRINGS
GB2 = 4 piles k = 100000 kN/m
GB3 = 4 piles

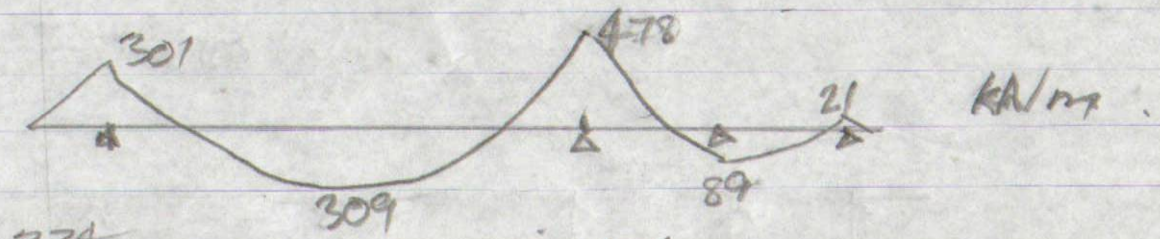


## Support reactions GB2

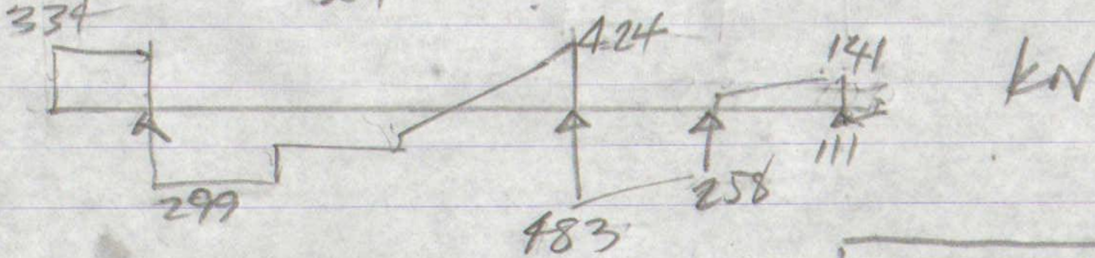
File 11401-raftslab GB2




BMD*




SFD*

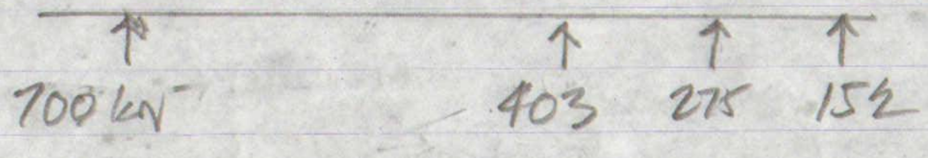



*NOTE THESE ARE WORKING LOADS NOT ULTIMATE

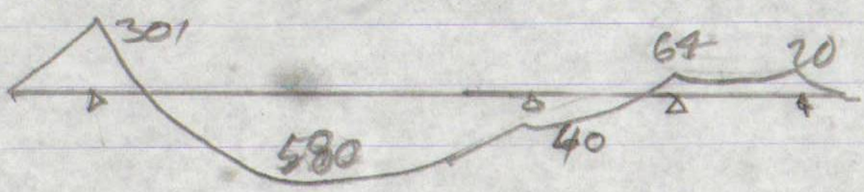
## SPRING SUPPORTS - GB2

File 11401-raftslab GB2-spring

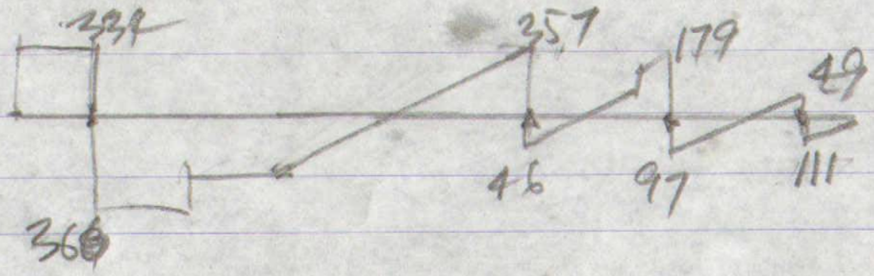
Reactions



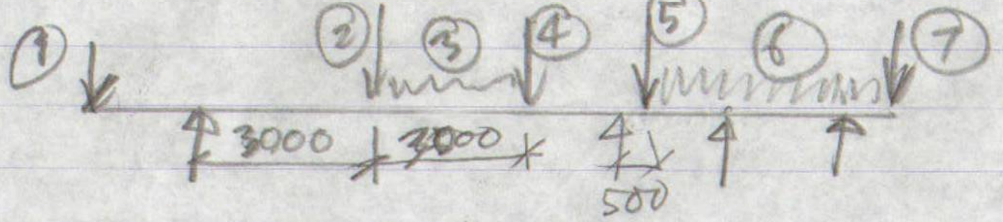

BMD*




SFD*



**GB3** SOUTH EDGE BEAM OF STAIR/LIFT LOBBY RAFT SLAB
SAME GEOMETRY AS GB2 BUT REDUCED LOADS.




(1) RC Block wall + stair slab.

Wall (1.3m + 3.5m) x 14m x .2 x 22kN/m³ = 295kN
Stair slab 3 x 2.0m x 6kPa x 1m — 36 kN
live 3 x 2.0m x 2kPa x 1m — 12 kN

**343kN**

(2) Stair @ landing slab — 36 kN
live — 12 kN
Framed floor 1.8m x 0.6 kPa x 2m — 2.2
1.8m x 1.5 kPa x 2m — 5.4
RC column 0.6 x .2 x 24.5 x 14m — 42
Existing brick wt
1m x .23 x 22kN/m x 3.5 x 3 — 53kN

**151kN**

(3) UDL Dead. (1.8m x 0.6) x 3 flrs + 1.3m x 4.5 kPa x 4/0
= 26.6kN/m
Live 1.8 x 1.5 x 3 + 1.3 x 2kPa x 3
+ 1.3 x 5kPa. = 22.4kN/m
GF wall 3.5m x .2 x 22kN/m³ = 15.4

64.4kN/m

(4) Extg brick wall — 53kN
Slab point load.
1m x 4.5 x 1.3m x 4 — 23.4kN
live 1m x 2kPa x 1.3m x 3 + 1m x 1.3m x 5kPa — 14.3 kN

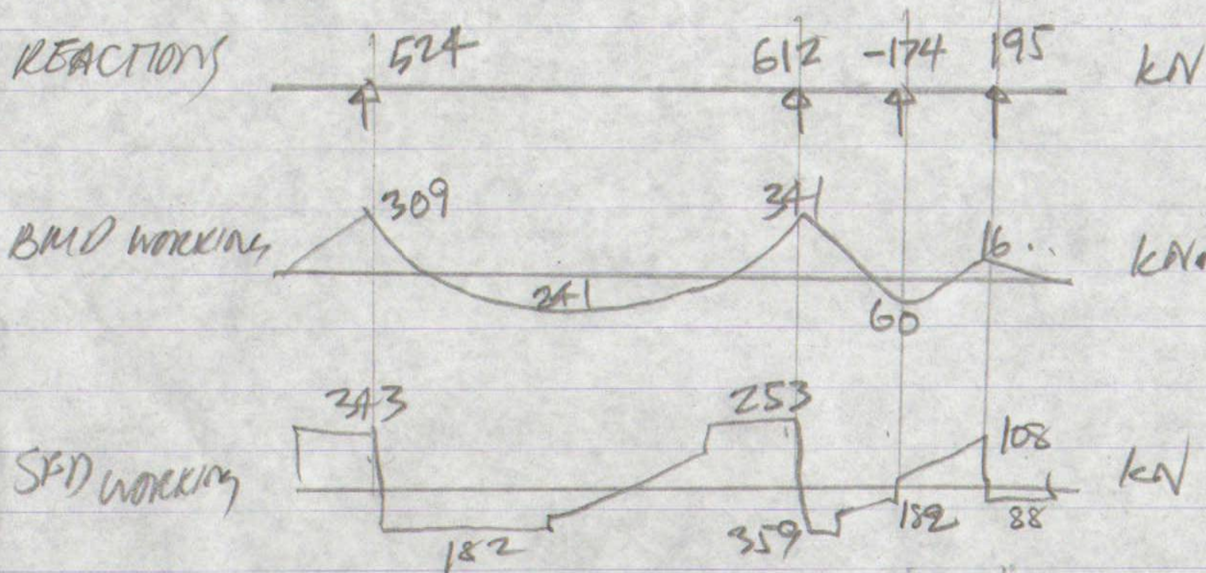
90.7kN

(5) Slab point load dead. 23.4 kN
live 14.3 kN
lift frontwall 1m x .2 x 22 x 14 62 kN } 100 kN

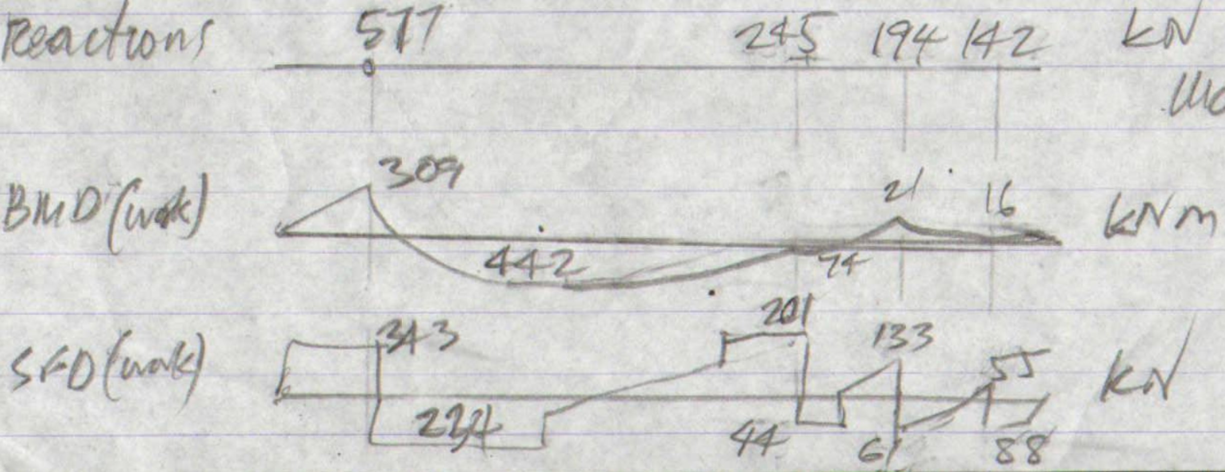
(6) lift wall UDL 64.7 kN/m
Plant slab. 1.3 x 4.1 kPa 5.9 kN/m
" live 1.3 x 5 kPa 6.5 kN/m } 77 kN/m

(7) lift (eastern) wall 64.7 kN/m 64.7 kN/m

Fixed supports (GB3)

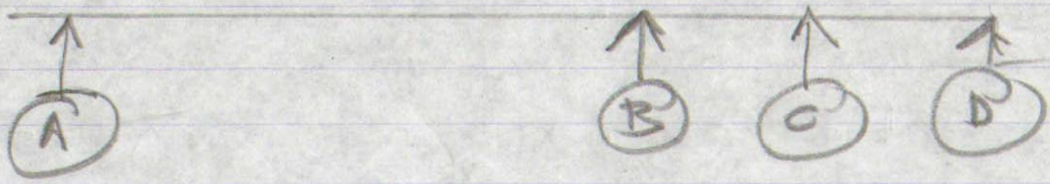



SPRING SUPPORTS




Max Δ = 8.1 mm

Add support reactions for GB2 & GB3




(A) = 700 + 577 = 1277 kN / 8 piles = 160 kN / pile

(B) = 403 + 245 = 648 / 4 = 162 kN / pile

(C) 275 + 194 = 469 / 4 = 118 kN / pile

(D) 152 + 142 = 294 / 4 = 74 kN / pile

Reducing number of piles on C & D would reduce spring stiffness & put more load on (B)

Wet self weight of concrete not included as poured on existing ground & allowed for in bearing pressures over sewer.

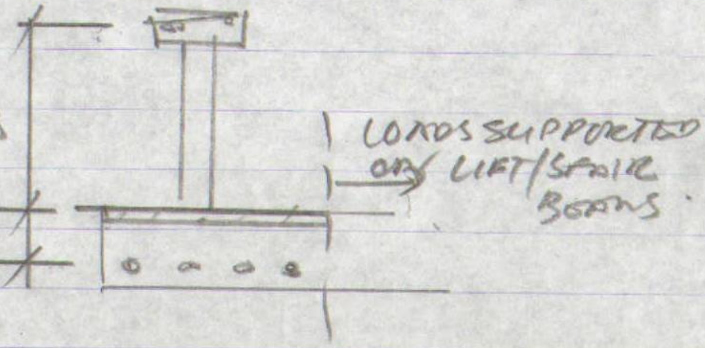
However, the raft slab self weight will be included in its ultimate limit state design if sand settles.

Note no short term live load reduction factor used here either.

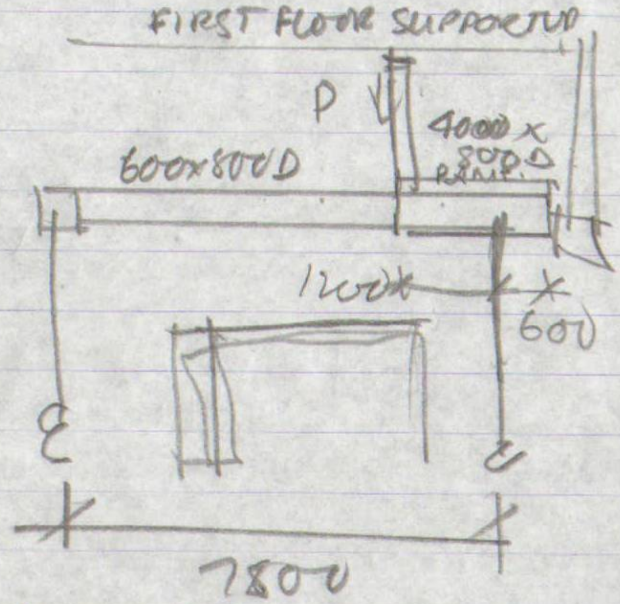
→ USE 160 kN SWL piles

# BEAM GB4

This beam is essentially to rectify the eccentricity of the RC block wall for the hallway running from Market lane to the stair/lift lobby.




PLAN




$P = 4.2 \times 0.2 \times 22\,kN/m^3 = 18.5\,kN/m$
$\times 5m$ long $= 93\,kN$

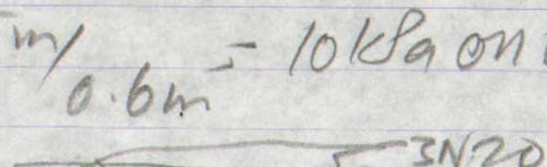
Extra deadload from GB4 + ramp
$(0.8 \times 24.5 + 3\,kPa) \times 5m = 113\,kN/m$
Live $5m \times 4\,kPa$. $= 20\,kN/m$.

Design using RAPT with self weight included.

Assume footing supports 1500 wide hallway floor

Ground floor $4\,kPa \times 1.5m / 0.6m = 10\,kPa$ on 600 wide

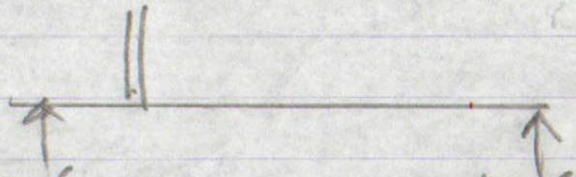
600 x 800 Deep. → Rapt –




→ $\Delta = 14mm$

Reduce Δ add bars.
→ Use 6N20 top & btm + N12 stirrups. $\Delta = 8.5mm$ / OK.

<u>Beam GB1</u>



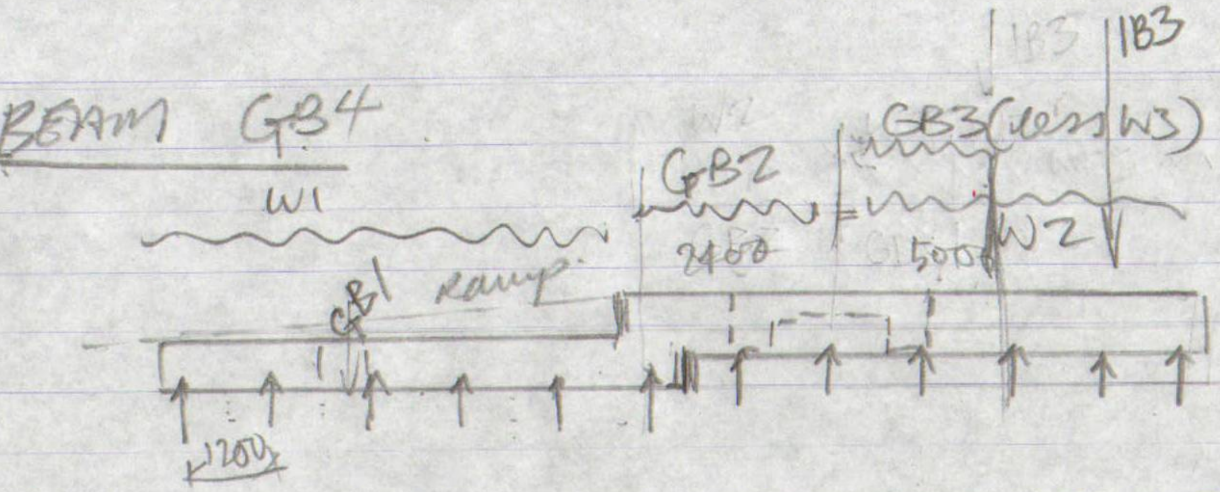
Reactions

| | |
|---|---|
| 50.6 | 50.6 |
| 61.6 | 28.4 |
| 210.2 | 88.2 |
| 322.4 kN | 167.2 kN + pile cap. |

→ 3 piles    2 piles

Refer RAFT Report 11401-FTG BEAM GB1-rept.pdf.

## BEAM GB4




Model without the step for simplicity

W1 = load from RC block wall = 18.5 kN/m

Additional dead load from ramp & finishes 3kPa × 2m — 6 kN/m

+ live load 2m × 4kPa — 8 kN/m

**33 kN/m**

Add GB1 self weight & live load.

Dead: 12kN/m × 3.9m 47kN

Live 4kPa × 1.5m × 3.9m 24kN ] **71 kN**

GB2 load from GB2 reaction over 2.5m. 700 kN/2.5 = **280 kN/m**

W2 = end wall load from GB3 distributed over 5m

343 kN (p. 2.05) / 5m = **68.6 kN/m**

GB3 (less W3) (577 − 343) / 1.5m = **156 kN/m**

Beam IB3 − reaction SLS − **192 kN**

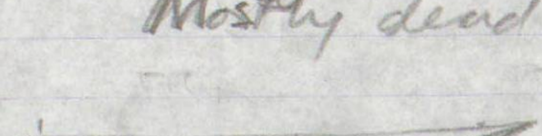
→ Footing beam generally 2000 wide × 800 deep

→ High pile loads → no room to add extra piles except in south end

- Raft slab actually has integral RC block wall over.
- Input element as 4m high × 0.2m wall (ignore beam for now)
- Plus add extra pile
- Wall stiffness distributes load more evenly

Max reaction 150kN Use Pile SWL = 160kN

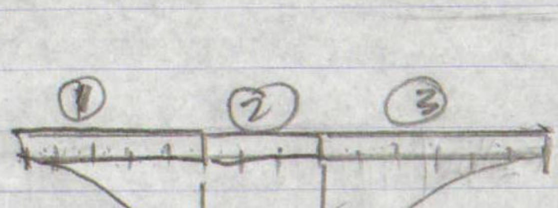
GB4 - Conservatively design ftg for forces from analyses with wall stiffness included. Mostly dead load but use factor 1.35 (ULS) conservatively




$M^* = 1583 \times 1.35 = 2137$ kNm.

$1.2M_{cr} = 1.2 \times .6/\sqrt{32} \times 800^2 \times 2000$

$= 869$ kNm




① 2000 × 800, d = 720

20N20 BTM = $\phi M_u = 1715$ kNm

$V^*_{max} = 352$ kN

$\phi V_{uc} = 803$ kN @ support.

$\phi V_{umax} = 9216$ kN

② 2400 × 800

24N20 $\phi M_u = 2084$ kNm

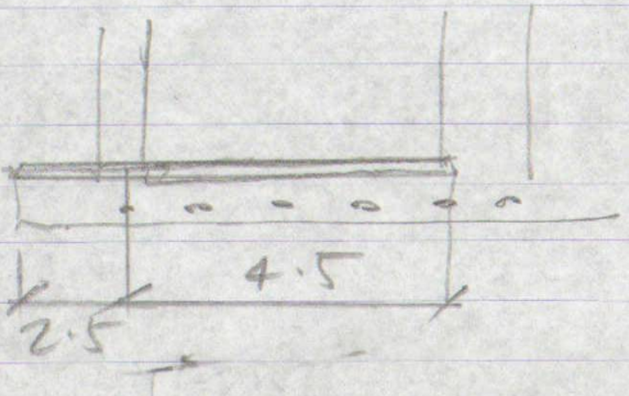
25N20 " = 2166 kNm

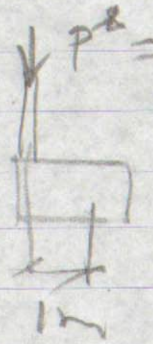
$V^* = 452$ kN

$\phi V_{uc} = 1231$ kN @ < d from support.

③ 1000 × 800 $M^* = 2024$ kNm 14N28 $\phi M_u = 2100$ kNm

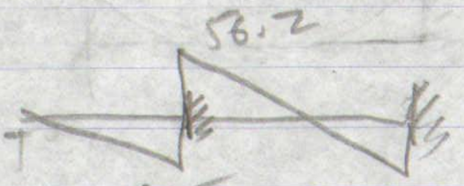
Check torsion of GB4 in between GB1 & GB2 & beyond GB1




$P^* = 1.35 \times 4.2 \times .2 \times 22$
$= 25\ kN/m$.
$t = 1m \times P$
$= 25\ kNm/m$

TMD




$T^* = 62.5\ kNm$.

$\phi T_{umax} = 0.7 \times .2 \times 32 \times 2000 \times \frac{800^2}{3} E{-6}$
$= 2867\ kNm$

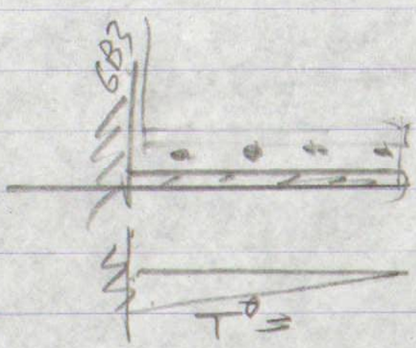
$\frac{62.5}{2867} + \frac{385}{9216} << 1$.

$\phi T_{uc} = 0.7 \times .3\sqrt{32} \times 2000 \times \frac{800^2}{3} E{-6} = 507\ kNm$

$0.25 \phi T_{uc} = 127\ kNm \geq 62.5\ kNm$ no torsion req.

<u>Beyond GB3</u>

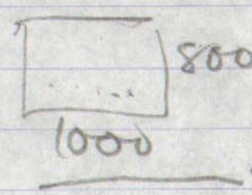
– Denote GB5




$t = 68.6\ kN/m \times 0.35m$
$= 24.0\ kNm/m$

$T^* = 1.35 \times 24.0 \times 4m$
$= 130\ kNm$

Footing




At End of GB3

$\phi T_{uc} = 253\ kNm$

$V^* = 194\ kN$

$\phi V_{uc} = 506\ kN$

$\frac{130}{253} + \frac{194}{506} = 0.9 > 0.5$

Need torsional fitments for south end of beam

$\phi T_{us} \geq T^* = 130 kN/m$.

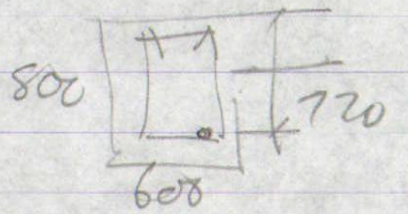
$A_{sw}/s \rightarrow 130E6 / 0.7 \times 500 \times 2 \times 640 \times 840$
$= 0.345$
$= 86 mm^2 @ 250$ N12-250 closed ties

Longitudinal reo $0.5 \times 500 \times 0.345 \times ((640+840) \times 2)$
$= 255 mm^2$ each corner $= 570$ extra in btm

→ Needed 14N28 bending → 15N28 total btm.

## Ultimate limit state design of GB2 & GB3.

From microstran $M^*_{+ve} = 1.35 \times 580\text{kNm}$
$= 783\text{kNm}$.




$1.2M_{cr}$ (600x800) = 260kNm

Try 5N28 btm $\phi M_u = 893\text{kNm}$
$> M^*$

Top $M^* = 1.35 \times 310 = 420\text{kNm}$

4N20 + 2N16 top $A_{st} = 1640\text{mm}^2$ $\phi M_u = 472\text{kNm}$
$> M^*$

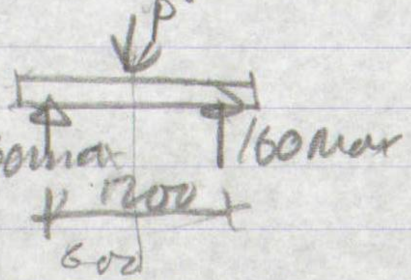
Shear. $V^*_{max} = 360\text{kN}$

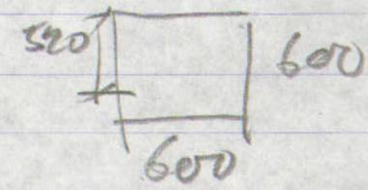
$\phi V_{uc} = 357\text{kN}$

$\phi V_{u\,min} = 539\text{kN}$ provide min shear steel.
→ N12-250 stirrups

Footing PF1

Simplistically




$P^*_{max}$

$= 320 \times 1.35 = 432kN$

$M^* = 432 \times 1.2m / 4 = 130kNm$

$1.2M_{cr} = 146kNm$.

4N20 Btm $\phi M_u = 251kNm$

$\phi V_{uc} = 227kN$

$V^* = 216kN$

$\phi V_{umax} = 358kN$

Provide min shear ties N12-250 stirrups.