DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Financial and Structural study of the advantages of using Autoclaved Aerated Concrete AAC

vs Clay bricks

Project

BO-SANDS

BUILDING TYPE: 2 C

Owner

MAXIM

STRUCTURAL DESIGN:-

DELTA BUILDING SYSTEMS
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SANDS

- **Introduction:-**

DELTA BLOCK

DELTA Block are solid unreinforced Autoclaved aerated concrete AAC with a dry density of 550 kg/m³ . Blocks are available in a 200mm course height and are all 600mm long. Thicknesses of 100, 120 , 150, 200, 250, 300, 400 mm are available.

The blocks are glued together with DELTA MORTER Adhesive to form solid masonry walls OR can Glued together by ordinary MORTER (350 kg cement/m3 sand).

The normal finish for DELTA block walls Either to use a normal a conventional finishing layers or to use our system adding more economical and technical values to the project (separate study for the wall finishing layers can be presented if requested) is to render them with DELTA STUCCO A AND DELTA STUCCO B Render, which is trowelled on in two 5mm layer AND 2 mm layer, texture rendered and then coated with an acrylic paint. (refer to The DELTA BLOCK Coating Guide).

AUTOCLAVED AERATED CONCRETE TEN ADVANTAGES :-

Project description and statical system

This project is Residential compound located in the north coast , MATRUH,EGYPT, consist of different types of building

Type :-2 C

The building consist OF ground & 3 multi story

The statical system is (SOLID SLAB) beam & column system & shear wall , the building is totally designed to resist the vertical and horizontal loads acting on it and according to EGYPTIAN STANDARD.

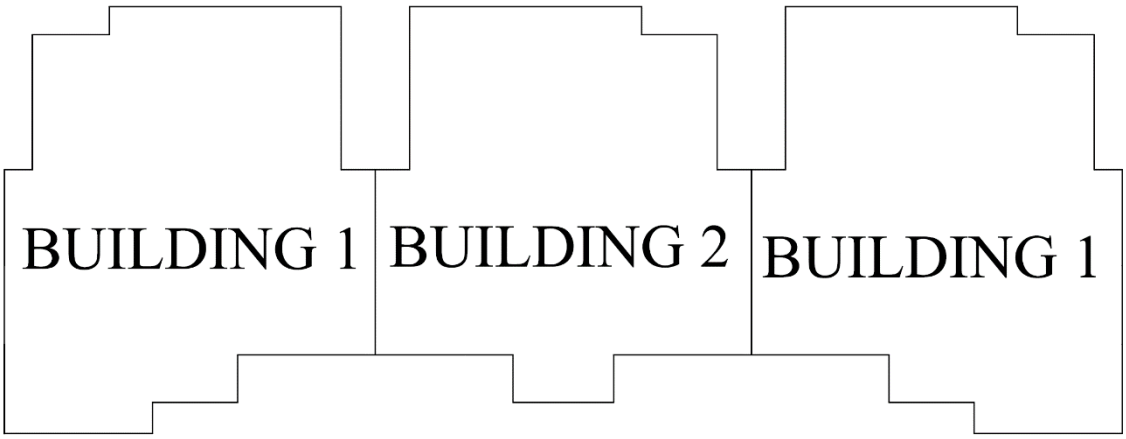
- **Structural loads**
    1. **Bearing capacity of soil 1.50 kg/cm2**
    2. **Common Live load 200 kg/m2**
    3. **Live load in balcony , bathroom and kitchen 300 kg/m2**
    4. **Common flooring cover 200 kg/m2**
    5. **Flooring cover at roof 300 kg/m2**
    6. **Density of walls 550 kg/m3**
    7. **Density of plastering mortar 1800 kg/m3**
    8. **Density of plain concrete 2200 kg/m3**
    9. **Density of reinforced concrete 2500 kg/m3**
- **Structural design consist the following**

1. **The design of reinforced concrete columns and reinforced walls**
2. **The design of reinforced concrete slabs and beams**

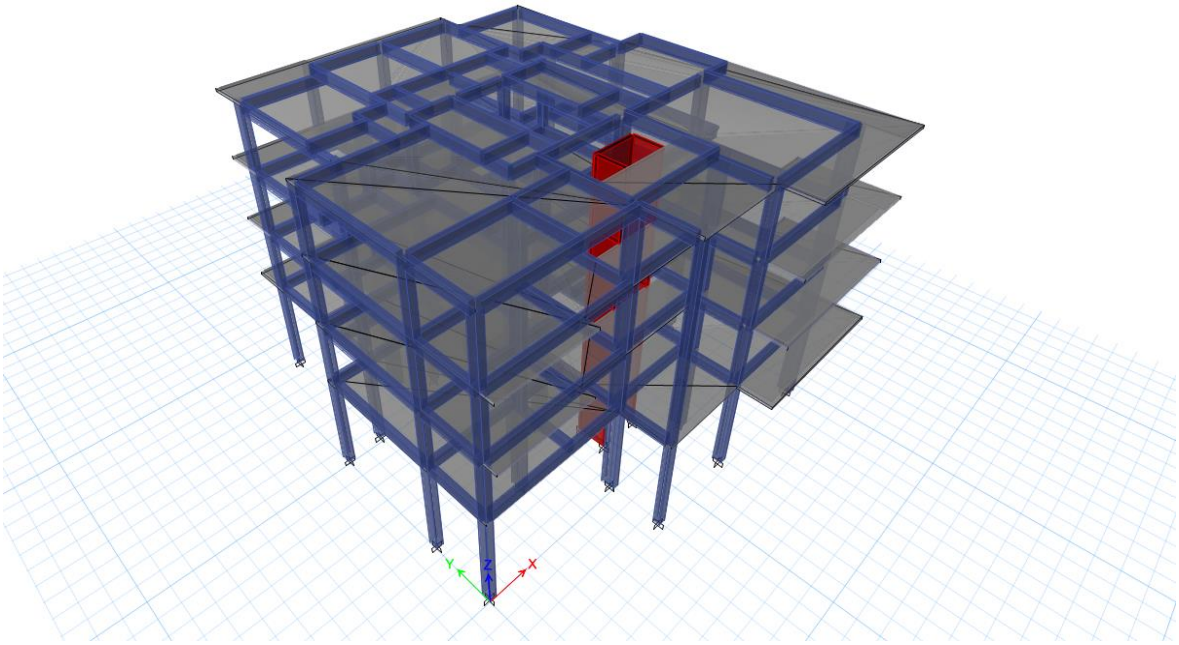
- **Design standard:-**
    1. **Egyptian code for Assessment of loads on building and structures- No.201/2012**
    2. **Egyptian code for Design and Construction for concrete structures No.203/2007**
    3. **Egyptian code for soil Mechanics, Design and construction foundation 202/2001**
- **Analysis software :**
    1. **ETABS 2016**
    2. **SAFE 2016**

TYPE 2 C

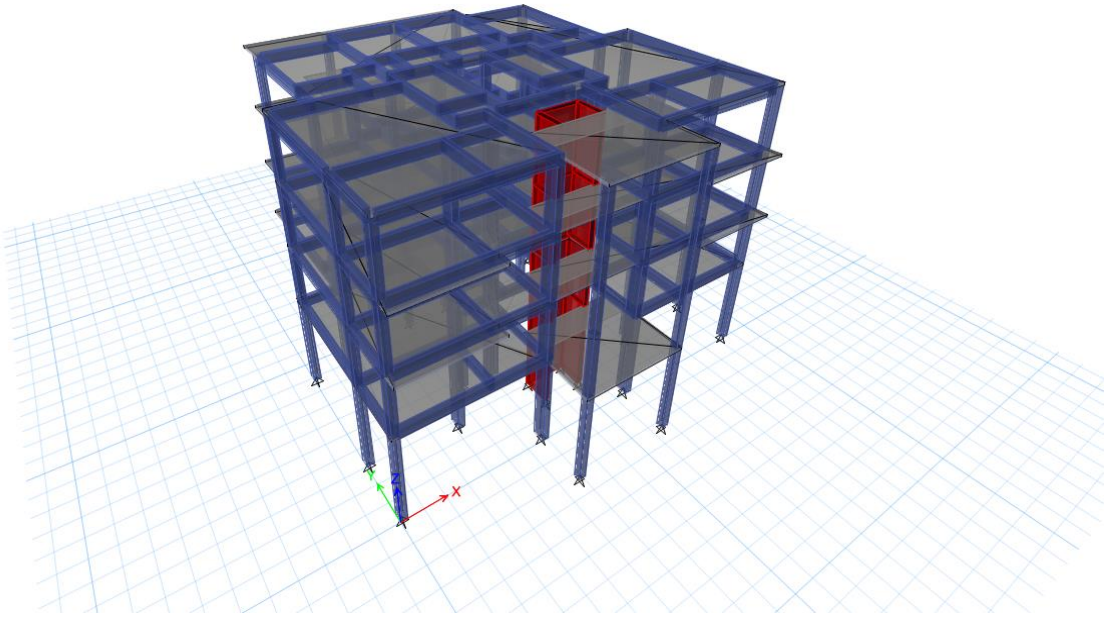
1-1 ETABS MODEL



1-2 3D ETABS MODEL

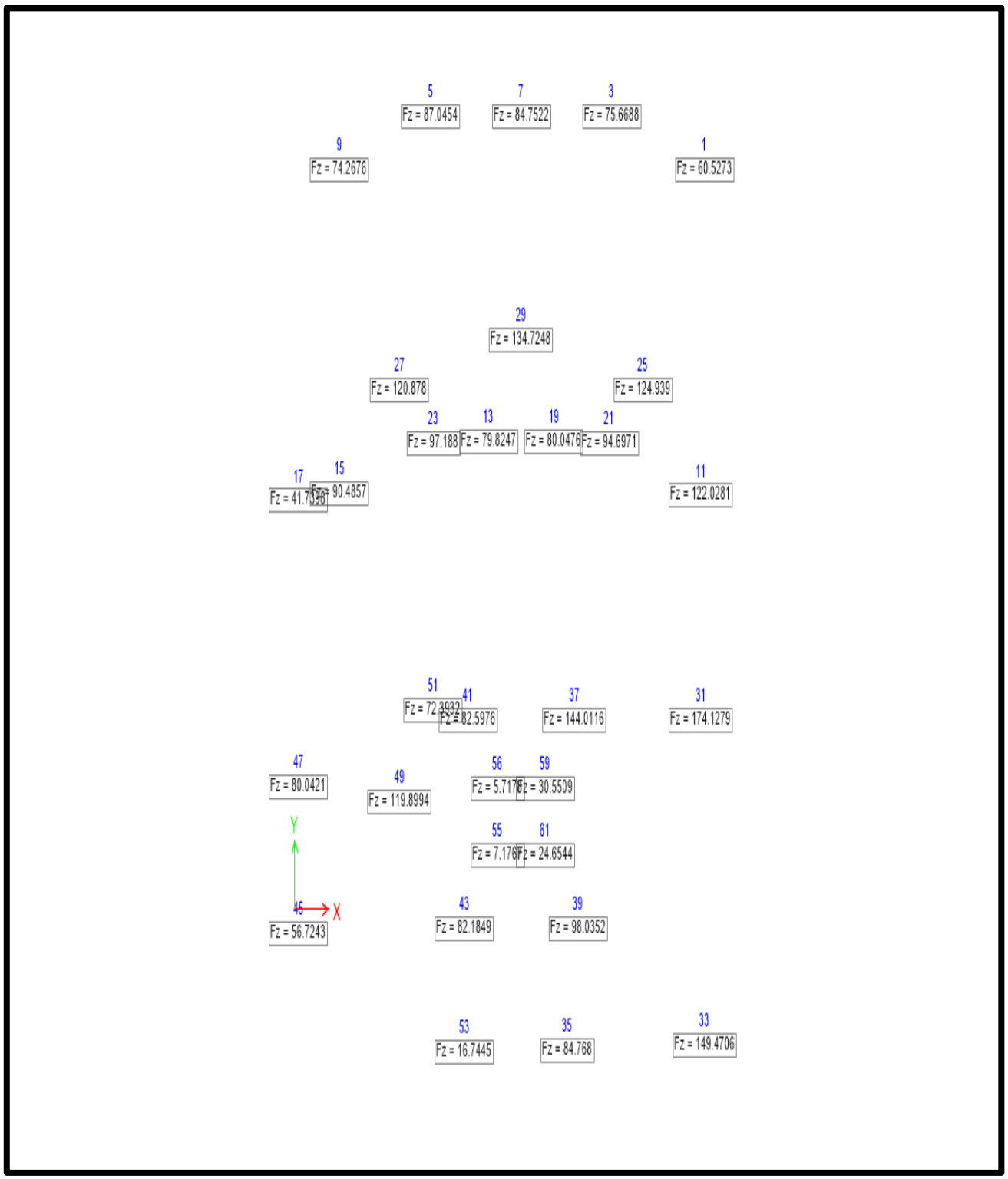


BUILDING 1

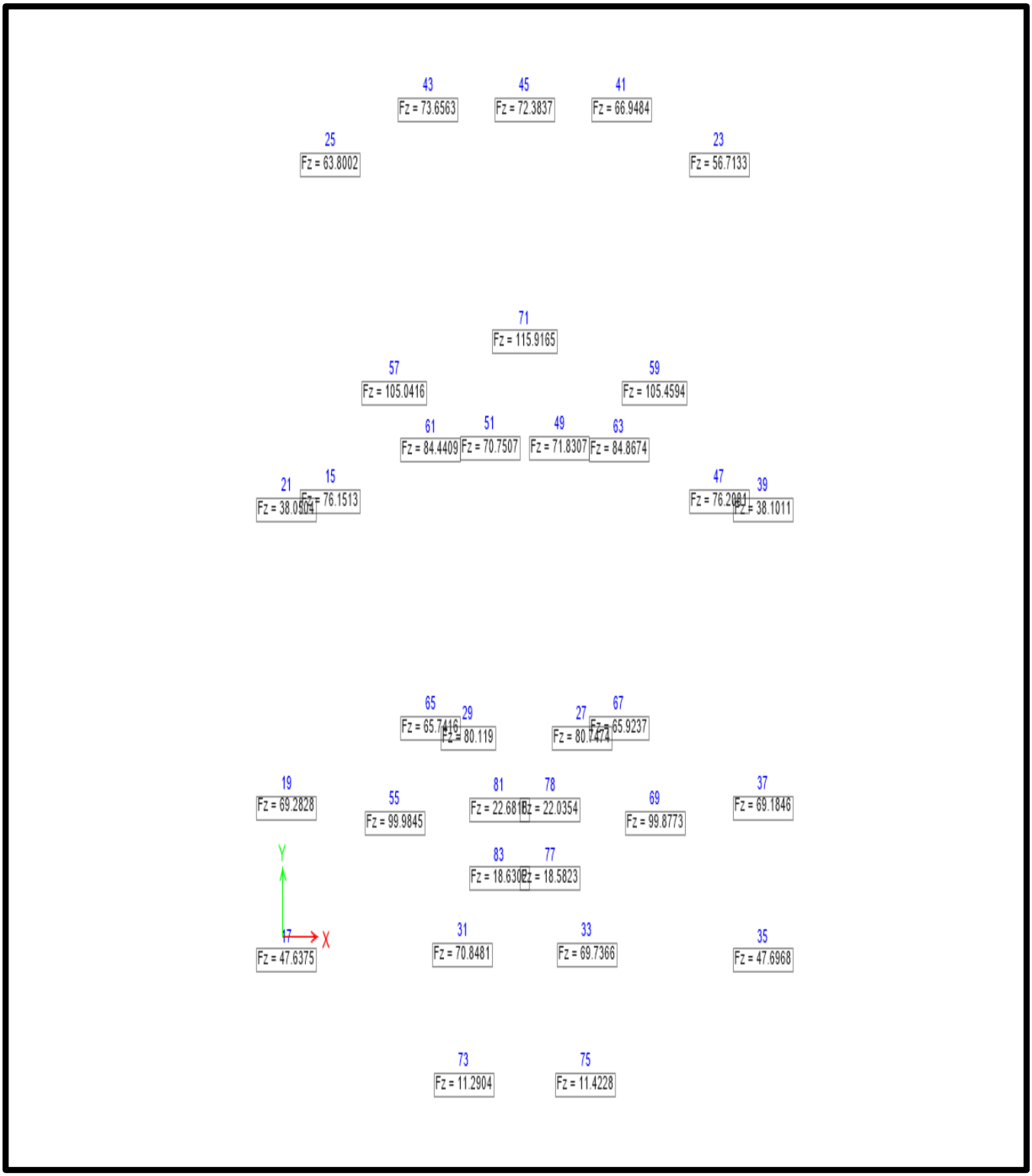


BUILDING 2

- **LOADS ON FOUNDATIONS**



LOADS ON BUILDING 1



L OADS ON BUILDING 2

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Design of foundations

Project name	:	bo_sand
Location	:	north coast
Footing no	:	f1

Given Data

Fcu = 300 Kg/cm2 Fy = 3600 Kg/cm2 Pu = 80.0 t. qna = 15 t/m2 b = 0.40 m a = 0.25 m t P.C. = 0.40 m

Design Procedueres

Pw = Pu /1.5 = 57.1 t

A p.c. = Pw/qna = 3.8 m2

L' =2.05 m B' =1.90 m

Fn = Pu / L' *B' = 14.67 t/m2

C = t p.c. * (Ft /3 Fn)^0.5

C =0.38 m

L = L' - 2C B = B' - 2C

L =1.30 m B =1.15 m

q = Pu / L *B = 38.22 t/m2

Depth for moment

Mu 1-1 = q * B * (L - b)² /8 = 4.45 m.t.

Mu 2-2 = q * L * (B - a)² /8 = 5.03 m.t.

d_{1-1} = 5 * (Mu / Fcu * B) ^0.5 = 18.0 cm

d_{2-2} = 5 * (Mu / Fcu * L) ^0.5 = 18.0 cm

d B.M. = 18.0 cm

Depth for shear

Q 1-1 = q * B * (L - b - d)/2 = 19780.2 -2.20 d

Q 2-2 = q * L * (B - a - d)/2 = 22360.2 -2.48 d

qcu = 0.49 (Fcu / 1.5)^0.5 = 6.93 Kg/cm2

q 1-1 = Q 1-1 / (B * d_{1-1})

q 2-2 = Q 2-2 / (L * d_{2-2})

d 1-1 = q (L - b) / ((qcu + q/2) /2) = 19.5 cm

d 2-2 = q (B - a) / ((qcu + q/2) /2) = 19.5 cm

d shear = 19.5 cm

Depth for punching

Qp = q (L*B - (a+d)*(b+d)) = 53321 -248 d -3.82d²

qpu = (0.5 + a/b) (Fcu / 1.5) ^0.5 = 14.14 Kg/cm2 ≤ (Fcu/1.5)^0.5

qp*2(a+b+2d)*d= 1838.5 d + 57 d²

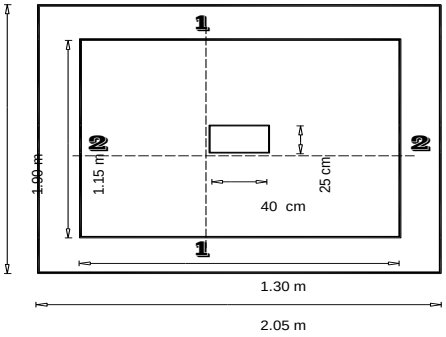
qp * 2(a+b+2d) = Qp

53321 -248.4 d -3.82d² = 1838.5 d + 57 d²

60.4 d² + 2087 d -53320.6 = 0

d punch =17.1 cm

Take d = 19.5 cm



Reinforcement steel

Long direction

As req = Mu1-1 / Fy * J * d = 7.69 cm2

As min = μ min * B * d = 6.84 cm2

As = 7.69 cm2

Use 7 Ø12 7 Ø12 /m Safe

As act. = 7.92 cm2

Short direction

As req = Mu2-2 / Fy * J * d = 8.70 cm2

As min = μ min * L * d = 7.73 cm2

As = 8.70 cm2

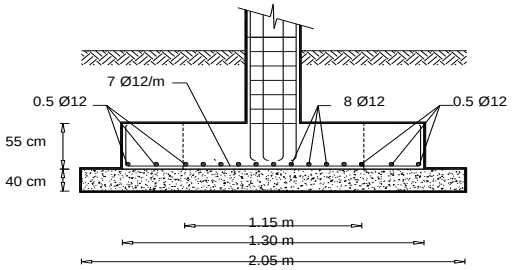
As (central zone of width B) = 8.16 cm2

Use 8 Ø12 7 Ø12 /m Safe

As (end zones) = 0.53 cm2

Use 1 Ø12 7 Ø12 /m Safe

As act. = 10.18 cm2



Check of Bond stress

qbu = 0.95 * (Fcu / 1.5)^0.5 = 13.435

Qb1-1 = q * B * (B - b) /2 = 19.78 t.

db1-1 = Qb1-1 / qbu * ∑o = 55.8 cm

Qb2-2 = q * L * (L - b) /2 = 22.36 t.

db2-2 = Qb2-2 / qbu * ∑o = 49.1 cm

d bond = 55.8 cm

Check for anchorage length

dd avilable = (L - b)/2+d-cover = (B - a)/2+d-cover = 100.0 Cm

dd long = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe

dd short = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe

d final = 50 cm **t** final = 55 cm

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name	:	bo sand
Location	:	north coast
Footing no	:	f2

Given Data

Fcu = 300 Kg/cm2 Fy = 3600 Kg/cm2 Pu = 100.0 t. qna = 15 t/m2 b = 0.40 m a = 0.25 m t P.C. = 0.40 m

Design Procedueres

Pw = Pu /1.5 = 71.4 t

A p.c. = Pw/qna = 4.8 m2

L' =2.30 m B' =2.15 m

Fn = Pu / L' *B' = 14.44 t/m2

C = t p.c. * (Ft /3 Fn)^0.5

C =0.38 m

L = L' - 2C B = B' - 2C

L =1.55 m B =1.40 m

q = Pu / L *B = 32.92 t/m2

Depth for moment

$Mu_{1-1} = q * B * (L - b)^2 /8 =$ 7.62 m.t.

$Mu_{2-2} = q * L * (B - a)^2 /8 =$ 8.43 m.t.

$d_{1-1} = 5 * (Mu / Fcu * B) ^0.5 =$ 21.3 cm

$d_{2-2} = 5 * (Mu / Fcu * L) ^0.5 =$ 21.3 cm

$d_{B.M.} =$ 21.3 cm

Depth for shear

$Q_{1-1} = q * B * (L - b - d)/2 =$ 26497.7 -2.30 d

$Q_{2-2} = q * L * (B - a - d)/2 =$ 29336.7 -2.55 d

qcu = 0.49 (Fcu / 1.5)^0.5 = 6.93 Kg/cm2

$q_{1-1} = Q_{1-1} / (B * d_{1-1})$

$q_{2-2} = Q_{2-2} / (L * d_{2-2})$

$d_{1-1} = q (L - b) / ((qcu + q/2) /2) =$ 22.1 cm

$d_{2-2} = q (B - a) / ((qcu + q/2) /2) =$ 22.1 cm

d_{shear} = 22.1 cm

Depth for punching

Qp = q (L*B - (a+d)*(b+d)) = 68137 -214 d -3.29d²

qpu = (0.5 + a/b) (Fcu / 1.5) ^0.5 = 14.14 Kg/cm2 ≤ (Fcu/1.5)^0.5

qp*2(a+b+2d)*d= 1838.5 d + 57 d²

qp * 2(a+b+2d) = Qp

68137 -214.0 d -3.29d² = 1838.5 d + 57 d²

59.9 d² + 2052 d -68136.9 = 0

d_{punch} = 20.7 cm

Take d = 22.1 cm

Reinforcement steel

Long direction

As_{req} = Mu_{1-1} / Fy * J * d = 11.61 cm2

$As_{min} = \mu_{min} * B * d =$ 9.44 cm2

As = 11.61 cm2

Use 11 Ø12 8 Ø12 /m Safe

$As_{act.}$ = 12.45 cm2

Short direction

As_{req} = Mu_{2-2} / Fy * J * d = 12.85 cm2

$As_{min} = \mu_{min} * L * d =$ 10.45 cm2

As = 12.85 cm2

As (central zone of width B) = 12.20 cm2

Use 11 Ø12 8 Ø12 /m Safe

As (end zones) = 0.65 cm2

Use 1 Ø12 7 Ø12 /m Safe

$As_{act.}$ = 13.58 cm2

Check of Bond stress

qbu = 0.95 * (Fcu / 1.5)^0.5 = 13.435

$Qb_{1-1} = q * B * (B - b) /2 =$ 26.50 t.

$db_{1-1} = Qb_{1-1} / qbu * \sum o =$ 47.6 cm

$Qb_{2-2} = q * L * (L - b) /2 =$ 29.34 t.

$db_{2-2} = Qb_{2-2} / qbu * \sum o =$ 48.3 cm

d_{bond} = 48.3 cm

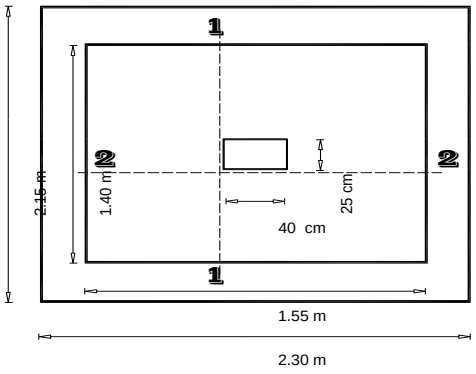
Check for anchorage length

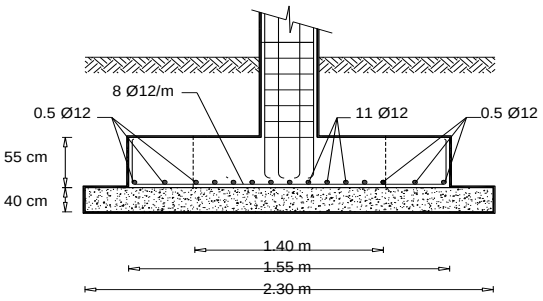
$dd_{avilable}$ = (L - b)/2+d-cover = (B - a)/2+d-cover = 102.5 Cm

dd_{long} = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe

dd_{short} = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe

d_{final} = 50 cm **t_{final} = 55 cm**





DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name	:	bo sand
Location	:	north coast
Footing no	:	f3

Given Data

Fcu = 300 Kg/cm2 Fy = 3600 Kg/cm2 Pu = 120.0 t. qna = 15 t/m2 b = 0.60 m a = 0.25 m t P.C. = 0.40 m

Design Procedueres

Pw = Pu /1.5 = 85.7 t
A p.c. = Pw/qna = 5.7 m2
L' =2.60 m B' =2.25 m
Fn = Pu / L' *B' = 14.65 t/m2
C = t p.c. * (Ft /3 Fn)^0.5
C =0.38 m
L = L' - 2C B = B' - 2C
L =1.85 m B =1.50 m
q = Pu / L *B = 30.89 t/m2

Depth for moment

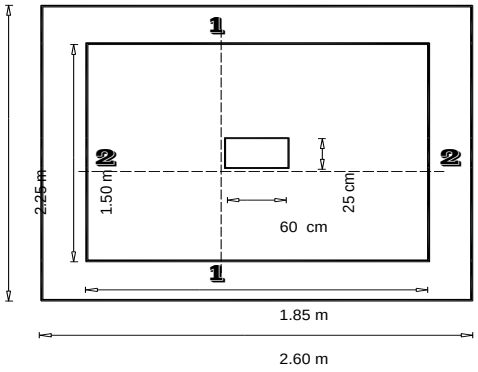
Mu 1-1 = q * B * (L - b)² /8 = 9.05 m.t.
Mu 2-2 = q * L * (B - a)² /8 = 11.16 m.t.
d1-1 = 5 * (Mu / Fcu * B) ^0.5 = 22.4 cm
d2-2 = 5 * (Mu / Fcu * L) ^0.5 = 22.4 cm
d B.M. = 22.4 cm

Depth for shear

Q 1-1 = q * B * (L - b - d)/2 = 28957.5 -2.32 d
Q 2-2 = q * L * (B - a - d)/2 = 35714.3 -2.86 d
qcu = 0.49 (Fcu / 1.5)^0.5 = 6.93 Kg/cm2
q 1-1 = Q 1-1 / (B * d1-1)
q 2-2 = Q 2-2 / (L * d2-2)
d 1-1 = q (L - b) / ((qcu + q/2) /2) = 22.8 cm
d 2-2 = q (B - a) / ((qcu + q/2) /2) = 22.8 cm
d shear = 22.8 cm

Depth for punching

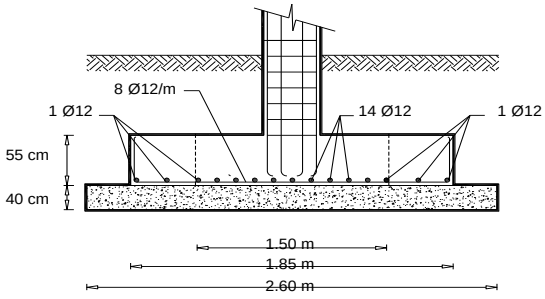
Qp = q (L*B - (a+d)*(b+d)) = 81081 -263 d -3.09d²
qpu = (0.5 + a/b) (Fcu / 1.5) ^0.5 = 12.96 Kg/cm2 ≤ (Fcu/1.5)^0.5
qp*2(a+b+2d)*d= 2203.8 d + 52 d²
qp * 2(a+b+2d) = Qp
81081 -262.5 d -3.09d² = 2203.8 d + 52 d²
54.9 d² + 2466 d -81081.1 = 0
d punch =22.0 cm
Take d = 22.8 cm



Reinforcement steel

Long direction
As req = Mu1-1 / Fy * J * d = 13.36 cm2
As min = μ min * B * d = 10.44 cm2
As = 13.36 cm2
Use 12 Ø12 8 Ø12 /m Safe
As act. = 13.58 cm2

Short direction
As req = Mu2-2 / Fy * J * d = 16.48 cm2
As min = μ min * L * d = 12.88 cm2
As = 16.48 cm2
As (central zone of width B) = 14.75 cm2
Use 14 Ø12 9 Ø12 /m Safe
As (end zones) = 1.72 cm2
Use 2 Ø12 6 Ø12 /m Safe
As act. = 18.10 cm2



Check of Bond stress

qbu = 0.95 * (Fcu / 1.5)^0.5 = 13.435
Qb1-1 = q * B * (B - b) /2 = 28.96 t.
db1-1 = Qb1-1 / qbu * ∑o = 47.7 cm
Qb2-2 = q * L * (L - b) /2 = 35.71 t.
db2-2 = Qb2-2 / qbu * ∑o = 44.1 cm
d bond = 47.7 cm

Check for anchorage length

dd avilable = (L - b)/2+d-cover = (B - a)/2+d-cover = 107.5 Cm
dd long = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe
dd short = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe

d final = 50 cm **t** final = 55 cm

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name	:	bo sand
Location	:	north coast
Footing no	:	f4

Given Data

Fcu = 300 Kg/cm2 Fy = 3600 Kg/cm2 Pu = 150.0 t. qna = 15 t/m2 b = 0.60 m a = 0.25 m t P.C. = 0.40 m

Design Procedueres

Pw = Pu /1.5 = 107.1 t
A p.c. = Pw/qna = 7.1 m2
L' =2.90 m B' =2.55 m
Fn = Pu / L' *B' = 14.49 t/m2
C = t p.c. * (Ft /3 Fn)^0.5
C =0.38 m
L = L' - 2C B = B' - 2C
L =2.15 m B =1.80 m
q = Pu / L *B = 27.69 t/m2

Depth for moment

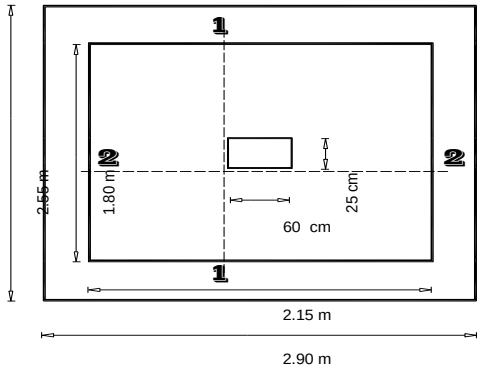
Mu 1-1 = q * B * (L - b)² /8 = 14.97 m.t.
Mu 2-2 = q * L * (B - a)² /8 = 17.88 m.t.
d_{1-1} = 5 * (Mu / Fcu * B) ^0.5 = 26.3 cm
d_{2-2} = 5 * (Mu / Fcu * L) ^0.5 = 26.3 cm
d B.M. = 26.3 cm

Depth for shear

Q 1-1 = q * B * (L - b - d)/2 = 38621.3 -2.49 d
Q 2-2 = q * L * (B - a - d)/2 = 46131 -2.98 d
qcu = 0.49 (Fcu / 1.5)^0.5 = 6.93 Kg/cm2
q 1-1 = Q 1-1 / (B * d_{1-1})
q 2-2 = Q 2-2 / (L * d_{2-2})
d 1-1 = q (L - b) / ((qcu + q/2) /2) = 25.8 cm
d 2-2 = q (B - a) / ((qcu + q/2) /2) = 25.8 cm
d shear = 25.8 cm

Depth for punching

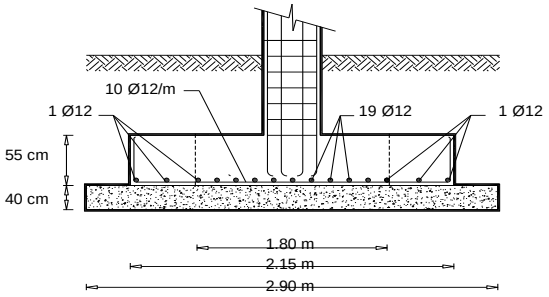
Qp = q (L*B - (a+d)*(b+d)) = 102990 -235 d -2.77d²
qpu = (0.5 + a/b) (Fcu / 1.5) ^0.5 = 12.96 Kg/cm2 ≤ (Fcu/1.5)^0.5
qp*2(a+b+2d)*d= 2203.8 d + 52 d²
qp * 2(a+b+2d) = Qp
102990 -235.3 d -2.77d² = 2203.8 d + 52 d²
54.6 d² + 2439 d -102990.0 = 0
d punch =26.5 cm
Take d = 26.3 cm



Reinforcement steel

Long direction
As req = Mu1-1 / Fy * J * d = 19.12 cm2
As min = μ min * B * d = 14.48 cm2
As = 19.12 cm2
Use 17 Ø12 10 Ø12 /m Safe
As act. = 19.23 cm2

Short direction
As req = Mu2-2 / Fy * J * d = 22.84 cm2
As min = μ min * L * d = 17.29 cm2
As = 22.84 cm2
As (central zone of width B) = 20.81 cm2
Use 19 Ø12 11 Ø12 /m Use Bigger Ø
As (end zones) = 2.02 cm2
Use 2 Ø12 6 Ø12 /m Safe
As act. = 23.76 cm2



Check of Bond stress

qbu = 0.95 * (Fcu / 1.5)^0.5 = 13.435
Qb1-1 = q * B * (B - b) /2 = 38.62 t.
db1-1 = Qb1-1 / qbu * ∑o = 44.9 cm
Qb2-2 = q * L * (L - b) /2 = 46.13 t.
db2-2 = Qb2-2 / qbu * ∑o = 43.4 cm
d bond = 44.9 cm

Check for anchorage length

dd avilable = (L - b)/2+d-cover = (B - a)/2+d-cover = 117.5 Cm
dd long = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe
dd short = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe

d final = 50 cm **t** final = 55 cm

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name	:	bo sand
Location	:	north coast
Footing no	:	f5

Given Data

Fcu = 300 Kg/cm2 Fy = 3600 Kg/cm2 Pu = 180.0 t. qna = 15 t/m2 b = 0.60 m a = 0.25 m t P.C. = 0.40 m

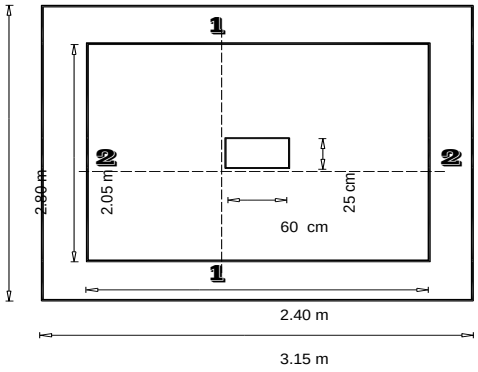
Design Procedueres

Pw = Pu /1.5 = 128.6 t
A p.c. = Pw/qna = 8.6 m2
L' =3.15 m B' =2.80 m
Fn = Pu / L' *B' = 14.58 t/m2
C = t p.c. * (Ft /3 Fn)^0.5
C =0.38 m
L = L' - 2C B = B' - 2C
L =2.40 m B =2.05 m
q = Pu / L *B = 26.13 t/m2

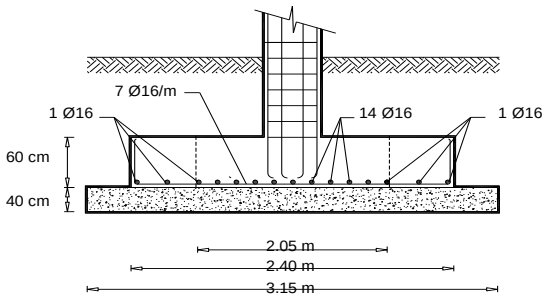
Depth for moment
Mu 1-1 = q * B * (L - b)² /8 = 21.70 m.t.
Mu 2-2 = q * L * (B - a)² /8 = 25.40 m.t.
d_{1-1} = 5 * (Mu / Fcu * B) ^0.5 = 29.7 cm
d_{2-2} = 5 * (Mu / Fcu * L) ^0.5 = 29.7 cm
d B.M. = 29.7 cm

Depth for shear
Q 1-1 = q * B * (L - b - d)/2 = 48214.3 -2.68 d
Q 2-2 = q * L * (B - a - d)/2 = 56446 -3.14 d
qcu = 0.49 (Fcu / 1.5)^0.5 = 6.93 Kg/cm2
q 1-1 = Q 1-1 / (B * d_{1-1})
q 2-2 = Q 2-2 / (L * d_{2-2})
d 1-1 = q (L - b) / ((qcu + q/2) /2) = 28.6 cm
d 2-2 = q (B - a) / ((qcu + q/2) /2) = 28.6 cm
d shear = 28.6 cm

Depth for punching
Qp = q (L*B - (a+d)*(b+d)) = 124652 -222 d -2.61d²
qpu = (0.5 + a/b) (Fcu / 1.5) ^0.5 = 12.96 Kg/cm2 ≤ (Fcu/1.5)^0.5
qp*2(a+b+2d)*d= 2203.8 d + 52 d²
qp * 2(a+b+2d) = Qp
124652 -222.1 d -2.61d² = 2203.8 d + 52 d²
54.5 d² + 2426 d -124651.6 = 0
d punch =30.5 cm
Take d = 29.7 cm



Reinforcement steel
Long direction
As req = Mu1-1 / Fy * J * d = 24.57 cm2
As min = μ min * B * d = 18.60 cm2
As = 24.57 cm2
Use 13 Ø16 7 Ø16 /m Safe
As act. = 26.15 cm2
Short direction
As req = Mu2-2 / Fy * J * d = 28.76 cm2
As min = μ min * L * d = 21.78 cm2
As = 28.76 cm2
As (central zone of width B) = 26.50 cm2
Use 14 Ø16 7 Ø16 /m Safe
As (end zones) = 2.26 cm2
Use 2 Ø16 6 Ø16 /m Safe
As act. = 32.18 cm2



Check of Bond stress
qbu = 0.95 * (Fcu / 1.5)^0.5 = 13.435
Qb1-1 = q * B * (B - b) /2 = 48.21 t.
db1-1 = Qb1-1 / qbu * ∑o = 54.9 cm
Qb2-2 = q * L * (L - b) /2 = 56.45 t.
db2-2 = Qb2-2 / qbu * ∑o = 52.3 cm
d bond = 54.9 cm

Check for anchorage length
dd avilable = (L - b)/2+d-cover = (B - a)/2+d-cover = 140.0 Cm
dd long = As (Fy / 1.15) / (π * Ø * qbc) = 93.3 Cm Safe
dd short = As (Fy / 1.15) / (π * Ø * qbc) = 93.3 Cm Safe

d final = 55 cm **t** final = 60 cm

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name	:	bo_sand
Location	:	north coast
Footing no	:	f6

Given Data

Fcu = 300 Kg/cm2 Fy = 3600 Kg/cm2 Pu = 140.0 t. qna = 15 t/m2 b = 0.70 m a = 0.25 m t P.C. = 0.40 m

Design Procedueres

Pw = Pu /1.5 = 100.0 t
A p.c. = Pw/qna = 6.7 m2
L' =2.85 m B' =2.40 m
Fn = Pu / L' *B' = 14.62 t/m2
C = t p.c. * (Ft /3 Fn)^0.5
C =0.38 m
L = L' - 2C B = B' - 2C
L =2.10 m B =1.65 m
q = Pu / L *B = 28.86 t/m2

Depth for moment

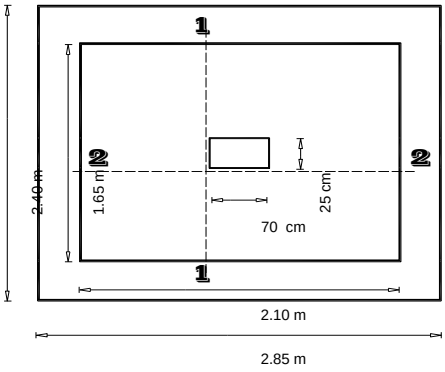
$Mu_{1-1} = q * B * (L - b)^2 /8 =$ 11.67 m.t.
$Mu_{2-2} = q * L * (B - a)^2 /8 =$ 14.85 m.t.
$d_{1-1} = 5 * (Mu / Fcu * B) ^0.5 =$ 24.3 cm
$d_{2-2} = 5 * (Mu / Fcu * L) ^0.5 =$ 24.3 cm
d B.M. = 24.3 cm

Depth for shear

$Q_{1-1} = q * B * (L - b - d)/2 =$ 33333.3 -2.38 d
$Q_{2-2} = q * L * (B - a - d)/2 =$ 42424.2 -3.03 d
qcu = 0.49 (Fcu / 1.5)^0.5 = 6.93 Kg/cm2
$q_{1-1} = Q_{1-1} / (B * d_{1-1})$
$q_{2-2} = Q_{2-2} / (L * d_{2-2})$
$d_{1-1} = q (L - b) / ((qcu + q/2) /2) =$ 24.1 cm
$d_{2-2} = q (B - a) / ((qcu + q/2) /2) =$ 24.1 cm
d shear = 24.1 cm

Depth for punching

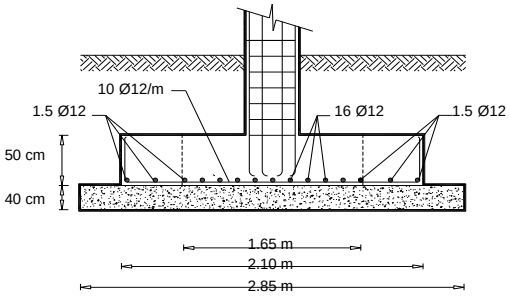
Qp = q (L*B - (a+d)*(b+d)) = 94949 -274 d -2.89d²
qpu = (0.5 + a/b) (Fcu / 1.5) ^0.5 = 12.12 Kg/cm2 ≤ (Fcu/1.5)^0.5
qp*2(a+b+2d)*d= 2303.1 d + 48 d²
qp * 2(a+b+2d) = Qp
94949 -274.2 d -2.89d² = 2303.1 d + 48 d²
51.4 d² + 2577 d -94949.5 = 0
d punch =24.7 cm
Take d = 24.3 cm



Reinforcement steel

Long direction
$As_{req} = Mu_{1-1} / Fy * J * d =$ 16.16 cm2
$As_{min} = \mu_{min} * B * d =$ 12.24 cm2
As = 16.16 cm2
Use 15 Ø12 10 Ø12 /m Safe
$As_{act.} =$ 16.97 cm2

Short direction
$As_{req} = Mu_{2-2} / Fy * J * d =$ 20.57 cm2
$As_{min} = \mu_{min} * L * d =$ 15.58 cm2
As = 20.57 cm2
As (central zone of width B) = 18.10 cm2
Use 16 Ø12 10 Ø12 /m Safe
As (end zones) = 2.47 cm2
Use 3 Ø12 7 Ø12 /m Safe
$As_{act.} =$ 21.50 cm2



Check of Bond stress

qbu = 0.95 * (Fcu / 1.5)^0.5 = 13.435
Qb1-1 = q * B * (B - b) /2 = 33.33 t.
db1-1 = Qb1-1 / qbu * ∑o = 43.9 cm
Qb2-2 = q * L * (L - b) /2 = 42.42 t.
db2-2 = Qb2-2 / qbu * ∑o = 44.1 cm
d bond = 44.1 cm

Check for anchorage length

dd avilable = (L - b)/2+d-cover = (B - a)/2+d-cover = 110.0 Cm
dd long = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe
dd short = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe

d final = 45 cm **t** final = 50 cm

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DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name	:	bo sand
Location	:	north coast
Footing no	:	f7

Given Data

Fcu = 300 Kg/cm2 Fy = 3600 Kg/cm2 Pu = 120.0 t. qna = 15 t/m2 b = 0.52 m a = 0.40 m t P.C. = 0.40 m

Design Procedueres

Pw = Pu /1.5 = 85.7 t
A p.c. = Pw/qna = 5.7 m2
L' =2.50 m B' =2.35 m
Fn = Pu / L' *B' = 14.59 t/m2
C = t p.c. * (Ft /3 Fn)^0.5
C =0.38 m
L = L' - 2C B = B' - 2C
L =1.75 m B =1.60 m
q = Pu / L *B = 30.61 t/m2

Depth for moment

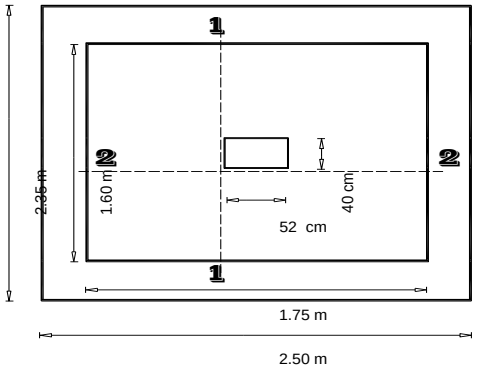
Mu 1-1 = q * B * (L - b)² /8 = 9.26 m.t.
Mu 2-2 = q * L * (B - a)² /8 = 9.64 m.t.
d1-1 = 5 * (Mu / Fcu * B) ^0.5 = 22.0 cm
d2-2 = 5 * (Mu / Fcu * L) ^0.5 = 21.4 cm
d B.M. = 22.0 cm

Depth for shear

Q 1-1 = q * B * (L - b - d)/2 = 30122.4 -2.45 d
Q 2-2 = q * L * (B - a - d)/2 = 32142.9 -2.68 d
qcu = 0.49 (Fcu / 1.5)^0.5 = 6.93 Kg/cm2
q 1-1 = Q 1-1 / (B * d1-1)
q 2-2 = Q 2-2 / (L * d2-2)
d 1-1 = q (L - b) / ((qcu + q/2) /2) = 22.3 cm
d 2-2 = q (B - a) / ((qcu + q/2) /2) = 21.7 cm
d shear = 22.3 cm

Depth for punching

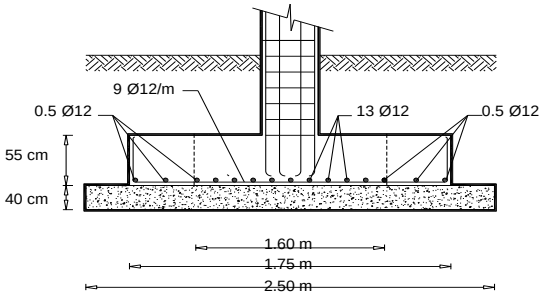
Qp = q (L*B - (a+d)*(b+d)) = 79347 -282 d -3.06d²
qpu = (0.5 + a/b) (Fcu / 1.5) ^0.5 = 14.14 Kg/cm2 ≤ (Fcu/1.5)^0.5
qp*2(a+b+2d)*d= 2602.2 d + 57 d²
qp * 2(a+b+2d) = Qp
79347 -281.6 d -3.06d² = 2602.2 d + 57 d²
59.6 d² + 2884 d -79346.9 = 0
d punch =19.6 cm
Take d = 22.3 cm



Reinforcement steel

Long direction
As req = Mu1-1 / Fy * J * d = 14.00 cm2
As min = μ min * B * d = 10.88 cm2
As = 14.00 cm2
Use 13 Ø12 9 Ø12 /m Safe
As act. = 14.71 cm2

Short direction
As req = Mu2-2 / Fy * J * d = 14.57 cm2
As min = μ min * L * d = 11.90 cm2
As = 14.57 cm2
As (central zone of width B) = 13.92 cm2
Use 13 Ø12 8 Ø12 /m Safe
As (end zones) = 0.65 cm2
Use 1 Ø12 7 Ø12 /m Safe
As act. = 15.84 cm2



Check of Bond stress

qbu = 0.95 * (Fcu / 1.5)^0.5 = 13.435
Qb1-1 = q * B * (B - b) /2 = 30.12 t.
db1-1 = Qb1-1 / qbu * ∑o = 45.8 cm
Qb2-2 = q * L * (L - b) /2 = 32.14 t.
db2-2 = Qb2-2 / qbu * ∑o = 45.4 cm
d bond = 45.8 cm

Check for anchorage length

dd avilable = (L - b)/2+d-cover = (B - a)/2+d-cover = 105.0 Cm
dd long = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe
dd short = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe

d final = 50 cm **t** final = 55 cm

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name	:	bo sand
Location	:	north coast
Footing no	:	f8

Given Data

Fcu = 300 Kg/cm2 Fy = 3600 Kg/cm2 Pu = 170.0 t. qna = 15 t/m2 b = 0.52 m a = 0.40 m t P.C. = 0.40 m

Design Procedueres

Pw = Pu /1.5 = 121.4 t
A p.c. = Pw/qna = 8.1 m2
L' =2.95 m B' =2.80 m
Fn = Pu / L' *B' = 14.70 t/m2
C = t p.c. * (Ft /3 Fn)^0.5
C =0.38 m
L = L' - 2C B = B' - 2C
L =2.20 m B =2.05 m
q = Pu / L *B = 26.92 t/m2

Depth for moment

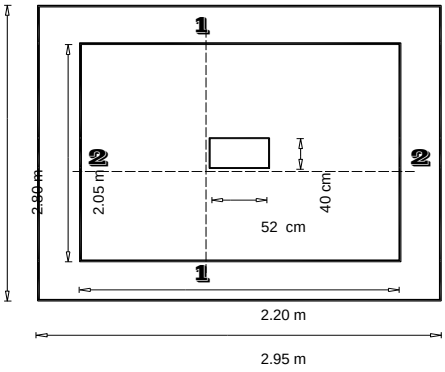
$Mu_{1-1} = q * B * (L - b)^2 /8 =$ 19.47 m.t.
$Mu_{2-2} = q * L * (B - a)^2 /8 =$ 20.16 m.t.
$d_{1-1} = 5 * (Mu / Fcu * B) ^0.5 =$ 28.1 cm
$d_{2-2} = 5 * (Mu / Fcu * L) ^0.5 =$ 27.6 cm
$d_{B.M.} =$ 28.1 cm

Depth for shear

$Q_{1-1} = q * B * (L - b - d)/2 =$ 46363.6 -2.76 d
$Q_{2-2} = q * L * (B - a - d)/2 =$ 48867.6 -2.96 d
qcu = 0.49 (Fcu / 1.5)^0.5 = 6.93 Kg/cm2
$q_{1-1} = Q_{1-1} / (B * d_{1-1})$
$q_{2-2} = Q_{2-2} / (L * d_{2-2})$
$d_{1-1} = q (L - b) / ((qcu + q/2) /2) =$ 27.3 cm
$d_{2-2} = q (B - a) / ((qcu + q/2) /2) =$ 26.8 cm
$d_{shear} =$ 27.3 cm

Depth for punching

Qp = q (L*B - (a+d)*(b+d)) = 115828 -248 d -2.69d²
qpu = (0.5 + a/b) (Fcu / 1.5) ^0.5 = 14.14 Kg/cm2 ≤ (Fcu/1.5)^0.5
qp*2(a+b+2d)*d= 2602.2 d + 57 d²
qp * 2(a+b+2d) = Qp
115828 -247.7 d -2.69d² = 2602.2 d + 57 d²
59.3 d² + 2850 d -115828.3 = 0
$d_{punch} =$ 26.3 cm
Take d = 28.1 cm



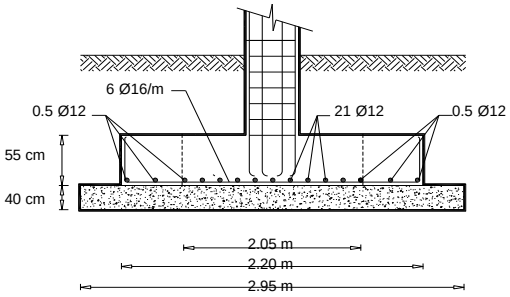
Reinforcement steel

Long direction

$As_{req} = Mu_{1-1} / Fy * J * d =$ 23.28 cm2
$As_{min} = \mu_{min} * B * d =$ 17.62 cm2
As = 23.28 cm2
Use 12 Ø16 6 Ø16 /m Safe
$As_{act.} =$ 24.14 cm2

Short direction

$As_{req} = Mu_{2-2} / Fy * J * d =$ 24.09 cm2
$As_{min} = \mu_{min} * L * d =$ 18.91 cm2
As = 24.09 cm2
As (central zone of width B) = 23.24 cm2
Use 21 Ø12 10 Ø12 /m Use Bigger Ø
As (end zones) = 0.85 cm2
Use 1 Ø12 7 Ø12 /m Safe
$As_{act.} =$ 24.89 cm2



Check of Bond stress

qbu = 0.95 * (Fcu / 1.5)^0.5 = 13.435
Qb1-1 = q * B * (B - b) /2 = 46.36 t.
db1-1 = Qb1-1 / qbu * ∑o = 57.2 cm
Qb2-2 = q * L * (L - b) /2 = 48.87 t.
db2-2 = Qb2-2 / qbu * ∑o = 32.9 cm
$d_{bond} =$ 57.2 cm

Check for anchorage length

$dd_{avilable}$ = (L - b)/2+d-cover = (B - a)/2+d-cover = 137.5 Cm
dd_{long} = As (Fy / 1.15) / (π * Ø * qbc) = 93.3 Cm Safe
dd_{short} = As (Fy / 1.15) / (π * Ø * qbc) = 70.0 Cm Safe

$d_{final} =$ 50 cm **$t_{final} =$ 55 cm**

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- **DESIGN OF COLUMNS**

Project name	:	BO SAND
Location	:	**NORTH COAST**
Column no	:	C1

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 80 ton b = 25 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Corner

Design Procedure

Pu = 0.35 Fcu Ac + 0.67 Fy As
b = 25 cm t = 40 cm
Ac actual = 1000.00 cm2
As = (Pu - 0.35 Fcu Ac) / 0.67 Fy
As = -10.36 cm2
As min = 0.006 Ac = 6.00 cm2
As max = 0.6% * 1000 = 60.00 cm2
Check As As min > As Take As = As min
As = 6.00 cm2 Ø = 16 mm ⇨ n = 4 ⇨ Bar spacing= 25.9 cm Safe
As actual = 8.05 cm2
S (stirrups spacing) = the biggest value of 15Ø and 20 cm = 20 cm
V (stirrups volume per meter height) = (100 / S) * 2(X + Y) * Asc = 276.6 cm3
V min = 0.0025 * 100 * b * t = 250.0 cm3
Check stirrups Safe Stirrups branches =

Project name	:	BO SAND
Location	:	**NORTH COAST**
Column no	:	C2

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 193 ton b = 25 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Corner

Design Procedure

Pu = 0.35 Fcu Ac + 0.67 Fy As
b = 25 cm t = 60 cm
Ac actual = 1500.00 cm2
As = (Pu - 0.35 Fcu Ac) / 0.67 Fy
As = 14.72 cm2
As min = 0.006 Ac = 9.00 cm2
As max = 0.6% * 1500 = 90.00 cm2
Check As As min < As < As max
As = 14.72 cm2 Ø = 16 mm ⇨ n = 8 ⇨ Bar spacing= 17.2 cm Safe
As actual = 16.09 cm2
S (stirrups spacing) = the biggest value of 15Ø and 20 cm = 20 cm
V (stirrups volume per meter height) = (100 / S) * 2(X + Y) * Asc = 377.1 cm3
V min = 0.0025 * 100 * b * t = 375.0 cm3
Check stirrups Safe Stirrups branches =

Project name	:	BO SAND
Location	:	NORTH COAST
Column no	:	C3

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 240 ton b = 25 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Corner

Design Procedure

Pu = 0.35 Fcu Ac + 0.67 Fy As
b = 25 cm t = 75 cm
Ac actual = 1875.00 cm2
As = (Pu - 0.35 Fcu Ac) / 0.67 Fy
As = 17.88 cm2
As min = 0.006 Ac = 11.25 cm2
As max = 0.6% * 1875 = 112.50 cm2
Check As As min < As < As max
As = 17.88 cm2 Ø = 16 mm ⇨ n = 10 ⇨ Bar spacing= 16.4 cm Safe
As actual = 20.11 cm2
S (stirrups spacing) = the biggest value of 15Ø and 20 cm = 20 cm
V (stirrups volume per meter height) = (100 / S) * 2(X + Y) * Asc = 452.6 cm3
V min = 0.0025 * 100 * b * t = 468.8 cm3
Check stirrups Increase Ø Stirrups Stirrups branches =

- **Design of slabs :- ground floor**
  1. **Loads Assign (WALL LOADS)**

Outer walls\m'

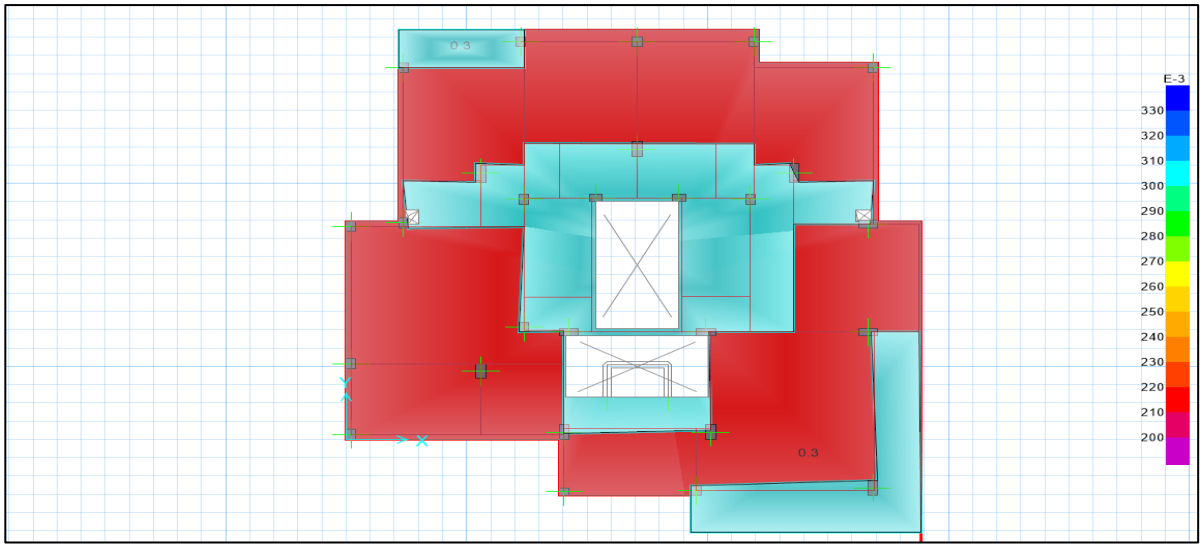
Walls height= 2.5 m , walls density =550 kg/m3 , walls thickness=0.25m
loads of walls without plastering \m'=2.5×0.55×0.20=0.344 t\m'
weight of plastering=0.04×1.8×3=0.21 t\m'
total wall loads\m'=0.485 t\m' ~ 0.52T\M`

Inner wall\m'

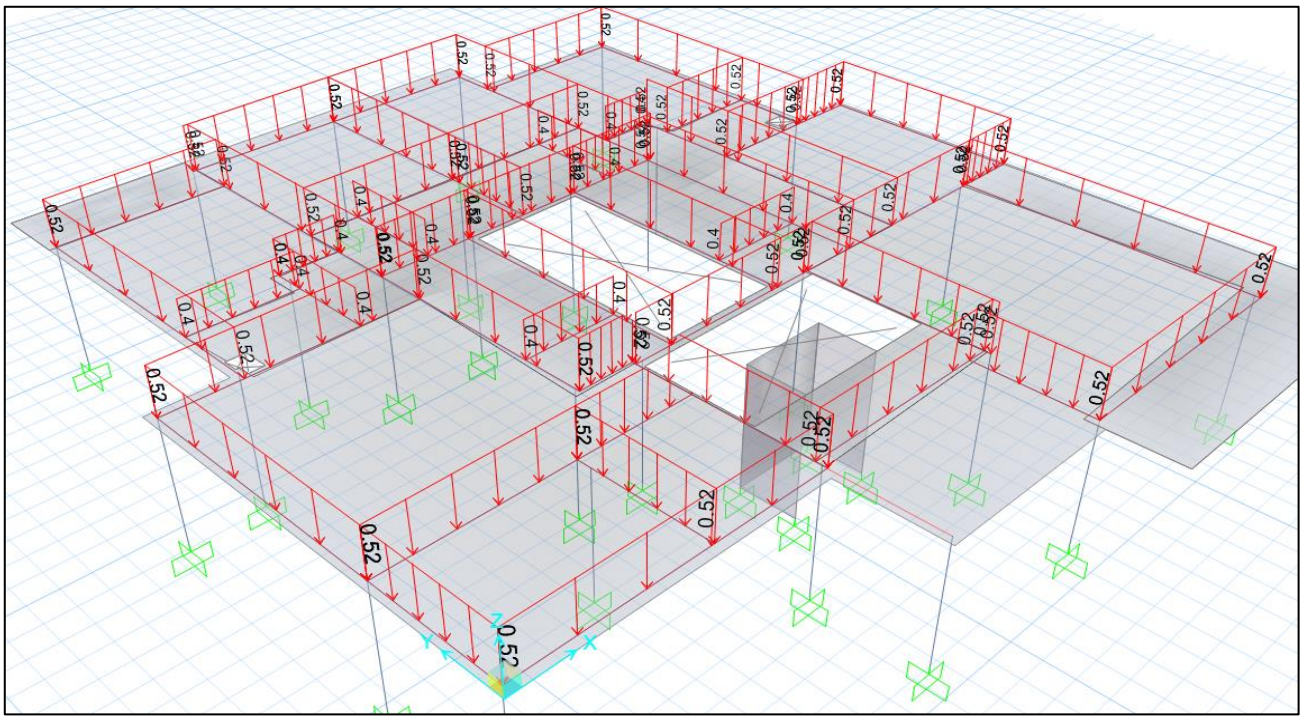
Walls height= 2.5 m , walls density =550 kg/m3 , walls thickness=0.12m
loads of walls without plastering \m'=2.5×0.55×0.12=0.198 t\m'
weight of plastering=0.04×1.8×3=0.21 t\m'
total wall loads\m'=0.40 t\m'

- **BUILDING 1**

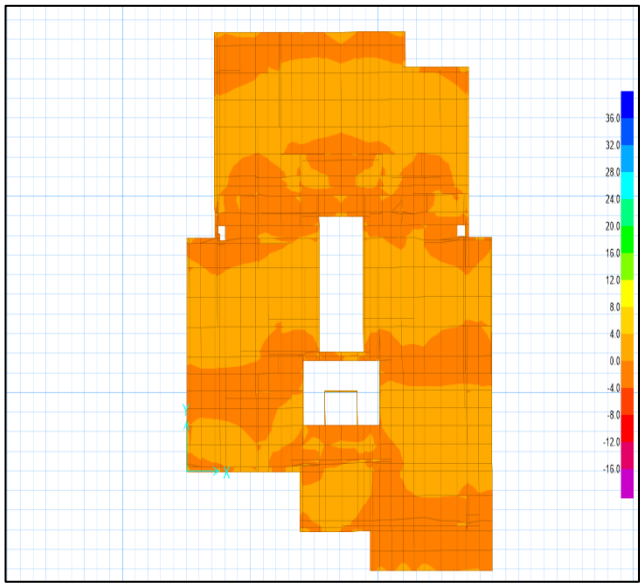
live loads



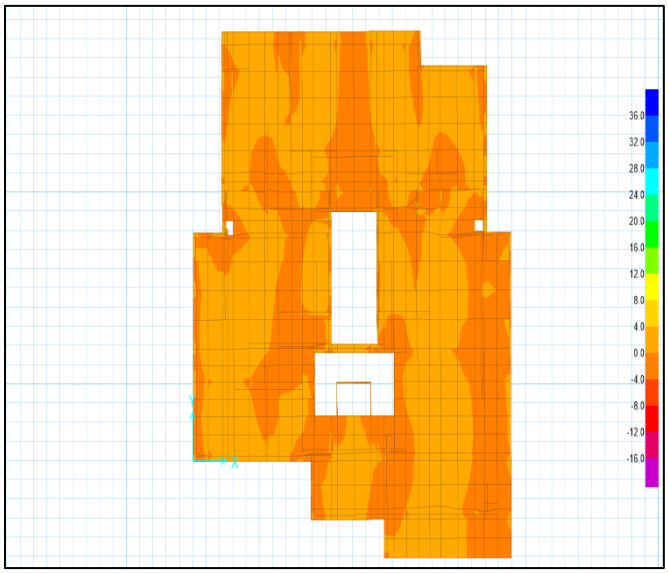
WALL LOADS



M1-1

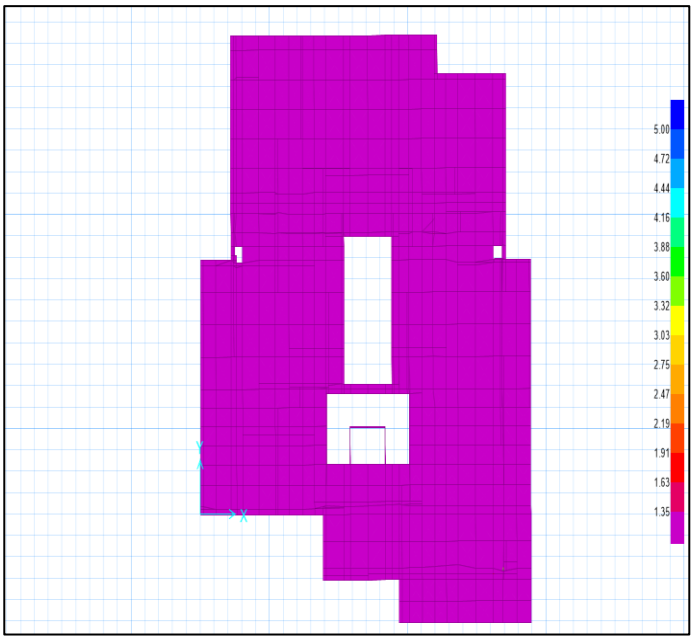


M2-2

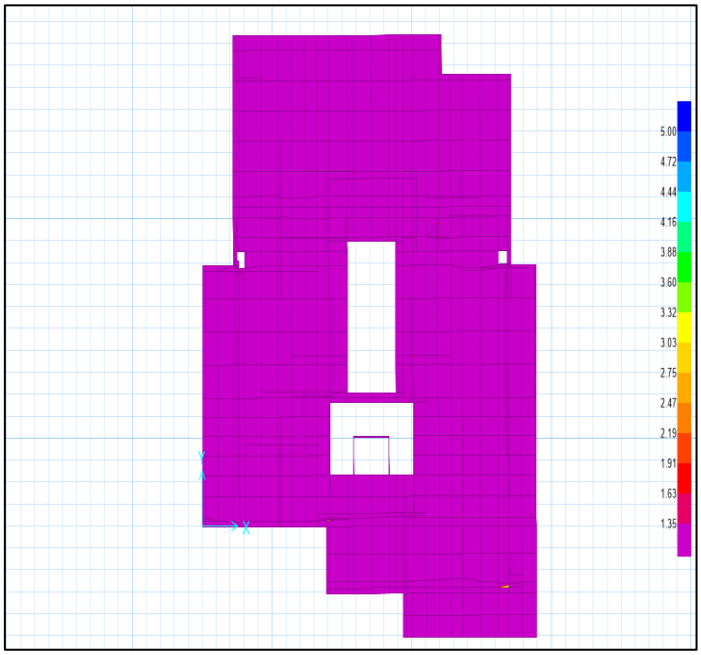


REINFORCMENT WITH BOTTOM MESH T10@165 mm

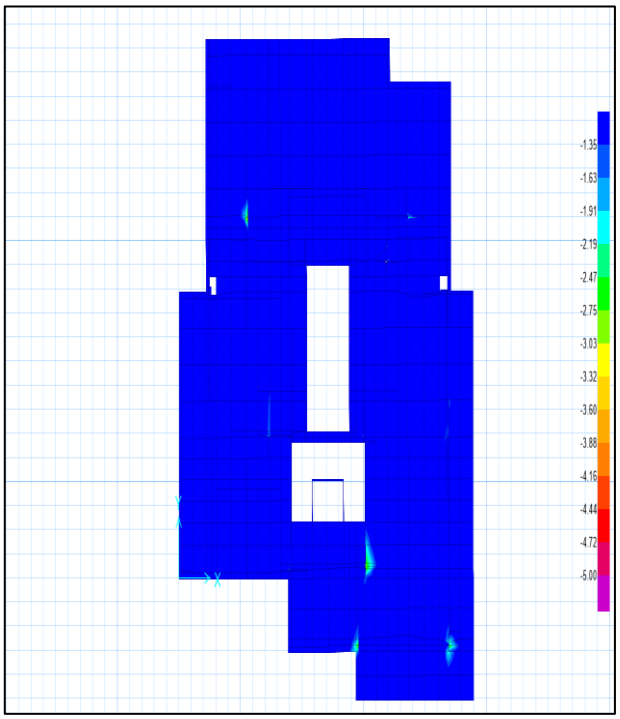
+ve M1-1



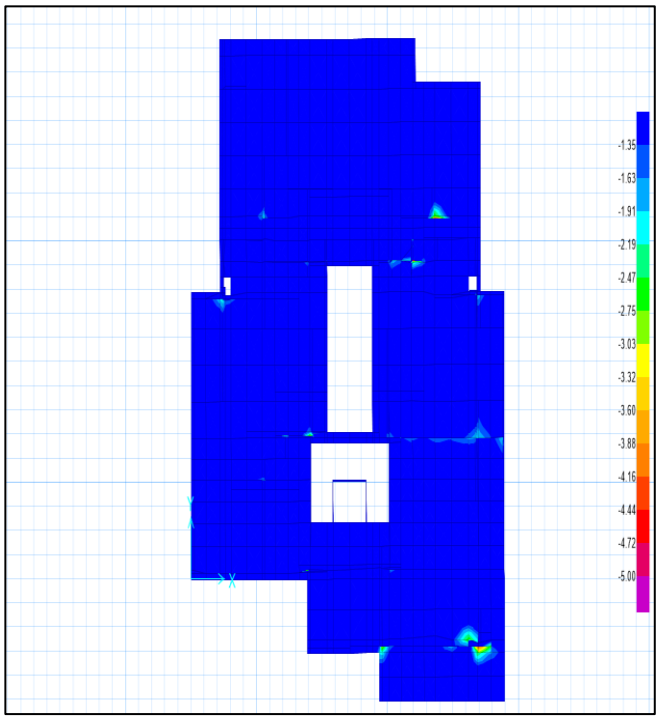
+ve m2-2



-Ve M1-1

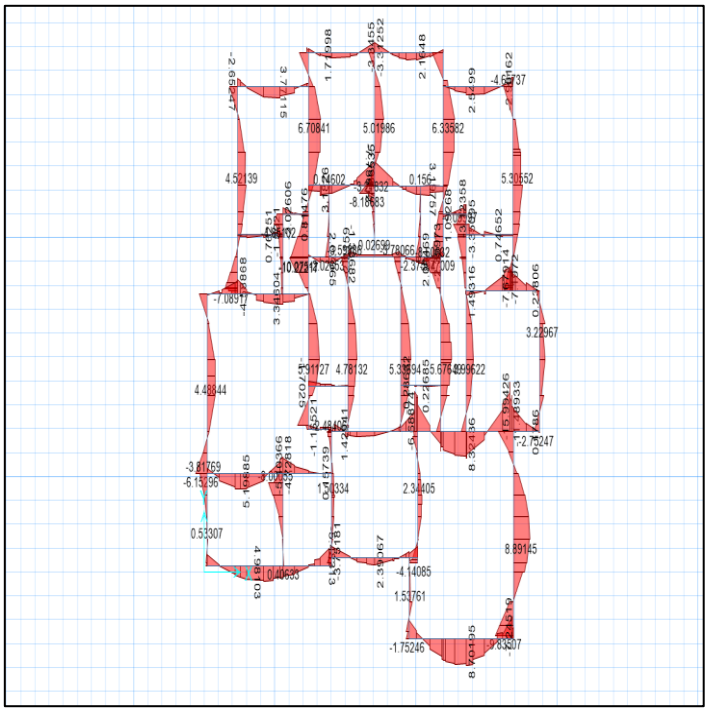


-Ve M2-2

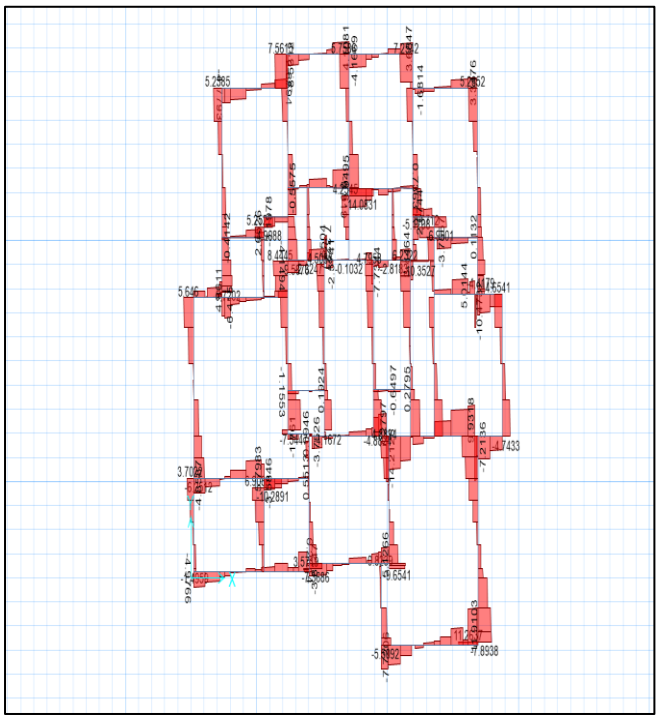


Beams stresses

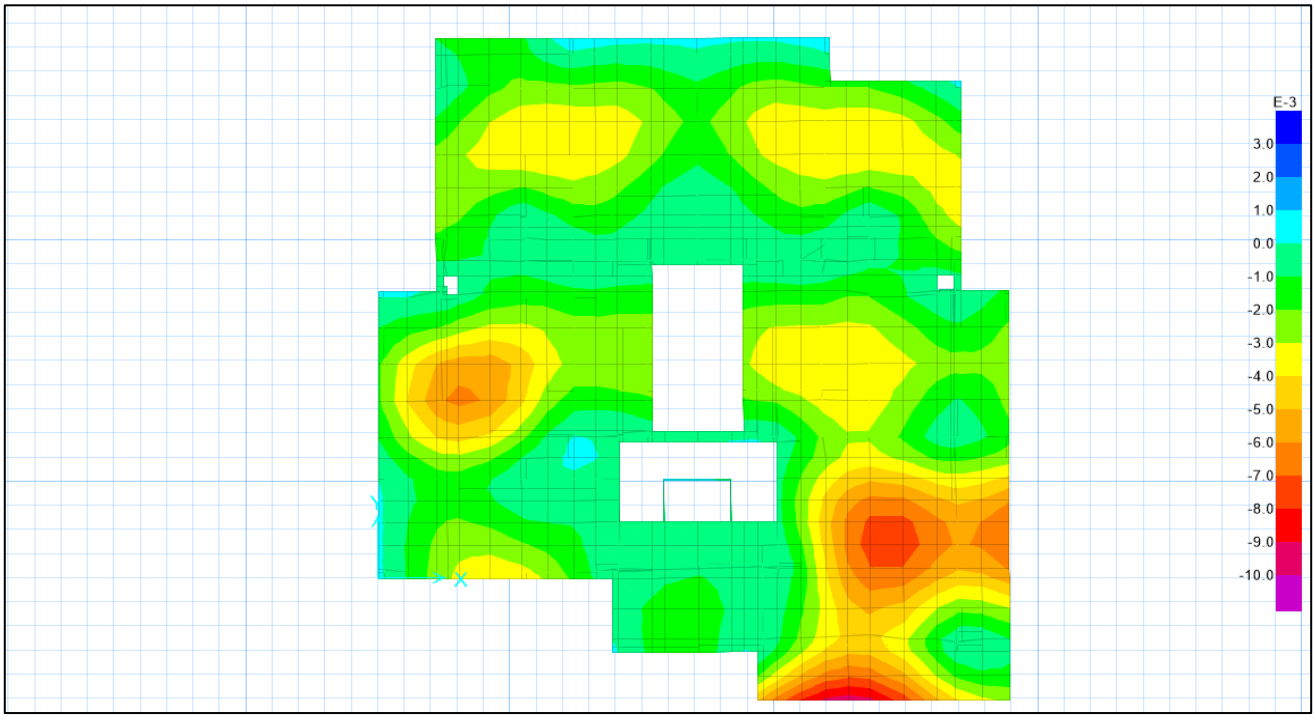
Moment



shear

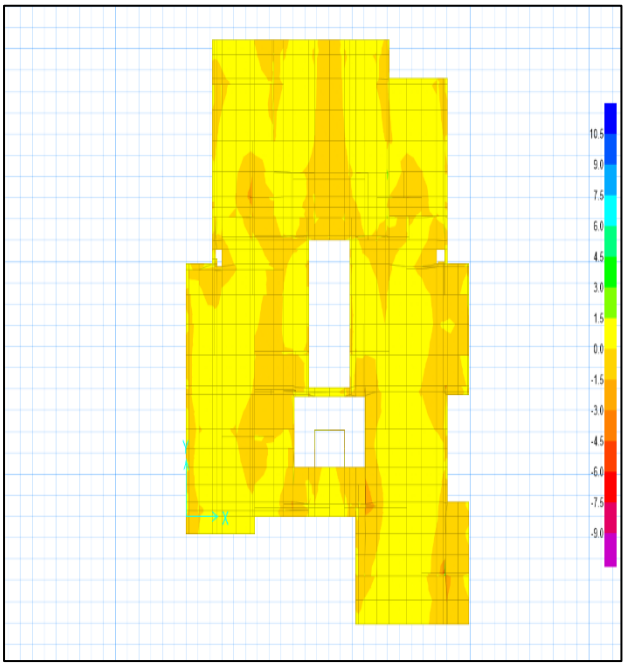


- **Deformations**

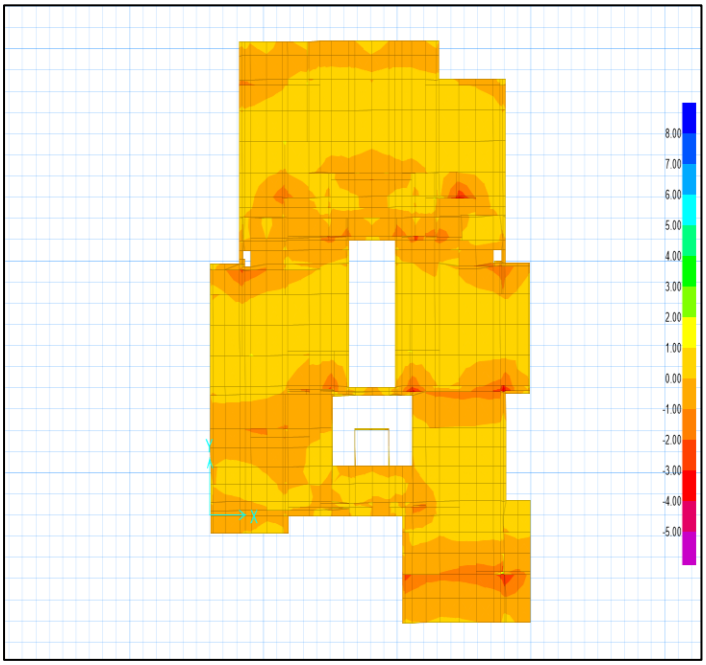


First floor:-

M1-1

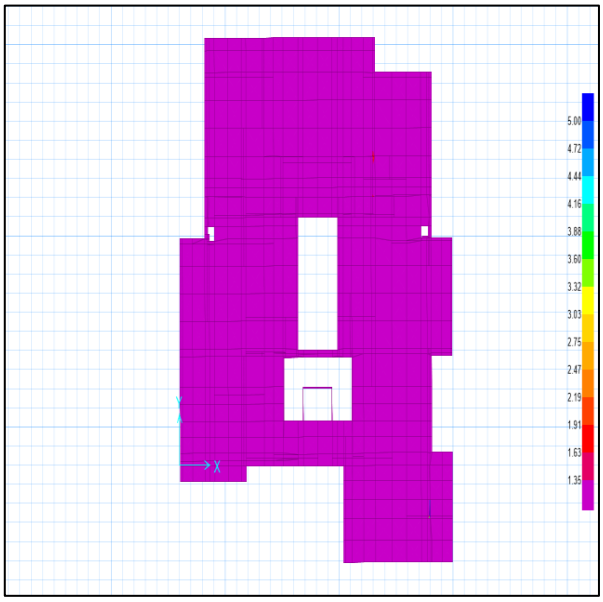


M2-2

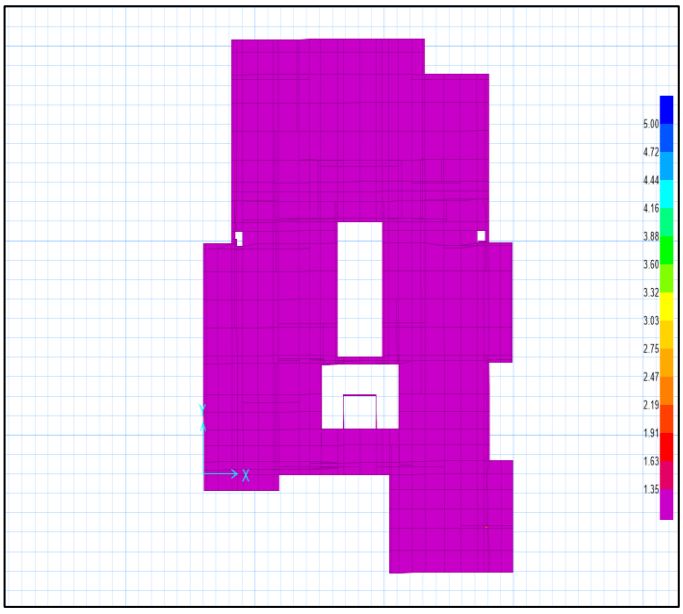


REINFORCMENT WITH BOTTOM MESH T10@165 mm

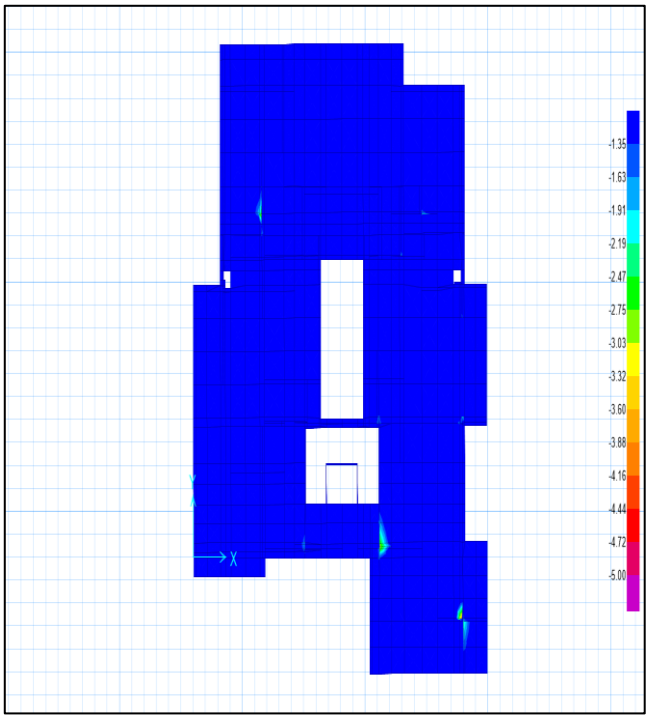
M1-1



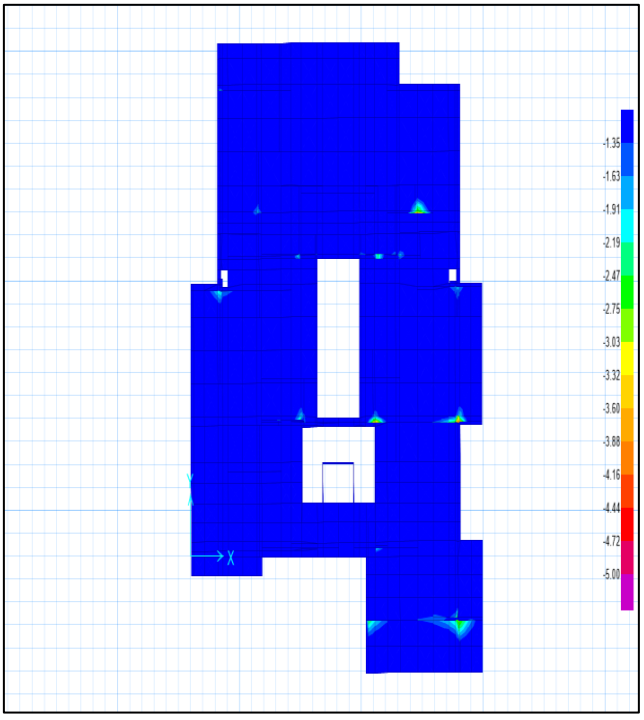
M2-2



-VE M1-1

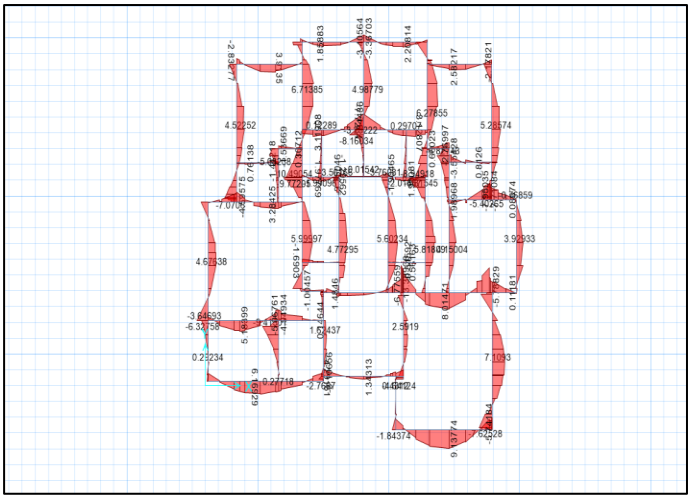


-VE M2-2

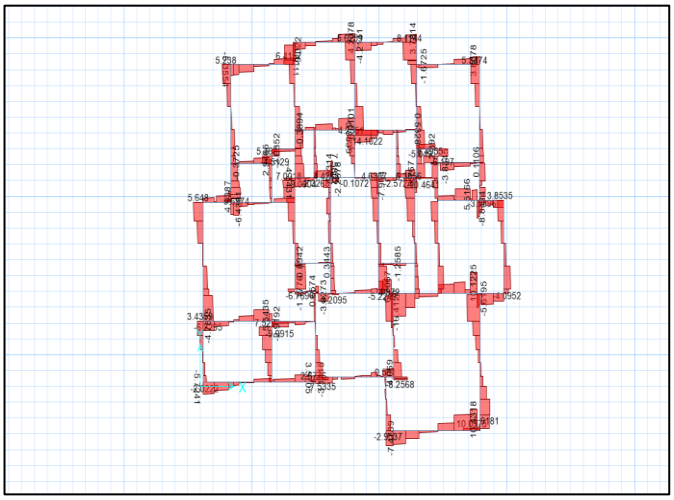


BEAM STRESSES

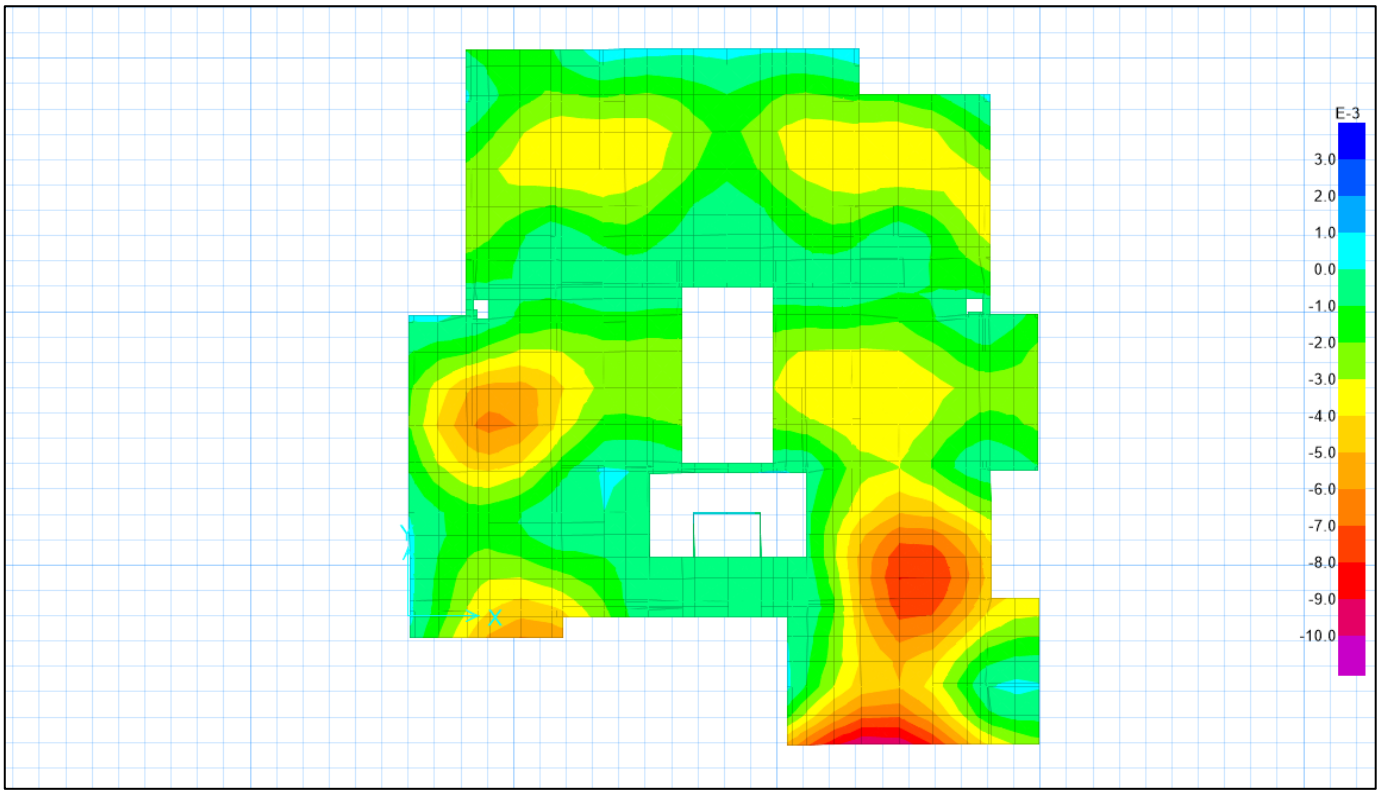
MOMENT



SHEAR

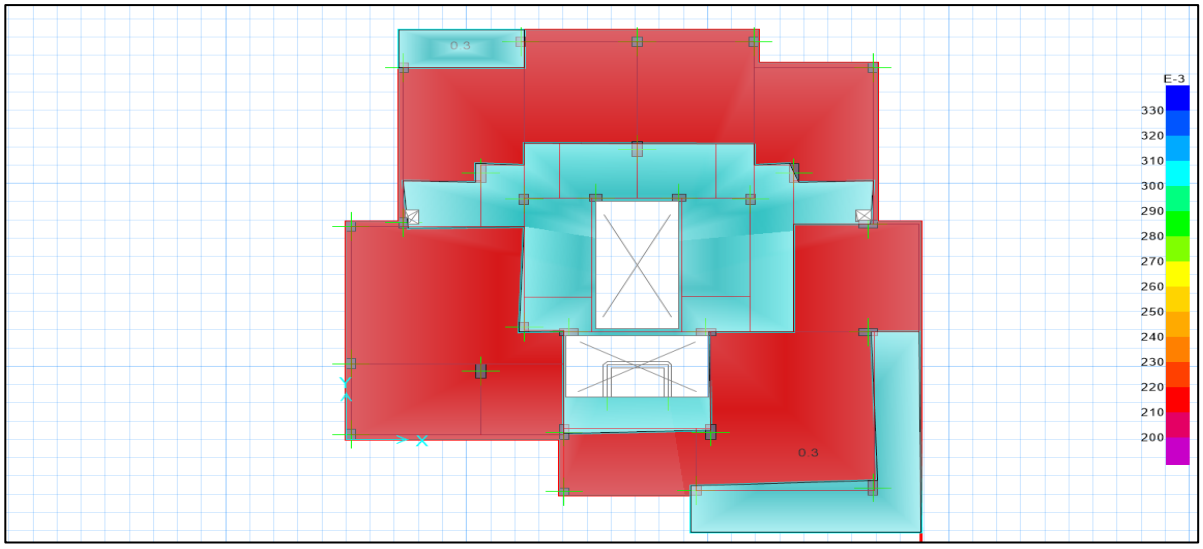


DEFORMATIONS

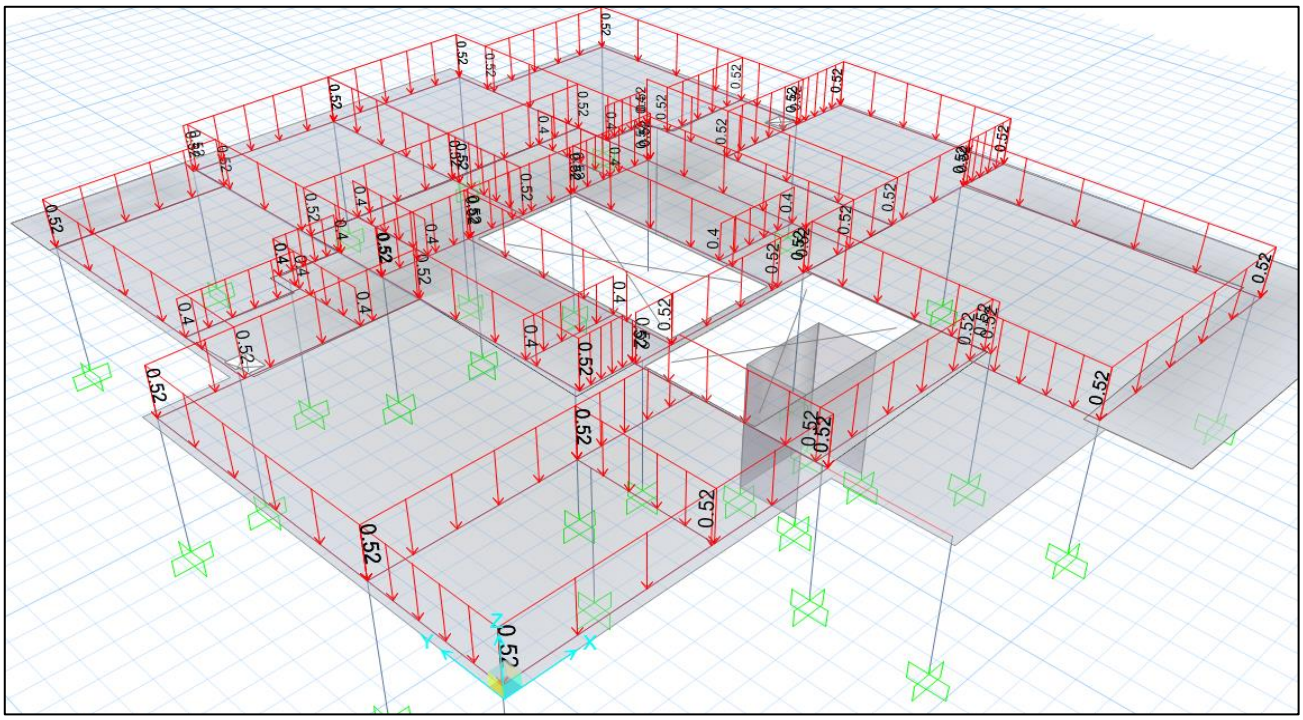


BUILDING 2

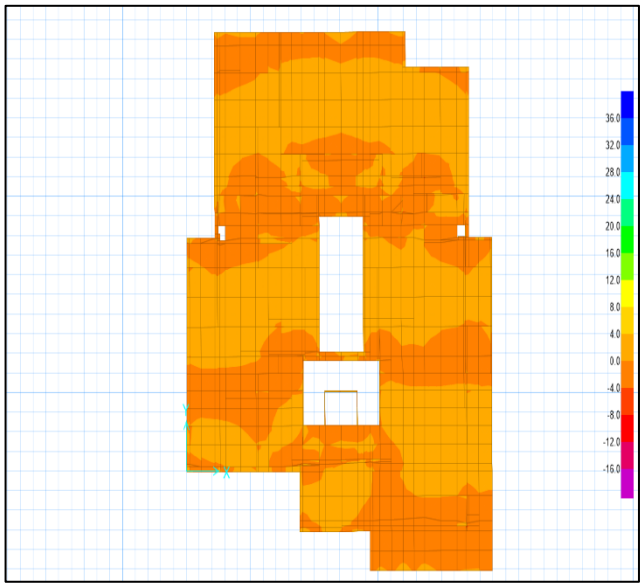
live loads



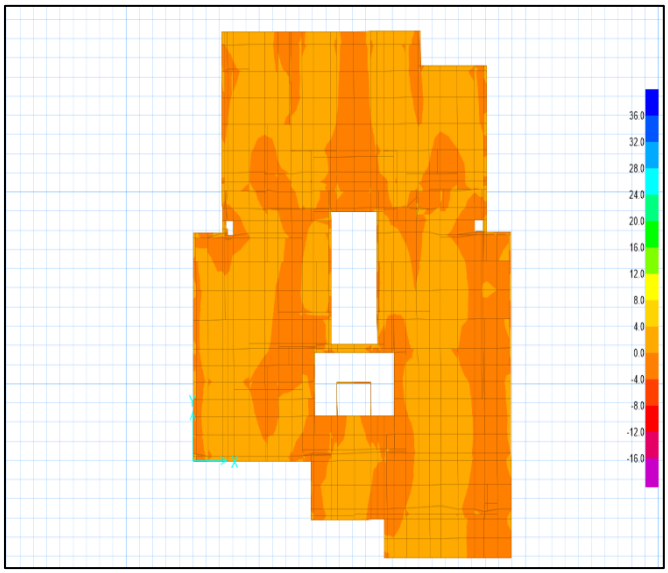
WALL LOADS



M1-1

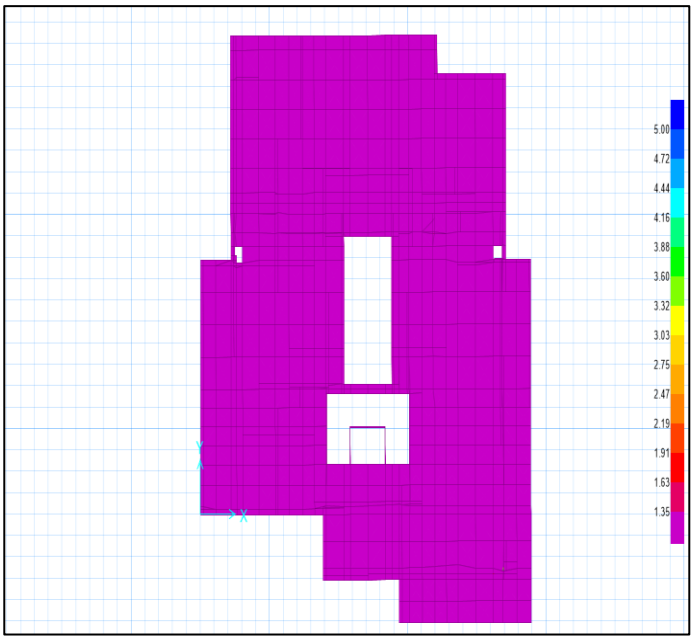


M2-2

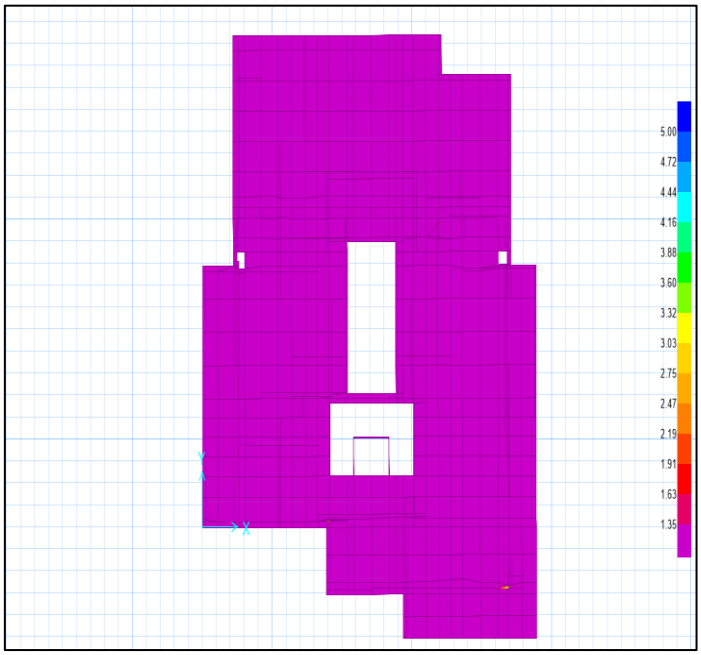


REINFORCMENT WITH BOTTOM MESH T10@165 mm

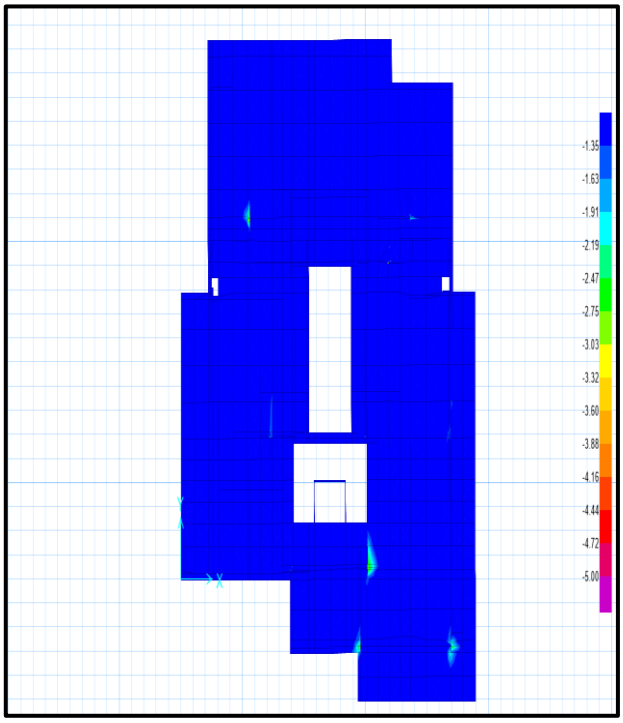
+ve M1-1



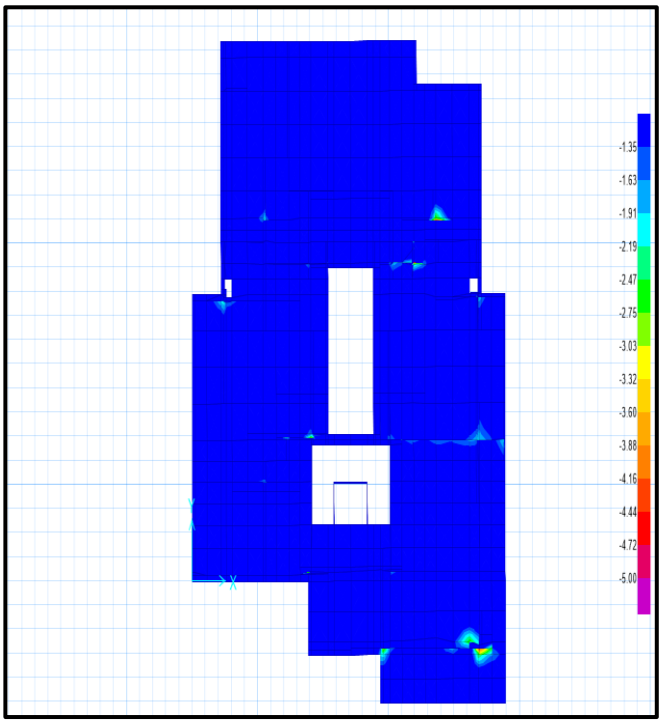
+ve m2-2



-Ve M1-1

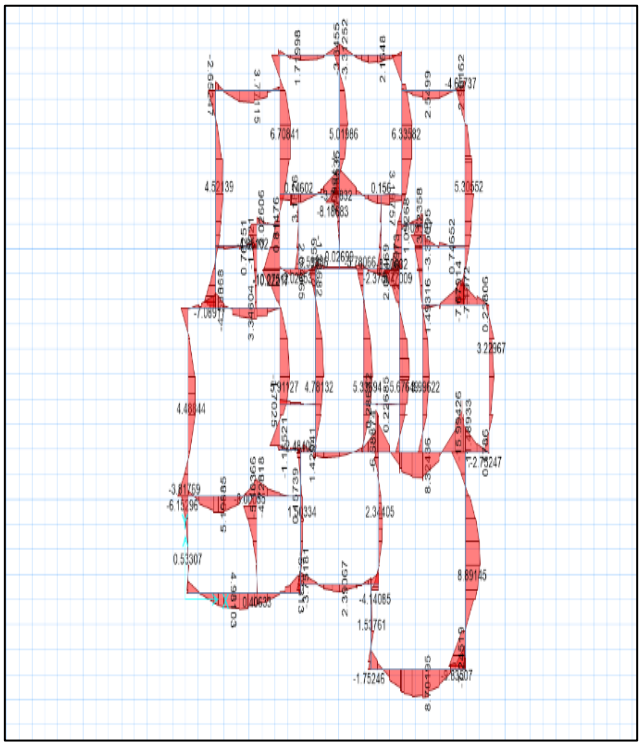


-Ve M2-2

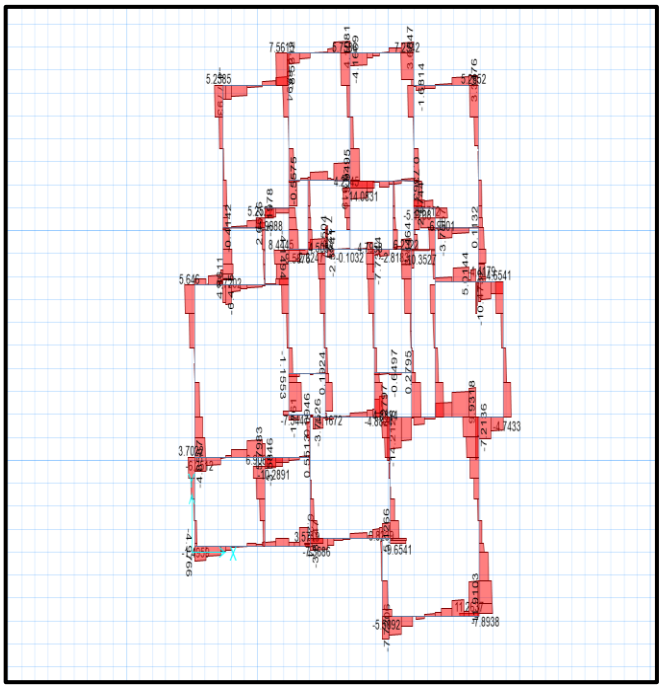


Beams stresses

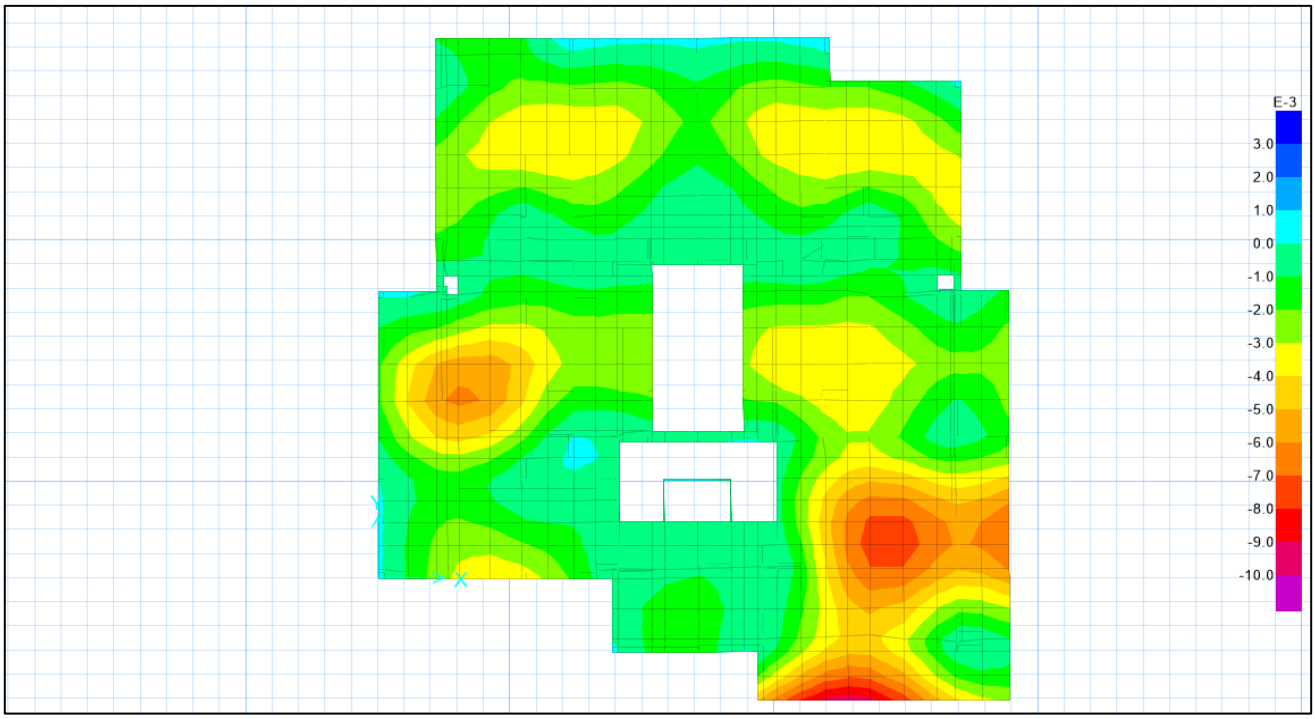
Moment



shear

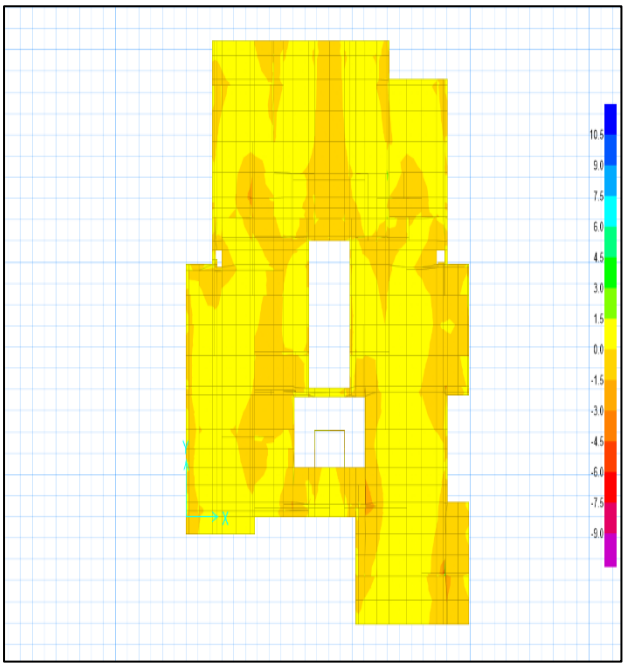


- **Deformations**

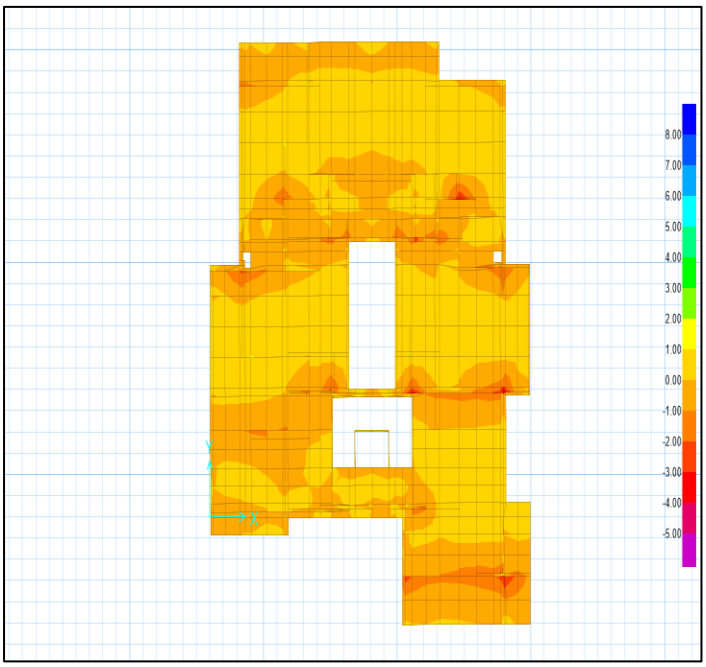


First floor:-

M1-1

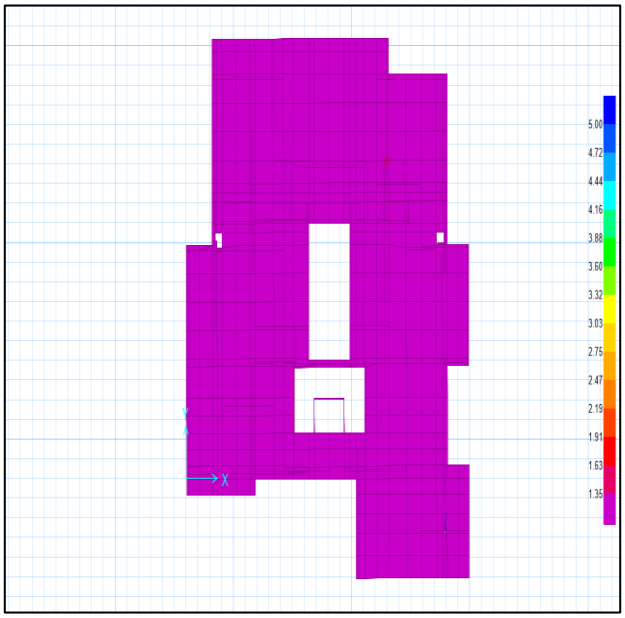


M2-2

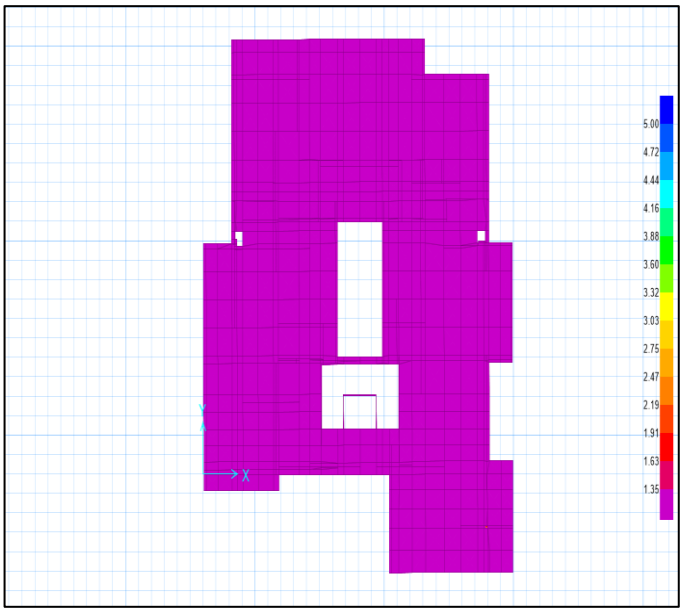


REINFORCMENT WITH BOTTOM MESH T10@165 mm

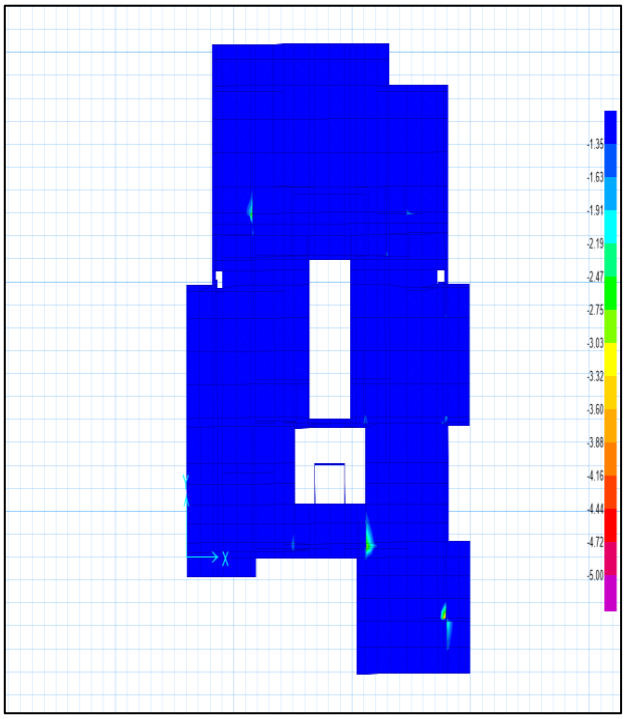
M1-1



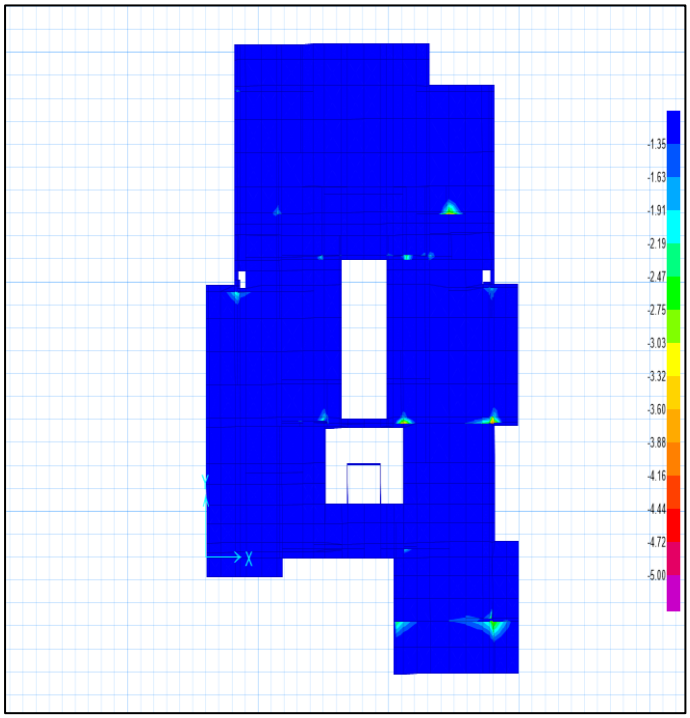
M2-2



-VE M1-1

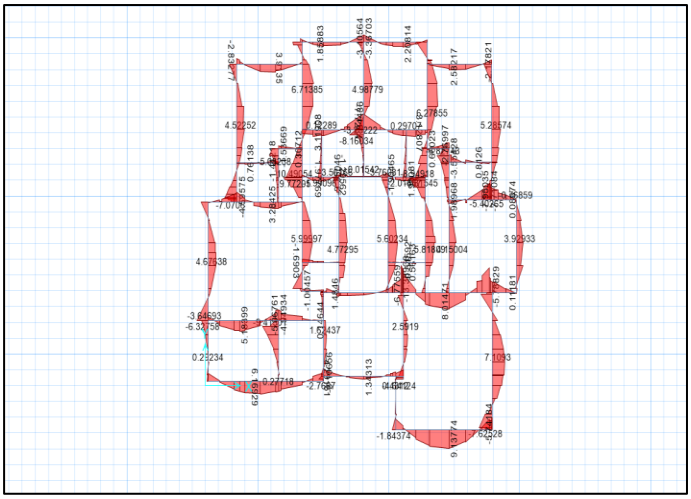


-VE M2-2

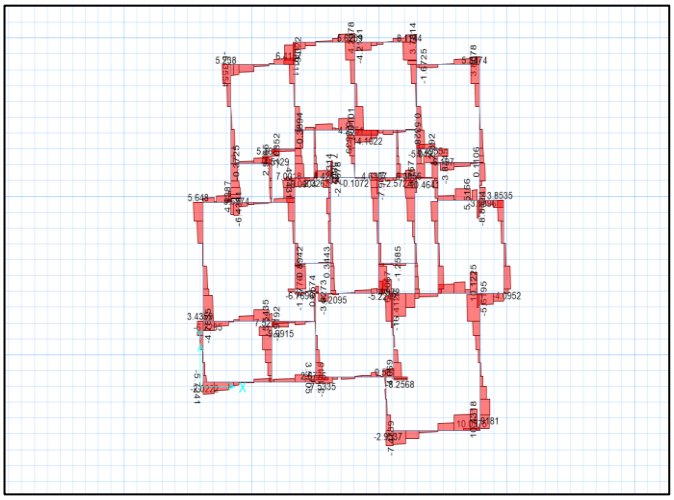


BEAM STRESSES

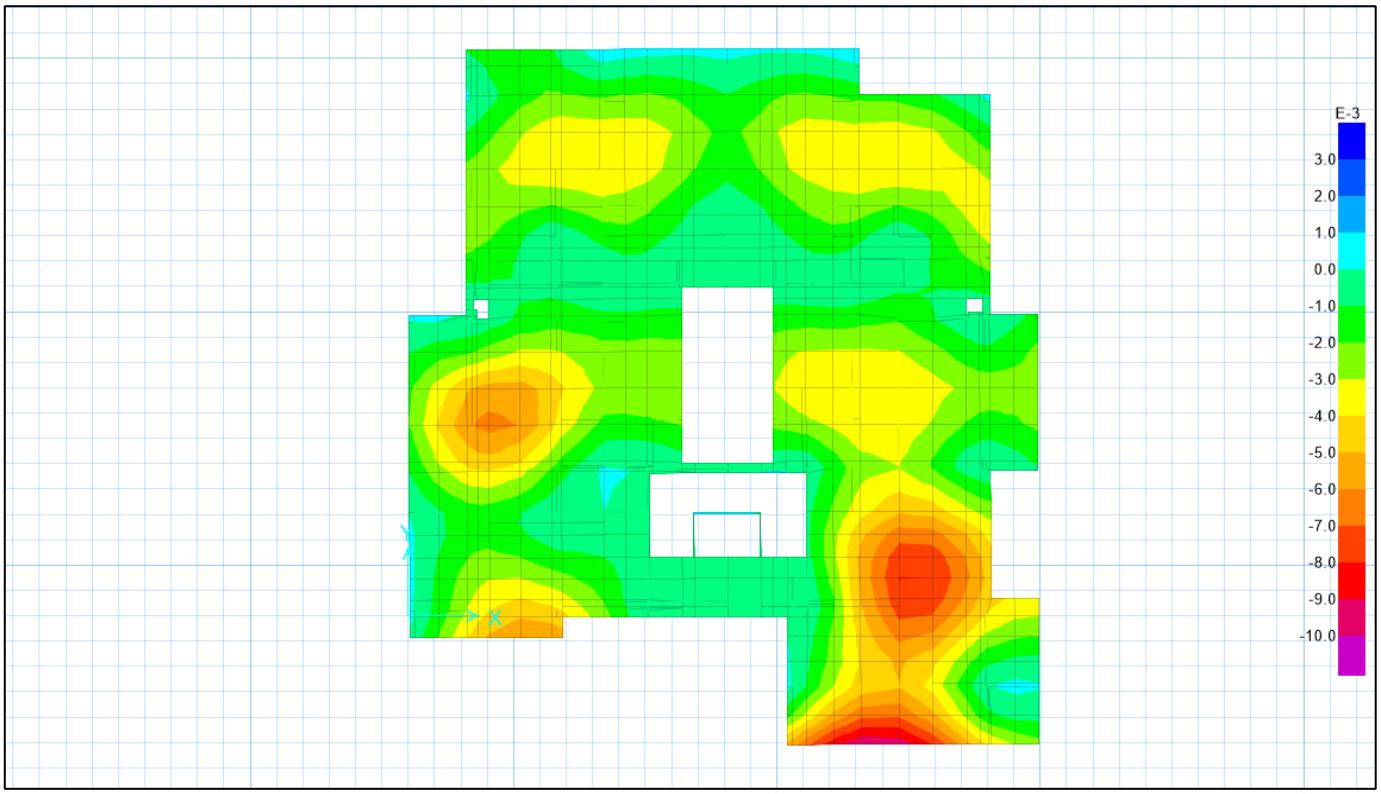
MOMENT



SHEAR

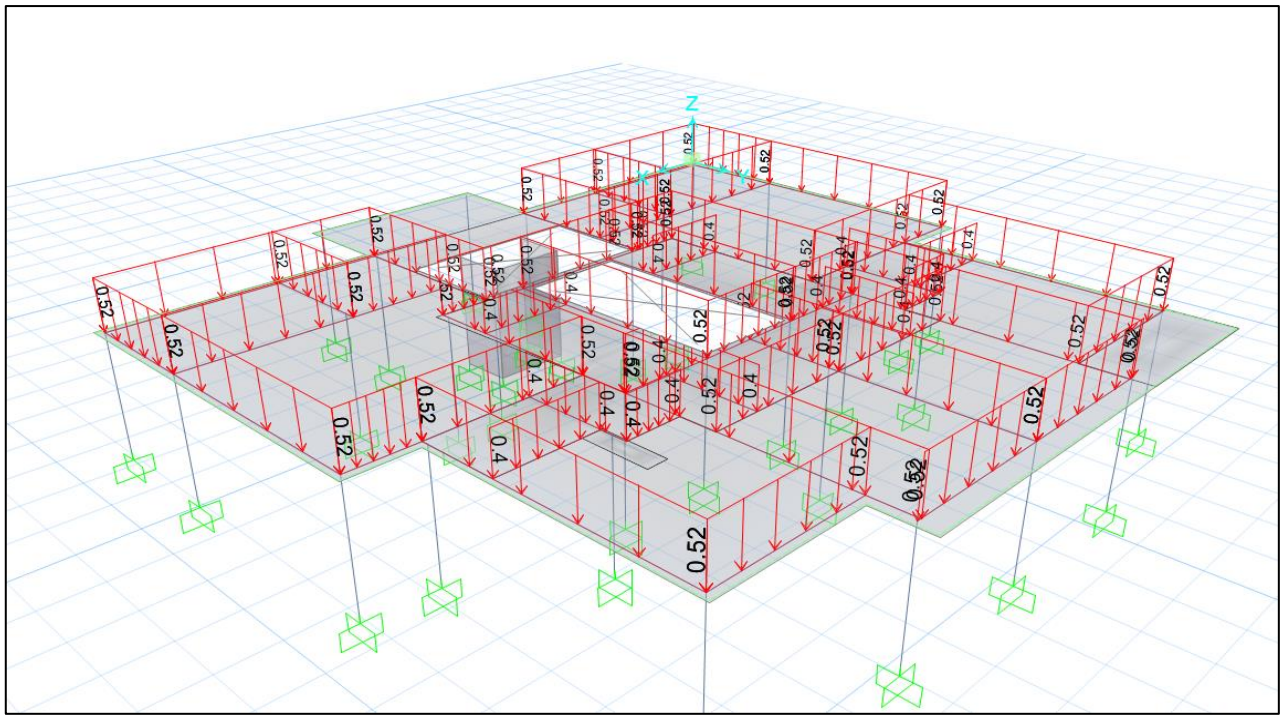


DEFORMATIONS

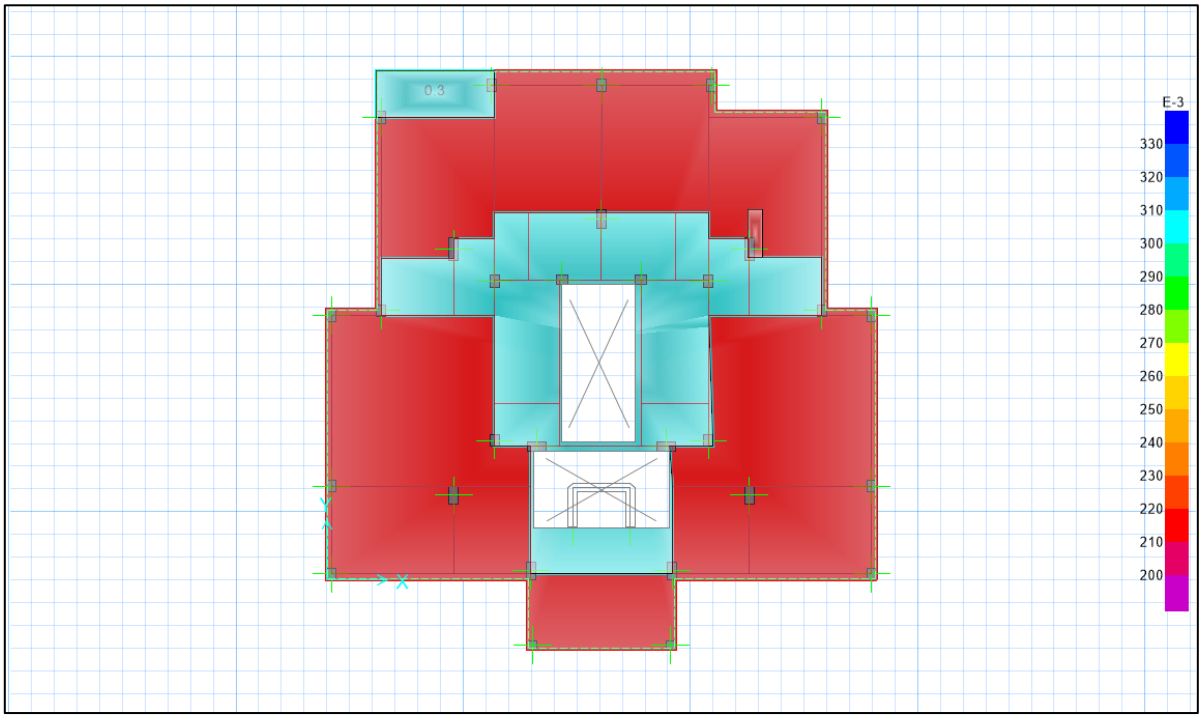


- **BUILDING 2(GROUND FLOOR)**

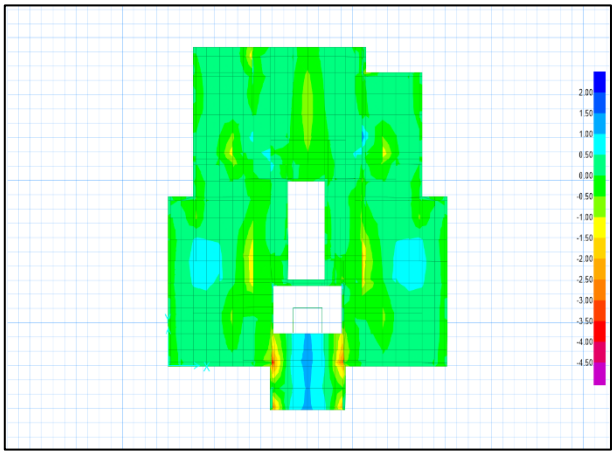
WALL LOADS



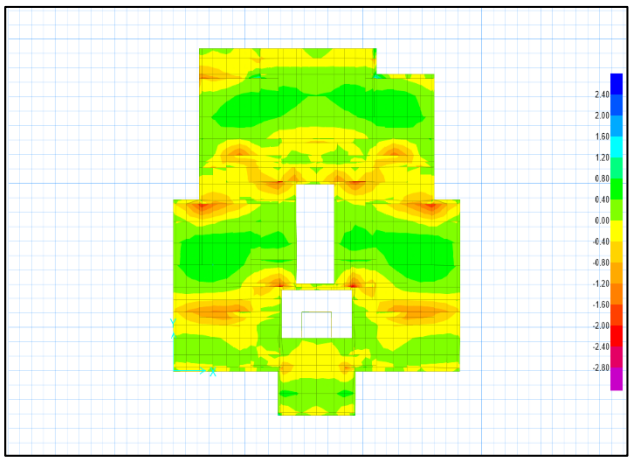
LIVE LOADS



M11 +VE

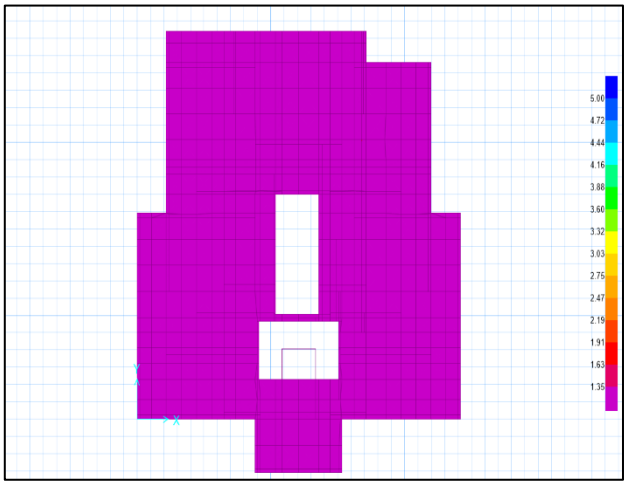


M22+VE

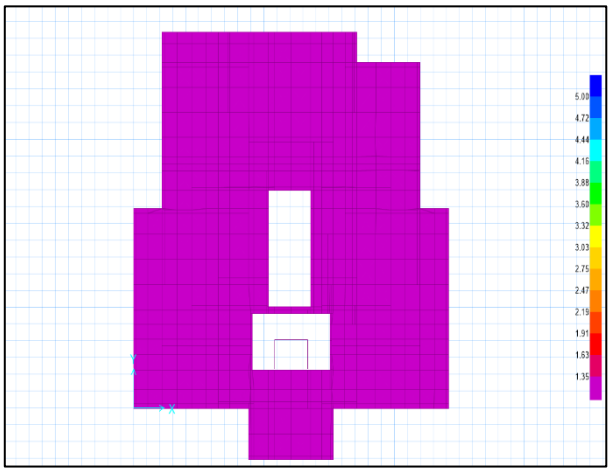


REINFORCMENT WITH BOTTOM MESH T10@165 mm

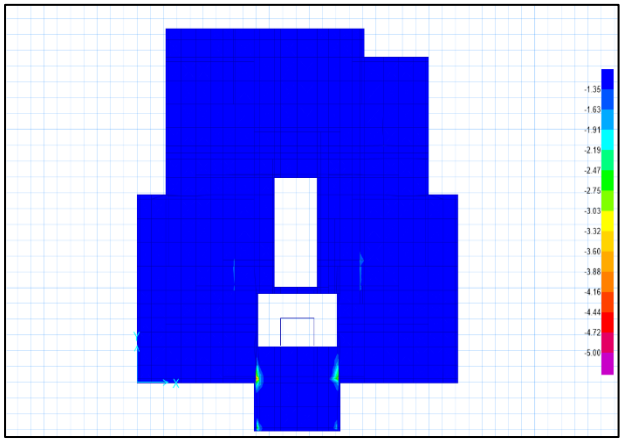
M11 +VE



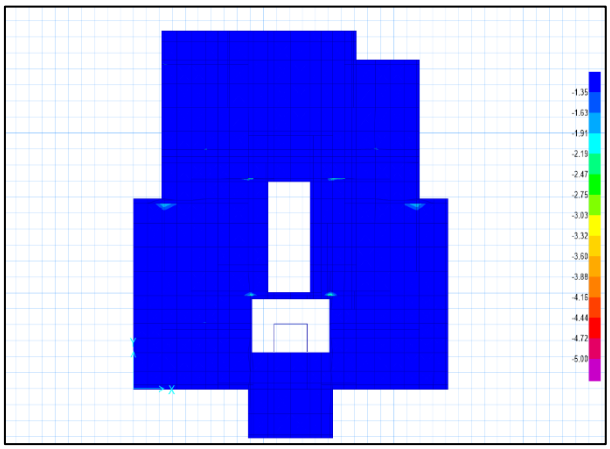
M22 +VE



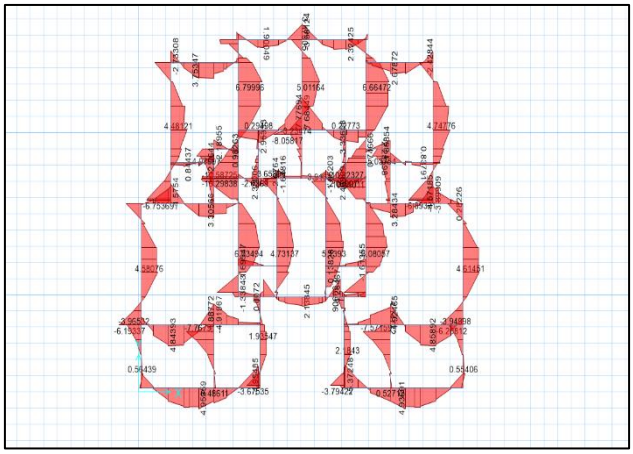
M11-VE



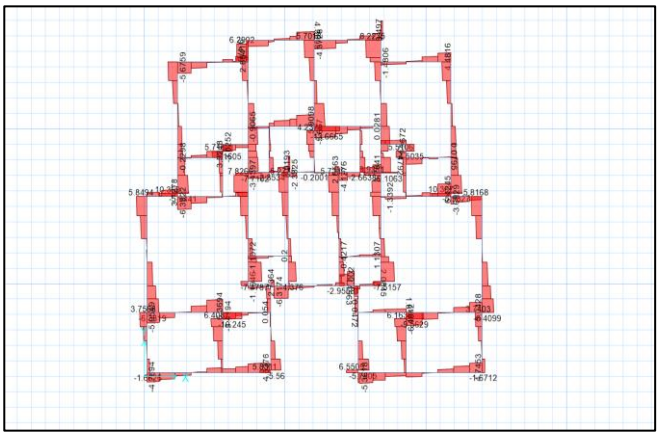
M22-VE

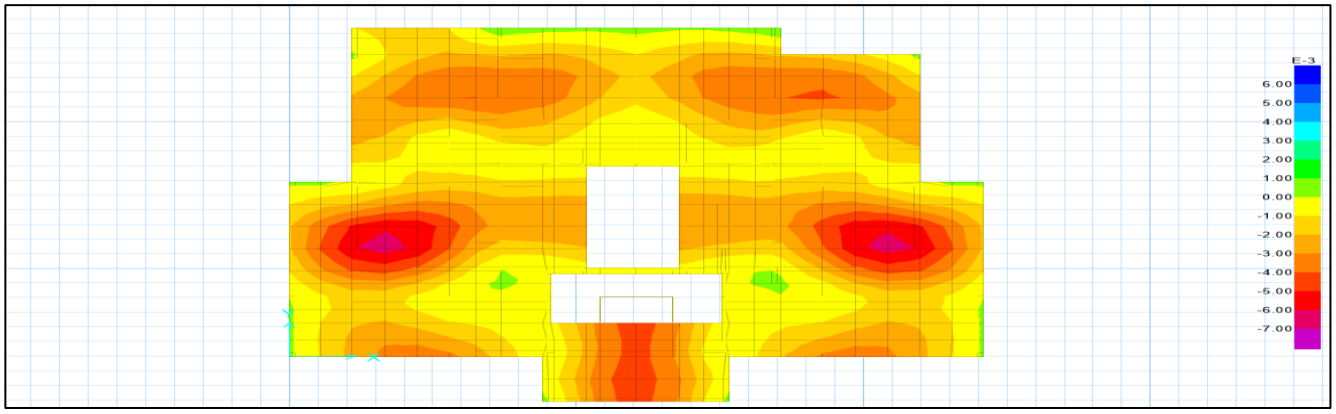


BEAMS MOMENT



BEAMS SHEAR

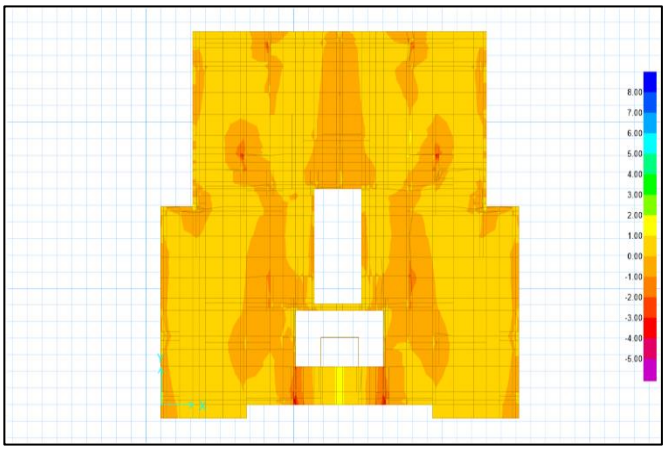




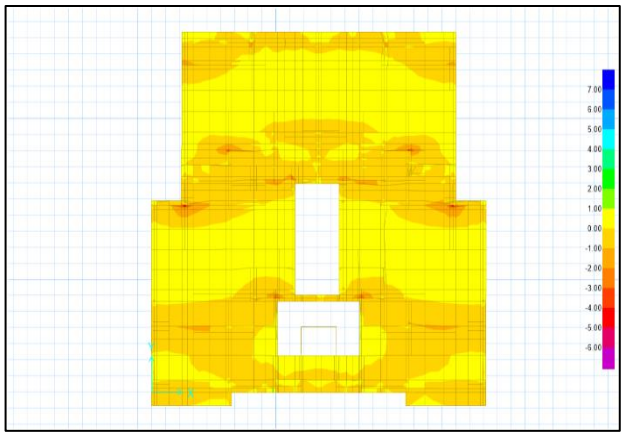
DEFORMATIONS

- **FIRST FLOOR**

M11 +VE

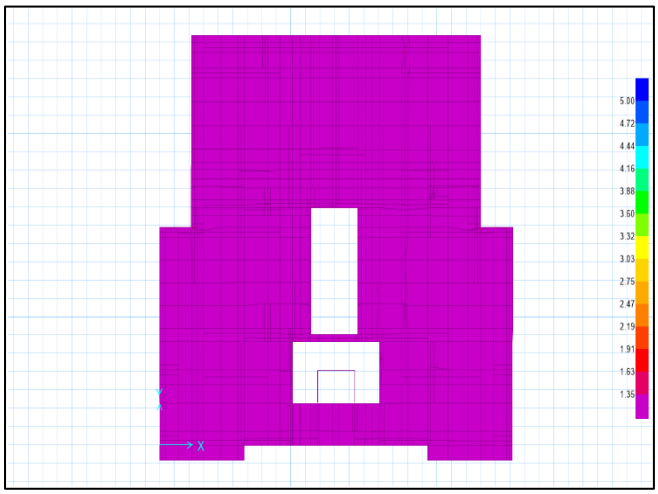


M22 +VE

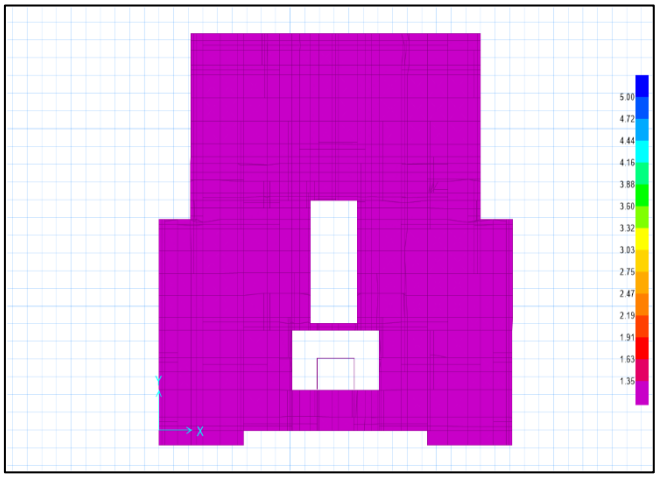


REINFORCMENT WITH BOTTOM MESH T10@165 mm

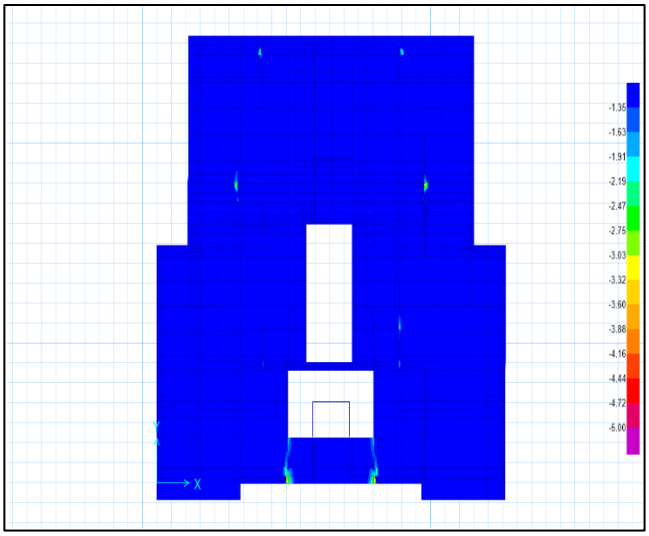
M11 +VE



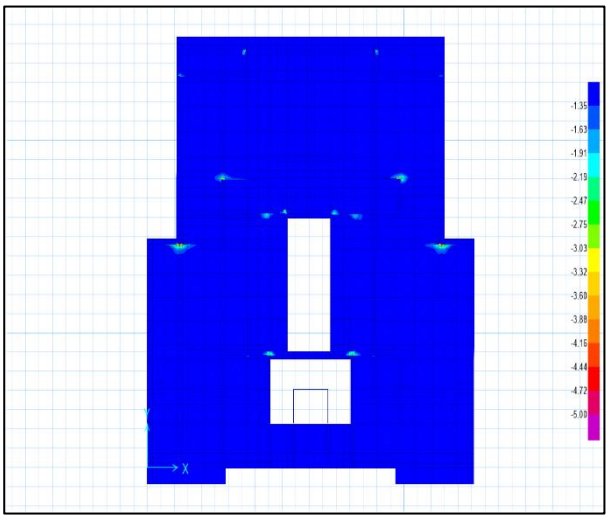
M22 +VE



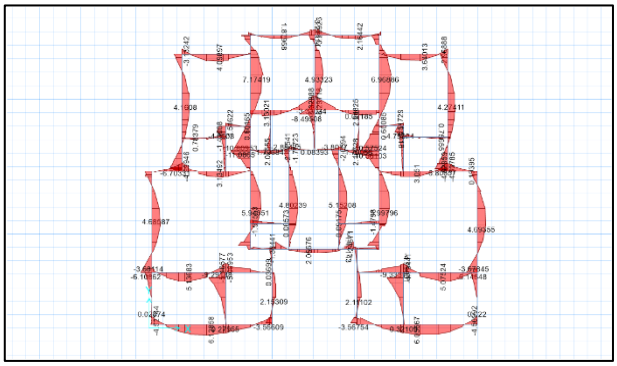
M11-VE



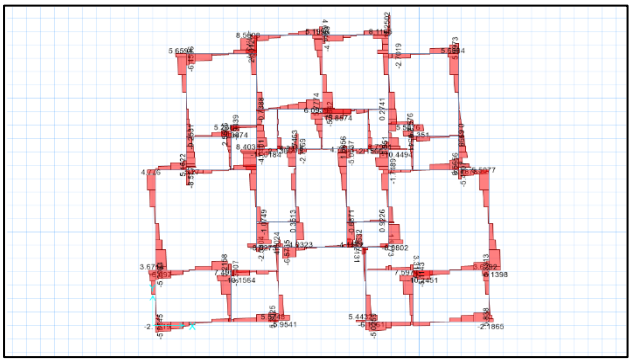
M22 –VE



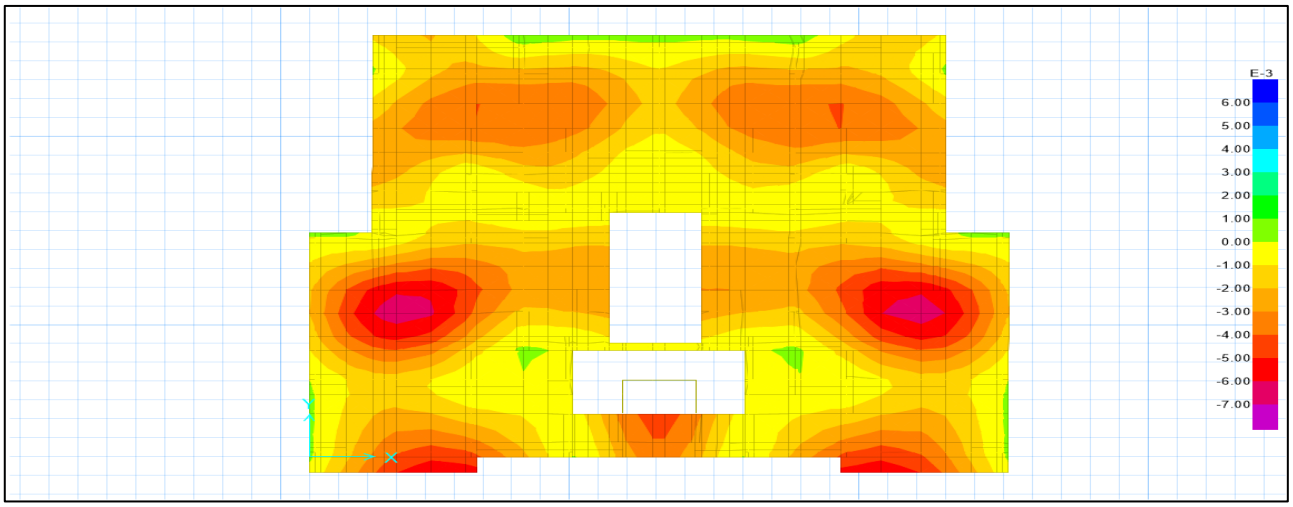
BEAMS MOMENT



BEAMS SHEAR



DEORMATIONS



ANALYSIS and Design OF SLABS , Beams

For The Shown figure (slab & beam stresses and deformations)

Allowable deformations for all slabs as the following

Maximum span =5.6 m

Two way solid slab continuous from one end , Thickness = Ls/40

Ts=5.2/45= 11.5 cm. 14 cm is satisfactory for this spans

Slabs of thickness 12 cm is very satisfied for spans up to 4.8 m

Deformations under loading must to be less than =L/250=2.24 cm .satisfied

WE choose 12 cm thickness of all floors

And 14 cm thickness of spans more than 5.2

And 16 cm thickness for cantilevers

- ### Reinforcement of slabs

BOTTOM mesh 6 Ø10\m'with thickness 12 cm will cover moment 1.35 m.t

BOTTOM mesh 6 Ø10\m'with thickness 14 cm will cover moment 1.63 m.t

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

- **Design of Beams**

Project name :**bo sand**
Location :**north coast**
Beam no :**b1**

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 2.90 m.t. Qu = 10 ton Mt = 0.0 m.t. b = 20 cm d = 45 cm

Design Procedueres

Fy = 3600 kg/cm2 From table get ⟹ Cmax/d = 0.44 and Rmax = 0.1943 Cmin/d = 0.125

μ_{max} = 0.0151 and μmin = 11/ Fy = 0.0031

$$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}} = 19.3 \text{ cm}$$

d = 45 cm Check d'/d ≤ 0.15 ⟹ Fs' = Fy/γs

From d get c/d = 0.125 Check $c_{min}/d < c/d < c_{max}/d$ ⟹ Safe

Mumax1 (moment Capacity for single reinforced section) = Rmax * Fcu/γc * b * d^2 = 15.74 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γ_s * (d - d') = 20.25 m.t.

Check Mu < Mumax1 ========> Single reinforced section

$$As = \frac{Mu}{Fy/\gamma s * d * (1 - 0.4*c/d)} = 2.17 \text{ cm2}$$

As' = 0.15*As = 0.32 cm2

Tension reinforcement

Choosen Φ_{main} = 12 mm ⟹ no. of Bars = 2

As actual = 2.26 cm2

μ = As/(b*d) = 0.003

Compression reinforcement

Choosen $\Phi_{secondary}$ = 10 mm ⟹ no. of Bars = 2

As' actual = 1.57 cm2

μ' = As'/(b*d) = 0.0017

Check μmin < μ < μmax ⟹ Decrease d

Check 0.1μ < μ' < 0.004 ⟹ Increase d

Check of Shear

qu = Qu / (b*d) =	11.11 kg/cm2	
qt = 3*$M_{torsion}$ / (b² * t) =	0.00 kg/cm2	
δsi = ((1+ (qt / qu)²)^0.5)^-1 =	1.000	
δti = ((1+ (qt / qu)²)^0.5)^-1 =	1.000	
q_{cu} = 0.75 * δsi *(Fcu/γ_c)^.5 =	10.61 kg/cm2	
q_{umax} = 2.2* δsi *(Fcu/γ_c)^.5 =	30.00 kg/cm2	≤ 30 kg/cm2
q_{tu} = 0.75 * δti *(Fcu/γ_c)^.5 =	10.61 kg/cm2	
q_{tumax} = 2.2 * δti *(Fcu/γ_c)^.5 =	31.11 kg/cm2	

If qcu < qu < qumax and qtu < qtcu ⟹ Reinforce to resist qu

Closed stirrups for Shear & Torsion

Shear

qsteel = qu - 0.5*qcu = 5.81 kg/cm2

μ = n*Ast_1 / (b * s) = qsteel / (Fystr/γ_s)

b < 40 cm take n = 2 2 Branches

Ast/Ss = 0.028 cm

Choose $\Phi_{stirrups}$ Ø8

No. of stirrups = 100/St + 100/Ss = 5.5342

Use Stirrups 6 Ø8 2 Branches

Torsion

qsteel = tu - 0.5*qtcu = 0.00 kg/cm2

x_1 , y_1 are stirrup dimensions Y1= 40 X1 = 15

α = 0.66 + 0.33* (y_1 / x_1) = 1.5

$$Ast/St = \frac{(qsteel * (b^2*t)/3)}{\alpha_t * x_1 * y_1 * (Fystr/\gamma_s)} = 0.000 \text{ cm}$$

Longitudinal bars for torsion

$$As.l. = \frac{2 * Astr * (x1 + y1) * Fystr.}{S * Fy} = 0.00 \text{ cm2}$$

Choosen $\Phi_{secondary}$ = 10 mm ⟹ no. of Bars = 0

Shrinkage bar

t < 70 no need to shrinkage bar

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name :bo sand
Location :north coast
Beam no :b2

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 4.90 m.t. Qu = 10 ton Mt = 0.0 m.t. b = 20 cm d = 45 cm

Design Procedueres

Fy = 3600 kg/cm2 From table get ⟹ Cmax/d = 0.44 and Rmax = 0.1943 Cmin/d = 0.125

μ_{max} = 0.0151 and μmin = 11/ Fy = 0.0031

$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}}$ = 25.1 cm

d = 45 cm Check d'/d ≤ 0.15 ⟹ Fs' = Fy/γs

From d get c/d = 0.125 Check $c_{min}/d < c/d < c_{max}/d$ ⟹ Safe

Mumax1 (moment Capacity for single reinforced section) = Rmax * Fcu/γc * b * d^2 = 15.74 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γs * (d - d') = 20.25 m.t.

Check Mu < Mumax1 ========> Single reinforced section

$As = \frac{Mu}{Fy/\gamma s * d * (1 - 0.4*c/d)}$ = 3.66 cm2

As' = 0.15*As = 0.55 cm2

Tension reinforcement

Choosen Φ_{main} = 16 mm ⟹ no. of Bars = 2

As actual = 4.02 cm2

μ = As/(b*d) = 0.004

Compression reinforcement

Choosen $\Phi_{secondary}$ = 10 mm ⟹ no. of Bars = 2

As' actual = 1.57 cm2

μ' = As'/(b*d) = 0.0017

Check μmin < μ < μmax ⟹ Safe

Check 0.1μ < μ' < 0.004 ⟹ Safe

Check of Shear

qu = Qu / (b*d) = 11.11 kg/cm2

qt = 3*$M_{torsion}$ / (b² * t) = 0.00 kg/cm2

δsi = ((1+ (qt / qu)²)^0.5)^-1 = 1.000

δti = ((1+ (qt / qu)²)^0.5)^-1 = 1.000

q_{cu} = 0.75 * δsi *(Fcu/γc)^.5 = 10.61 kg/cm2

q_{umax} = 2.2* δsi *(Fcu/γc)^.5 = 30.00 kg/cm2 ≤ 30 kg/cm2

q_{tu} = 0.75 * δti *(Fcu/γc)^.5 = 10.61 kg/cm2

q_{tumax} = 2.2 * δti *(Fcu/γc)^.5 = 31.11 kg/cm2

⟹

If qcu < qu < qumax and qtu < qtcu ⟹ Reinforce to resist qu

⟹

⟹

⟹

Closed stirrups for Shear & Torsion

Shear		Torsion		
qsteel = qu - 0.5*qcu =	5.81 kg/cm2	qsteel = tu - 0.5*qtcu =	0.00 kg/cm2	
μ = n*Ast_1 / (b * s) = qsteel / (Fystr/γs)		x_1 , y_1 are stirrup dimensions		Y1= 40 X1 = 15
b < 40 cm take n = 2	2 Branches	α = 0.66 + 0.33* (y_1 / x_1) =	1.5	
Ast/Ss =	0.028 cm	$Ast/St = \frac{(qsteel * (b^2*t)/3)}{\alpha_t * x_1 * y_1 * (Fystr/\gamma s)}$ =		0.000 cm

Choose $\Phi_{stirrups}$ Ø8

No. of stirrups = 100/St + 100/Ss = 5.5342

Use Stirrups 6 Ø8 2 Branches

Longitudinal bars for torsion

$As.l. = \frac{2 * Astr * (x1 + y1) * Fystr.}{S * Fy}$ = 0.00 cm2

Choosen $\Phi_{secondary}$ = 10 mm ⟹ no. of Bars = 0

Shrinkage bar

t < 70 no need to shrinkage bar

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name :bo sand
Location :north coast
Beam no :b3

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 5.18 m.t. Qu = 10 ton Mt = 0.0 m.t. b = 20 cm d = 45 cm

Design Procedueres

Fy = 3600 kg/cm2 From table get ⟹ Cmax/d = 0.44 and Rmax = 0.1943 Cmin/d = 0.125

μ_{max} = 0.0151 and μmin = 11/ Fy = 0.0031

$$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}} = 25.8 \text{ cm}$$

d = 45 cm Check d'/d ≤ 0.15 ⟹ Fs' = Fy/γs

From d get c/d = 0.126 Check $c_{min}/d < c/d < c_{max}/d$ ⟹ Safe

Mumax1 (moment Capacity for single reinforced section) = Rmax * Fcu/γc * b * d^2 = 15.74 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γs * (d - d') = 20.25 m.t.

Check Mu < Mumax1 =======> Single reinforced section

$$As = \frac{Mu}{Fy/\gamma s * d * (1- 0.4*c/d)} = 3.87 \text{ cm2}$$

As' = 0.15*As = 0.58 cm2

Tension reinforcement

Choosen Φ_{main} = 16 mm ⟹ no. of Bars = 2

As actual = 4.02 cm2

μ = As/(b*d) = 0.004

Compression reinforcement

Choosen $\Phi_{secondary}$ = 10 mm ⟹ no. of Bars = 2

As' actual = 1.57 cm2

μ' = As'/(b*d) = 0.0017

Check μmin < μ < μmax ⟹ Safe

Check 0.1μ < μ' < 0.004 ⟹ Safe

Check of Shear

qu = Qu / (b*d) =	11.11 kg/cm2		
qt = 3*$M_{torsion}$ / (b^2 * t) =	0.00 kg/cm2		
δsi = ((1+ (qt / qu)²)^0.5)^-1 =	1.000		
δti = ((1+ (qt / qu)²)^0.5)^-1 =	1.000		
q_{cu} = 0.75 * δsi *(Fcu/γc)^.5 =	10.61 kg/cm2		
q_{umax} = 2.2* δsi *(Fcu/γc)^.5 =	30.00 kg/cm2	≤ 30 kg/cm2	
q_{tu} = 0.75 * δti *(Fcu/γc)^.5 =	10.61 kg/cm2		
q_{tumax} = 2.2 * δti *(Fcu/γc)^.5 =	31.11 kg/cm2		

⟹

If qcu < qu < qumax and qtu < qtcu ⟹ Reinforce to resist qu

⟹

⟹

⟹

Closed stirrups for Shear & Torsion

Shear	Torsion
qsteel = qu - 0.5*qcu = 5.81 kg/cm2	qsteel = tu - 0.5*qtcu = 0.00 kg/cm2
μ = n*As_1 / (b * s) = qsteel / (Fystr/γ_s)	x_1 , y_1 are stirrup dimensions Y1= 40 X1 = 15
b < 40 cm take n = 2 2 Branches	α = 0.66 + 0.33* (y_1 / x_1) = 1.5
Ast/Ss = 0.028 cm	$Ast/St = \frac{(qsteel * (b^2*t)/3)}{\alpha_t*x_1*y_1* (Fystr/\gamma_s)}$ = 0.000 cm

Choose $\Phi_{stirrups}$ Ø8

No. of stirrups = 100/St + 100/Ss = 5.5342

Use Stirrups 6 Ø8 2 Branches

Longitudinal bars for torsion

$$As.l. = \frac{2 * Astr * (x1 + y1) * Fystr.}{S * Fy} = 0.00 \text{ cm2}$$

Choosen $\Phi_{secondary}$ = 10 mm ⟹ no. of Bars = 0

Shrinkage bar

t < 70 no need to shrinkage bar

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name :bo sand
Location :north coast
Beam no :b4

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 8.05 m.t. Qu = 10 ton Mt = 0.0 m.t. b = 20 cm d = 45 cm

Design Procedueres

Fy = 3600 kg/cm2 From table get ⟹ Cmax/d = 0.44 and Rmax = 0.1943 Cmin/d = 0.125

μ_{max} = 0.0151 and μmin = 11/ Fy = 0.0031

$$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}} = 32.2 \text{ cm}$$

d = 45 cm Check d'/d ≤ 0.15 ⟹ Fs' = Fy/γs

From d get c/d = 0.202 Check $c_{min}/d < c/d < c_{max}/d$ ⟹ Safe

Mumax1 (moment Capacity for single reinforced section) = Rmax * Fcu/γc * b * d^2 = 15.74 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γs * (d - d') = 20.25 m.t.

Check Mu < Mumax1 =======> Single reinforced section

$$As = \frac{Mu}{Fy/\gamma s * d * (1- 0.4*c/d)} = 6.21 \text{ cm2}$$

As' = 0.15*As = 0.93 cm2

Tension reinforcement

Choosen Φ_{main} = 16 mm ⟹ no. of Bars = 4

As actual = 8.05 cm2

μ = As/(b*d) = 0.009

Compression reinforcement

Choosen $\Phi_{secondary}$ = 10 mm ⟹ no. of Bars = 2

As' actual = 1.57 cm2

μ' = As'/(b*d) = 0.0017

Check μmin < μ < μmax ⟹ Safe

Check 0.1μ < μ' < 0.004 ⟹ Safe

Check of Shear

qu = Qu / (b*d) =	11.11 kg/cm2	
qt = 3*$M_{torsion}$ / (b² * t) =	0.00 kg/cm2	
δsi = ((1+ (qt / qu)²)^0.5)^-1 =	1.000	
δti = ((1+ (qt / qu)²)^0.5)^-1 =	1.000	
q_{cu} = 0.75 * δsi *(Fcu/γc)^.5 =	10.61 kg/cm2	
q_{umax} = 2.2* δsi *(Fcu/γc)^.5 =	30.00 kg/cm2	≤ 30 kg/cm2
q_{tu} = 0.75 * δti *(Fcu/γc)^.5 =	10.61 kg/cm2	
q_{tumax} = 2.2 * δti *(Fcu/γc)^.5 =	31.11 kg/cm2	

If qcu < qu < qumax and qtu < qtcu ⟹ Reinforce to resist qu

Closed stirrups for Shear & Torsion

Shear

qsteel = qu - 0.5*qcu = 5.81 kg/cm2

μ = n*Ast_1 / (b * s) = qsteel / (Fystr/γs)

b < 40 cm take n = 2 2 Branches

Ast/Ss = 0.028 cm

Torsion

qsteel = tu - 0.5*qtcu = 0.00 kg/cm2

x_1 , y_1 are stirrup dimensions Y1= 40 X1 = 15

α = 0.66 + 0.33* (y_1 / x_1) = 1.5

$$Ast/St = \frac{(qsteel * (b^2*t)/3)}{\alpha_t * x_1 * y_1 * (Fystr/\gamma_s)} = 0.000 \text{ cm}$$

Choose $\Phi_{stirrups}$ Ø8

No. of stirrups = 100/St + 100/Ss = 5.5342

Use Stirrups 6 Ø8 2 Branches

Longitudinal bars for torsion

$$As.l. = \frac{2 * Astr * (x1 + y1) * Fystr.}{S * Fy} = 0.00 \text{ cm2}$$

Choosen $\Phi_{secondary}$ = 10 mm ⟹ no. of Bars = 0

Shrinkage bar

t < 70 no need to shrinkage bar

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name :bo sand
Location :north coast
Beam no :b5

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 11.68 m.t. Qu = 10 ton Mt = 0.0 m.t. b = 20 cm d = 45 cm

Design Procedueres

Fy = 3600 kg/cm2 From table get ⟹ Cmax/d = 0.44 and Rmax = 0.1943 Cmin/d = 0.125

μ_{max} = 0.0151 and μmin = 11/ Fy = 0.0031

$$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}} = 38.8 \text{ cm}$$

d = 45 cm Check d'/d ≤ 0.15 ⟹ Fs' = Fy/γs

From d get c/d = 0.307 Check $c_{min}/d < c/d < c_{max}/d$ ⟹ Safe

Mumax1 (moment Capacity for single reinforced section) = Rmax * Fcu/γc * b * d^2 = 15.74 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γs * (d - d') = 20.25 m.t.

Check Mu < Mumax1 =======> Single reinforced section

$$As = \frac{Mu}{Fy/\gamma s * d * (1 - 0.4 * c/d)} = 9.45 \text{ cm2}$$

As' = 0.15*As = 1.42 cm2

Tension reinforcement

Choosen Φ_{main} = 18 mm ⟹ no. of Bars = 4

As actual = 10.18 cm2

μ = As/(b*d) = 0.011

Compression reinforcement

Choosen $\Phi_{secondary}$ = 10 mm ⟹ no. of Bars = 2

As' actual = 1.57 cm2

μ' = As'/(b*d) = 0.0017

Check μmin < μ < μmax ⟹ Safe

Check 0.1μ < μ' < 0.004 ⟹ Safe

Check of Shear

qu = Qu / (b*d) = 11.11 kg/cm2

qt = 3*$M_{torsion}$ / (b^2 * t) = 0.00 kg/cm2

δsi = ((1+ (qt / qu)²)^0.5)^-1 = 1.000

δti = ((1+ (qt / qu)²)^0.5)^-1 = 1.000

q_{cu} = 0.75 * δsi *(Fcu/γ_c)^.5 = 10.61 kg/cm2

q_{umax} = 2.2* δsi *(Fcu/γ_c)^.5 = 30.00 kg/cm2 ≤ 30 kg/cm2

q_{tu} = 0.75 * δti *(Fcu/γ_c)^.5 = 10.61 kg/cm2

q_{tumax} = 2.2 * δti *(Fcu/γ_c)^.5 = 31.11 kg/cm2

⟹

If qcu < qu < qumax and qtu < qtcu ⟹ Reinforce to resist qu

⟹

⟹

⟹

Closed stirrups for Shear & Torsion

Shear		Torsion		
qsteel = qu - 0.5*qcu =	5.81 kg/cm2	qsteel = tu - 0.5*qtcu =	0.00 kg/cm2	
μ = n*Ast_1 / (b * s) = qsteel / (Fystr/γ_s)		x_1 , y_1 are stirrup dimensions		Y1= 40 X1 = 15
b < 40 cm take n = 2	2 Branches	α = 0.66 + 0.33* (y_1 / x_1) =	1.5	
Ast/Ss =	0.028 cm	$Ast/St = \frac{(qsteel * (b^2 * t)/3)}{\alpha_t * x_1 * y_1 * (Fystr/\gamma_s)}$ =	0.000 cm	

Choose $\Phi_{stirrups}$ Ø8

No. of stirrups = 100/St + 100/Ss = 5.5342

Use Stirrups 6 Ø8 2 Branches

Longitudinal bars for torsion

$$As.l. = \frac{2 * Astr * (x1 + y1) * Fystr.}{S * Fy} = 0.00 \text{ cm2}$$

Choosen $\Phi_{secondary}$ = 10 mm ⟹ no. of Bars = 0

Shrinkage bar

t < 70 no need to shrinkage bar

QS, Comparison & Conclusion

ONE BUILDING (B3, GROUND +3 MUILTI STORIES)

1. FOUNDATIONS

1. Plain concrete

	DELTA BLOCK	CLAY BRICKS
TOTAL QUANTITY OF PC\M3	189.872	185.99
Difference	4	
% OF SAVING	------	

2. Reinforced concrete

	DELTA BLOCK	CLAY BRICKS
TOTAL QUANTITY OF RC\M3	144.8	160
QUANTITY OF SAVING	15.2	
% OF SAVING	9.5%	

2. COLUMNS AND WALLS

	DELTA BLOCK	CLAY BRICKS
TOTAL QUANTITY OF RC IN M3	165.5	174.1
QUANTITY OF SAVING	8.6	
% OF SAVING	4.94%	

3. FLOORS AND BEAMS

	DELTA BLOCK	CLAY BRICKS
Total quantity of concrete/GROUND	148.13	171.6
Total saving	23.47	
% of saving	13.6%	
Total quantity of concrete/FIRST	147.35	169.31
Total saving	21.96	
% of saving	12.9%	
Total quantity of concrete/SECOND	147.35	169.31
Total saving	21.96	
% of saving	12.9%	
Total quantity of concrete/THIRD	138.55	160.05
Total saving	21.5	
% of saving	13.4%	
Total quantity of saving/floors	88.89	
TOTAL % OF SAVING IN FLOORS	13.26%	

4. REINFORCEMENT		
	DELTA BLOCK	CLAY BRICKS
TOTAL QUANTITY OF STEEL IN FOUNDATIONS	15.92	19.28
% OF REINFORCEMENT IN FOUNDATIONS KG/M3	109.9	120.5
QUANTITY OF SAVING	3.36	
% OF SAVING	17.4%	
TOTAL QUANTITY OF STEEL IN WALLS & COL TON	32.56	33.36
% OF REINFORCEMENT IN COLUMNS &WALLS	197.3 KG/M3	191 KG/M3
QUANTITY OF SAVING	0.8	
% OF SAVING	2.4%	
TOTAL QUANTITY OF STEEL IN GROUND FLOOR TON	14.4	17.504
% OF REINFORCEMENT IN GROUND FLOOR TON	97.2KG/M3	102.0KG/M3
QUANTITY OF SAVING	3.105	
% OF SAVING	17.7%	
TOTAL QUANTITY OF STEEL IN FIRST FLOOR TON	14.43	16.92
% OF REINFORCEMENT IN FIRST FLOOR	97.9KG/M3	99.89KG/M3
QUANTITY OF SAVING	2.49	
% OF SAVING	14.71%	
TOTAL QUANTITY OF STEEL IN SECOND FLOOR TON	14.43	16.92
% OF REINFORCEMENT IN SECOND FLOOR	97.9KG/M3	99.89KG/M3
QUANTITY OF SAVING	2.49	
% OF SAVING	14.71%	
TOTAL QUANTITY OF STEEL IN third FLOOR TON	14.4	16.2
% OF REINFORCEMENT IN third FLOOR	103.94KG/M3	131.12KG/M3
QUANTITY OF SAVING	2.2	
% OF SAVING	13.58	
TOTAL QUANTITY OF SAVING	14.445	
TOTAL % OF SAVING	12.01%	

5. walls

	DELTA BLOCK	CLAY BRICKS
TOTAL OF QUANTITY 20 CM M3	487.2	487.2
TOTAL OF QUANTITY 12 CM M3	267	267
TOTAL OF QUANTITY M3	754.2	754.2
PRICE/M3 INCLUDED VAT 14%	820	446
TOTAL PRICE OF MASONRY (EGP)	618,444	336,373.2
TOTAL QUANTITY OF DELTA MORTAR	15.1 ton	84.8 ton
TOTAL PRICE OF DELTA MORTAR	33,975	106,000
TOTAL SAVING in	72,025	
%OF TOTAL SAVING	67.95 %	

TOTAL COST OF ONE BUILDING TYPE B3

	DELTA BLOCK	CLAY BRICKS
TOTAL QUANTITY OF PC \M3	189.87	185.99
COST OF M3 INCLUDED CON. &FORMERS	750	
TOTAL COST OF PC	142,402	139,492
TOTAL QUANTITY OF RC FOUNDATIONS \M3	144.8	160
COST OF M3 INCLUDED CON. &FORMERS WITHOUT REIN.	1000	
TOTAL COST OF RC foundations	144,800	160,000
TOTAL QUANTITY OF FLOORS AND COLUMNS IN M3	746.88	844.37
COST OF M3 INCLUDED CON. &FORMERS WITHOUT REIN.	1050	
TOTAL COST OF RC OF SLABS AND COLUMNS	784,224	886,588.5
TOTAL COST OF MASONRY /BLOCKS	618,444	336,373.2
TOTAL QUANTITY OF STEEL	106.14	120.585
TOTAL COST OF STEEL	1,326,750	1,507,312.5
TOTAL COST OF DELTA MORTAR	33,975	106,000
TOTAL COST OF BUILDING	3,050,595	3,135,765
TOTAL SAVING	85,170	
% OF SAVING IN BUILDING	2.72%	

Technical Department

Eng.Essam Samy