DELTA BUILDING SYSTEMS
MEMBER OF PLENA

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

Project

TRIO GARDENS

BUILDING TYPE: QUATTRO STANDARD

MAIN CONTRACTOR:- Hills construction

Owner M² DEVELOPMENTS

Main consultant AL AMAR CONSULTING GROUP

STRUCTURAL DESIGN:- DELTA BLOCK

- **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 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 compound consist of different types of building

Type :-Quattro Standard

The building consist of Basement & ground & 4 multi story and roof

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

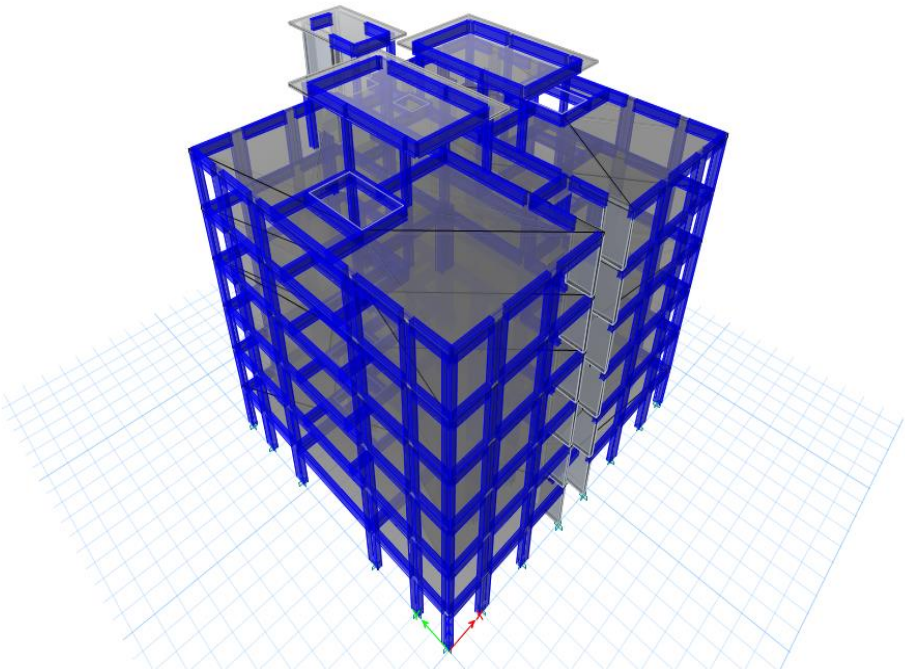
- **Structural loads**
    1. **Bearing capacity of soil 1.5 kg/cm2**
    2. **Common Live load 200 kg/m2**
    3. **Live load in balcony , bathroom and kitchen 300 kg/m2**
    4. **Common flooring cover 150 kg/m2**
    5. **Flooring cover at roof 240 kg/m2**
    6. **Density of walls 550 kg/m3**
    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**

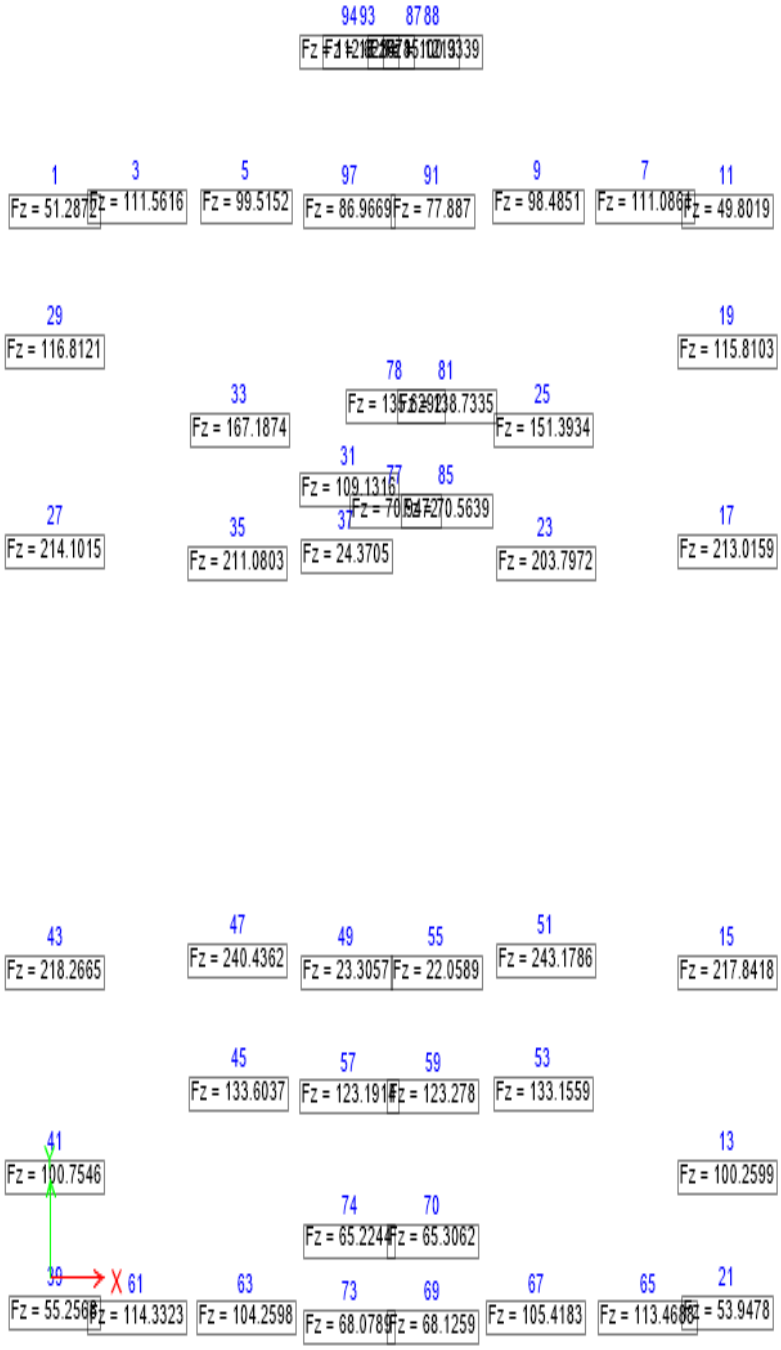
- **Design standard:-**
    1. **Egyptian code for Assessment of loads on building and structures-No.201/2012**
    2. **Egyptian code for Design and Construction for concrete structures No.203/2007**
    3. **Egyptian code for soil Mechanics, Design and construction foundation 202/2001**
- **Analysis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

QUATTRO STANDARD

1-1 ETABS 3D MODEL



- **LOADS ON FOUNDATIONS**



- **1-2 ETABS ULTIMATE BASE REACTION**

- **Design of columns – main columns**

Project name		:TRIO GARDENS
Location	:	NEW CAIRO
Column no	:	C1

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 60 ton b = 30 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Corner

Design Procedure

Pu = 0.35 Fcu Ac + 0.67 Fy As
b = 30 cm t = 50 cm
Ac actual = 1500.00 cm2
As = (Pu - 0.35 Fcu Ac) / 0.67 Fy
As = -40.42 cm2
As min = 0.006 Ac = 9.00 cm2
As max = 0.6% * 1500 = 90.00 cm2
Check As As min > As Take As = As min
As = 9.00 cm2 Ø = 16 mm ⇨ n = 6 ⇨ Bar spacing= 21.7 cm Safe
As actual = 12.07 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 = 352.0 cm3
V min = 0.0025 * 100 * b * t = 375.0 cm3
Check stirrups Increase Ø Stirrups Stirrups branches =

Project name		:TRIO GARDENS
Location	:	NEW CAIRO
Column no	:	C2

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 120 ton b = 30 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Edge

Design Procedure

Pu = 0.35 Fcu Ac + 0.67 Fy As
b = 30 cm t = 60 cm
Ac actual = 1800.00 cm2
As = (Pu - 0.35 Fcu Ac) / 0.67 Fy
As = -28.61 cm2
As min = 0.006 Ac = 10.80 cm2
As max = 0.5% * 1800 = 90.00 cm2
Check As As min > As Take As = As min
As = 10.80 cm2 Ø = 16 mm ⇨ n = 6 ⇨ Bar spacing= 25.1 cm Safe
As actual = 12.07 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 = 402.3 cm3
V min = 0.0025 * 100 * b * t = 450.0 cm3
Check stirrups Increase Ø Stirrups Stirrups branches =

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Project name	:	**trio gardens**
Location	:	**NEW CAIRO**
Column no	:	**c3**

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 220 ton b = 30 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Interior

Design Procedure

Pu = 0.35 Fcu Ac + 0.67 Fy As

b = 30 cm t = 80 cm

Ac actual = 2400.00 cm2

As = (Pu - 0.35 Fcu Ac) / 0.67 Fy

As = -13.27 cm2

As min = 0.006 Ac = 14.40 cm2

As max = 0.4% * 2400 = 96.00 cm2

Check As As min > As Take As = As min

As = 14.40 cm2 Ø = 16 mm ⇨ n = 8 ⇨ Bar spacing= 23.4 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 = 502.9 cm3

V min = 0.0025 * 100 * b * t = 600.0 cm3

Check stirrups Increase Ø Stirrups Stirrups branches =

Project name	:	**trio gardens**
Location	:	**NEW CAIRO**
Column no	:	**c4**

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 220 ton b = 30 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Interior

Design Procedure

Pu = 0.35 Fcu Ac + 0.67 Fy As

b = 30 cm t = 80 cm

Ac actual = 2400.00 cm2

As = (Pu - 0.35 Fcu Ac) / 0.67 Fy

As = -13.27 cm2

As min = 0.006 Ac = 14.40 cm2

As max = 0.4% * 2400 = 96.00 cm2

Check As As min > As Take As = As min

As = 14.40 cm2 Ø = 16 mm ⇨ n = 8 ⇨ Bar spacing= 23.4 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 = 502.9 cm3

V min = 0.0025 * 100 * b * t = 600.0 cm3

Check stirrups Increase Ø Stirrups Stirrups branches =

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Project name	:	**trio gardens**
Location	:	**NEW CAIRO**
Column no	:	**c5**

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 260 ton b = 30 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Interior

Design Procedure

Pu = 0.35 Fcu Ac + 0.67 Fy As

b = 30 cm t = 100 cm

Ac actual = 3000.00 cm2

As = (Pu - 0.35 Fcu Ac) / 0.67 Fy

As = -22.80 cm2

As min = 0.006 Ac = 18.00 cm2

As max = 0.4% * 3000 = 120.00 cm2

Check As As min > As Take As = As min

As = 18.00 cm2 Ø = 16 mm ⇨ n = 10 ⇨ Bar spacing= 22.4 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 = 603.4 cm3

V min = 0.0025 * 100 * b * t = 750.0 cm3

Check stirrups Increase Ø Stirrups Stirrups branches =

Project name	:	**trio gardens**
Location	:	**NEW CAIRO**
Column no	:	**c6**

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 200 ton b = 60 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Interior

Design Procedure

Pu = 0.35 Fcu Ac + 0.67 Fy As

b = 60 cm t = 80 cm

Ac actual = 4800.00 cm2

As = (Pu - 0.35 Fcu Ac) / 0.67 Fy

As = -126.04 cm2

As min = 0.006 Ac = 28.80 cm2

As max = 0.4% * 4800 = 192.00 cm2

Check As As min > As Take As = As min

As = 28.80 cm2 Ø = 16 mm ⇨ n = 16 ⇨ Bar spacing= 14.7 cm Safe

As actual = 32.18 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 = 653.7 cm3

V min = 0.0025 * 100 * b * t = 1200.0 cm3

Check stirrups Increase Ø Stirrups Stirrups branches =

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Planted columns

Project name : **trio gardens**
Location : **NEW CAIRO**
Column no : **pc1**

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 50 ton b = 25 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Interior

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 = -22.80 cm2
As min = 0.006 Ac = 6.00 cm2
As max = 0.4% * 1000 = 40.00 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 : **trio gardens**
Location : **NEW CAIRO**
Column no : **pc2**

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 170 ton b = 25 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Interior

Design Procedure

Pu = 0.35 Fcu Ac + 0.67 Fy As
b = 25 cm t = 50 cm
Ac actual = 1250.00 cm2
As = (Pu - 0.35 Fcu Ac) / 0.67 Fy
As = 16.07 cm2
As min = 0.006 Ac = 7.50 cm2
As max = 0.4% * 1250 = 50.00 cm2
Check As As min < As < As max
As = 16.07 cm2 Ø = 16 mm ⇨ n = 8 ⇨ Bar spacing= 14.7 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 = 326.9 cm3
V min = 0.0025 * 100 * b * t = 312.5 cm3
Check stirrups Safe Stirrups branches =

Project name	:	trio gardens
Location	:	NEW CAIRO
Column no	:	pc3

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 PU = 210 ton b = 25 cm Ø bars = Ø 16 Ø stirrups = Ø 8 Column location Interior

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 = 21.77 cm2

As min = 0.006 Ac = 9.00 cm2

As max = 0.4% * 1500 = 60.00 cm2

Check As As min < As < As max

As = 21.77 cm2 Ø = 16 mm ⇨ n = 12 ⇨ Bar spacing= 10.9 cm Safe

As actual = 24.14 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 =

PLANTED COLUMNS LOADS:-

floor	Pc1	Pc2	Pc3
Ground		29	25
First		36	27
Second		29	25
Third			33
Forth	35		48
Roof	20		25
Total-TON	55	94	183

This loads according to calculations and results from safe files.

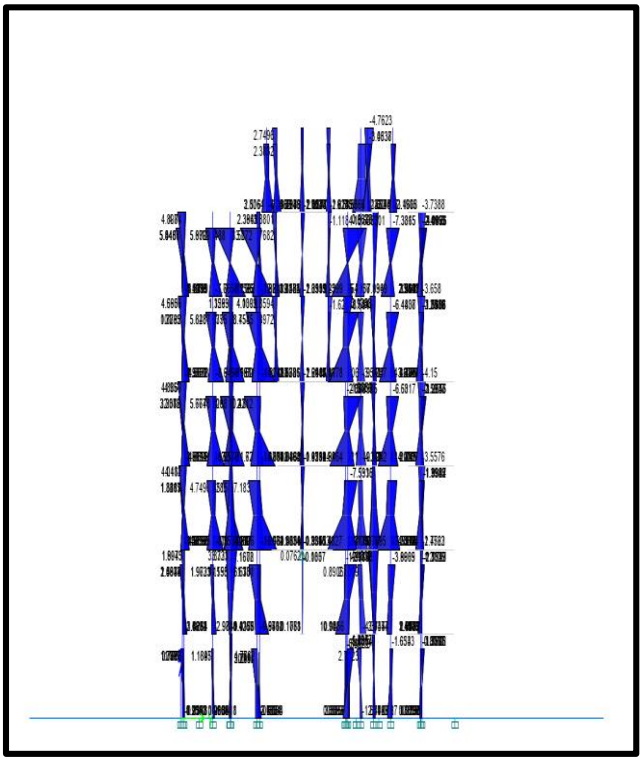
According to the following reasons &loads we are increase the percentage of reinforcement of columns :-

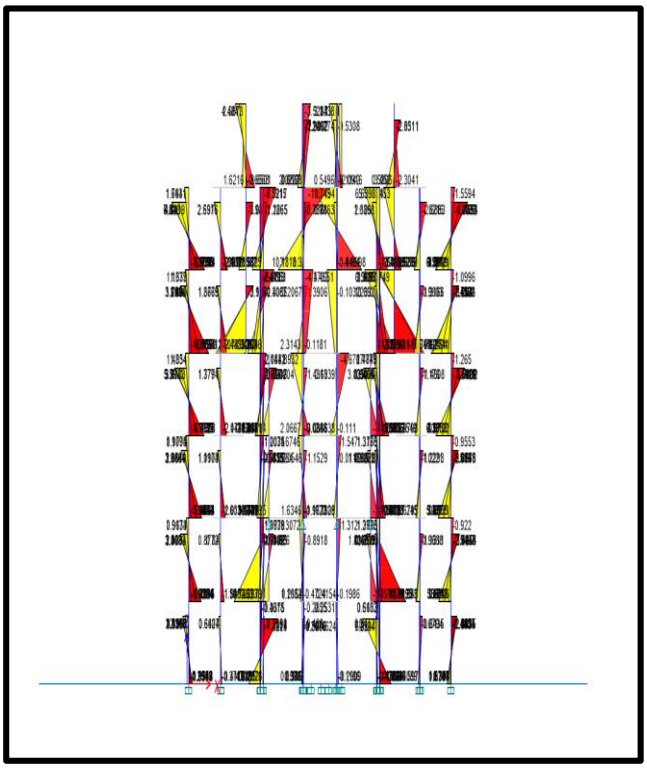
1- **Height of columns in ground floor**
2- **Lateral loads**

   We are take in consideration all of this loads and the following pictures showing this values of Additional moment

- **Moments in columns**
  1. **M2-2** **2.M3-3**

THIS moment in maximum state due to lateral loads , as the shown the moments values can be neglected

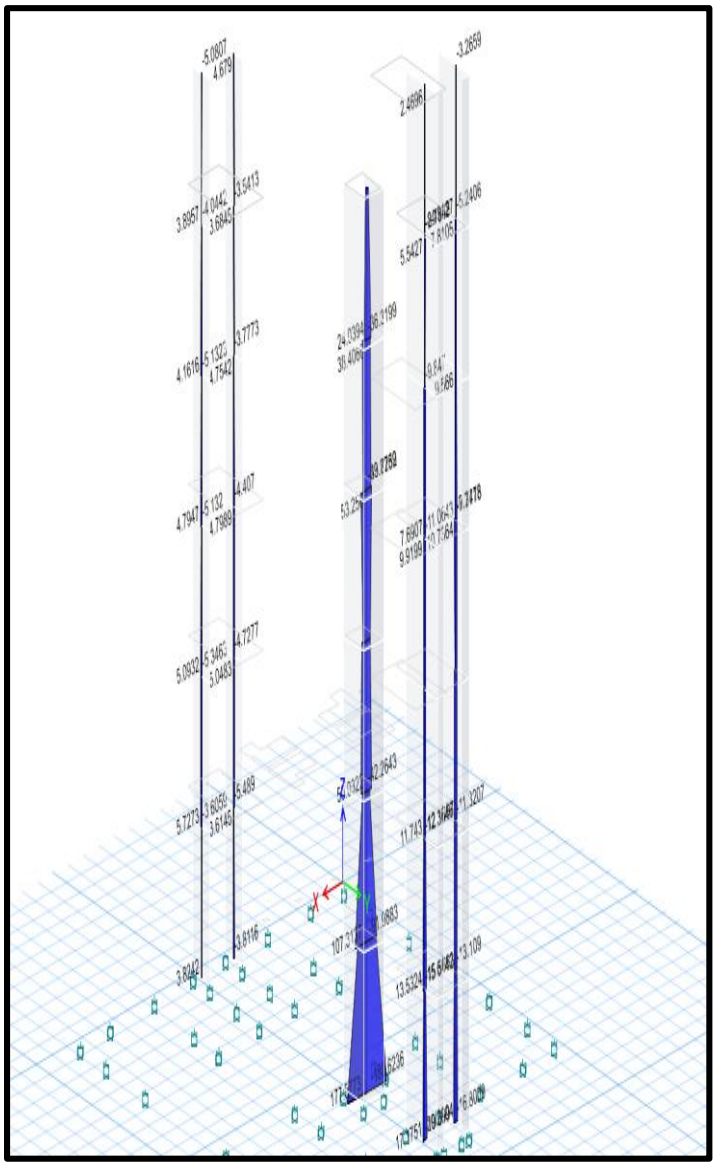




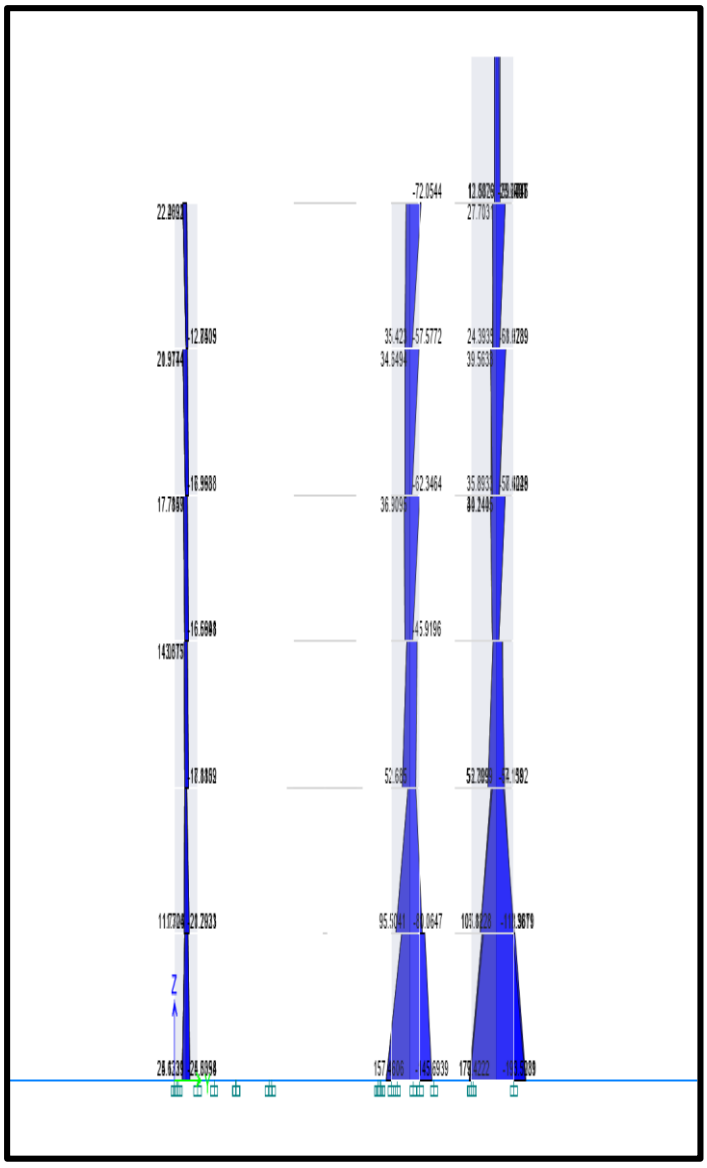
maximum moment due to lateral loads= 12 m.t

- **Moments on SHEAR WALLS &CORE**

M2-2



M3-3

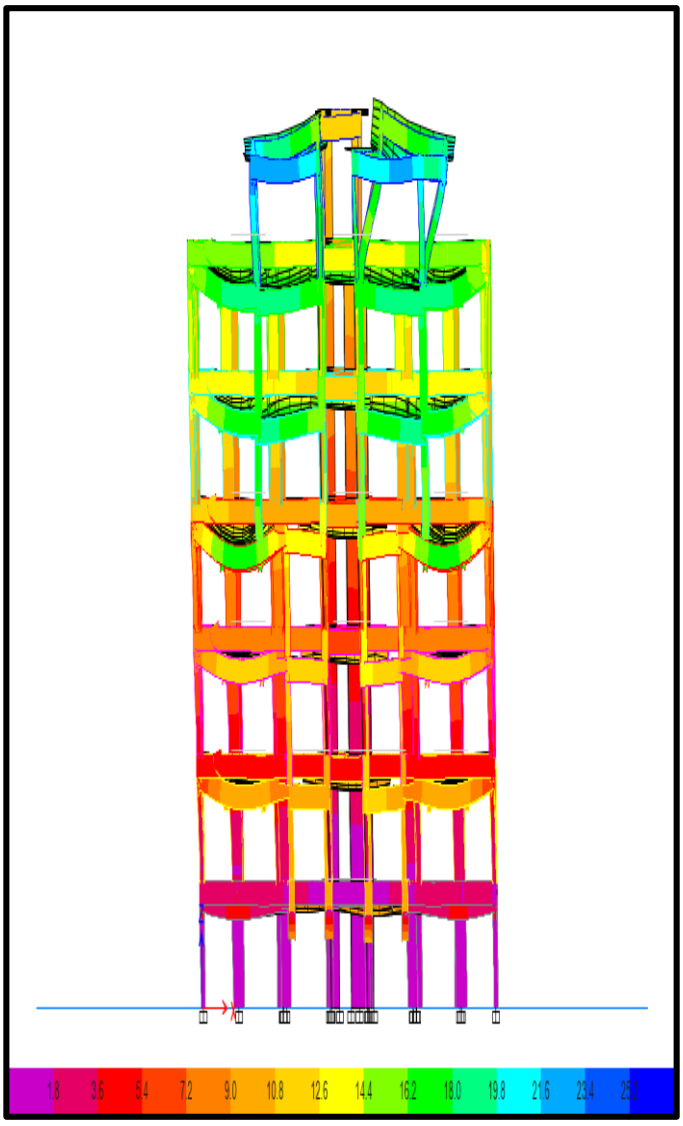


As the pervious photos the maximum moment in wall due to lateral loads =180 m.t and this value is totally naturalistic because DELTA BLOCK is very familiar to reduce seismic impact on buildings.

- **Displacement of building due to Lateral loads:**

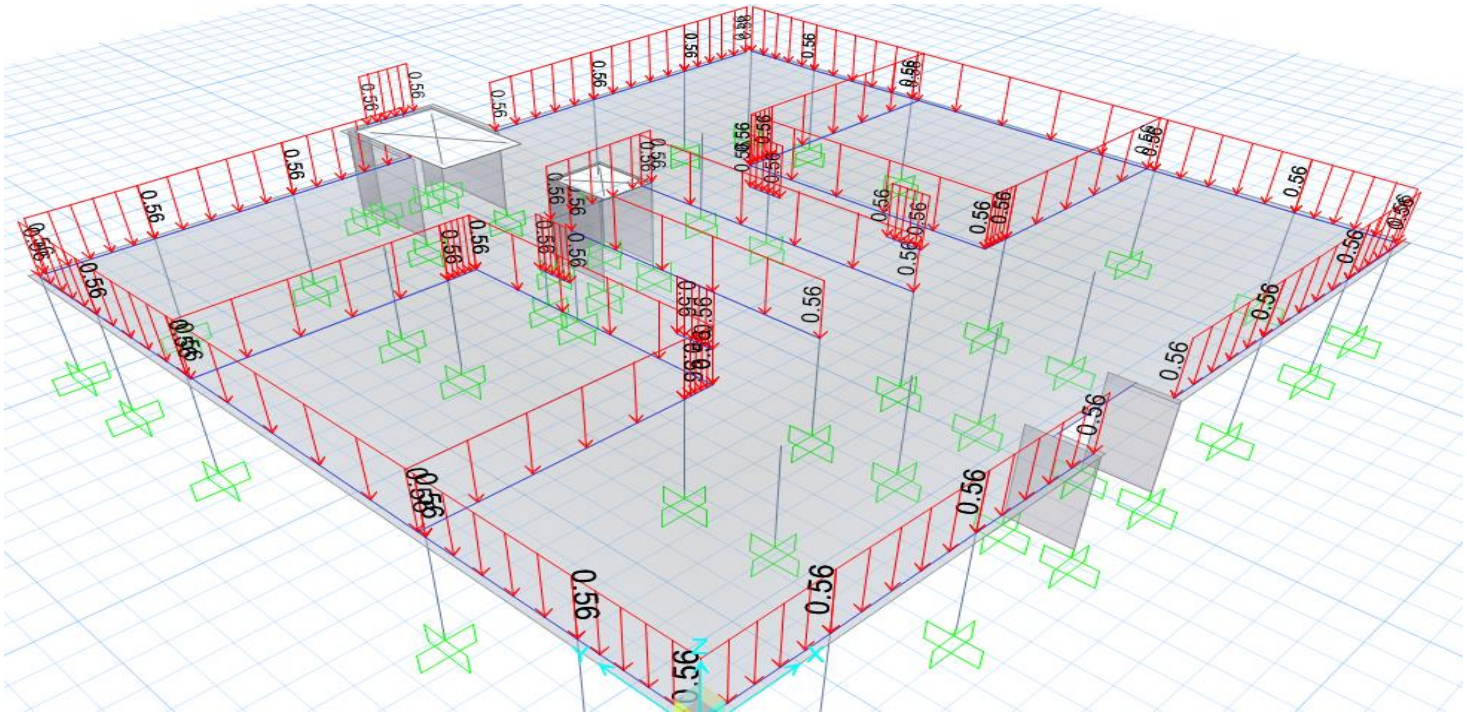
y direction

x direction



the maximum deformation and horizontal displacement due to lateral loads = 2 cm maximum , and the allowable is =H/480=19.2/480=4.00 cm , satisfied code conditions.

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



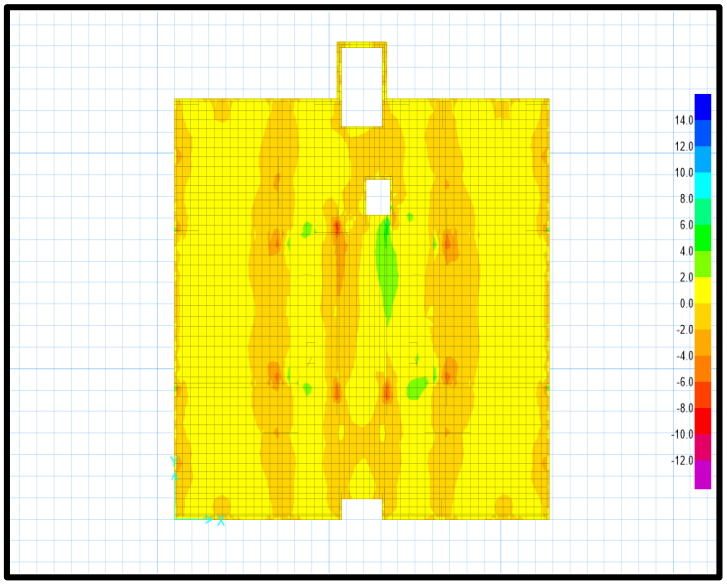
Outer walls\m'

Walls height= 2.8 m , walls density =550 kg/m3 , walls thickness=0.25m
loads of walls without plastering \m'=2.6×0.55×0.25=0.35 t\m'
weight of plastering=0.04×1.8×3=0.21 t\m'
total wall loads\m'=0.56 t\m'

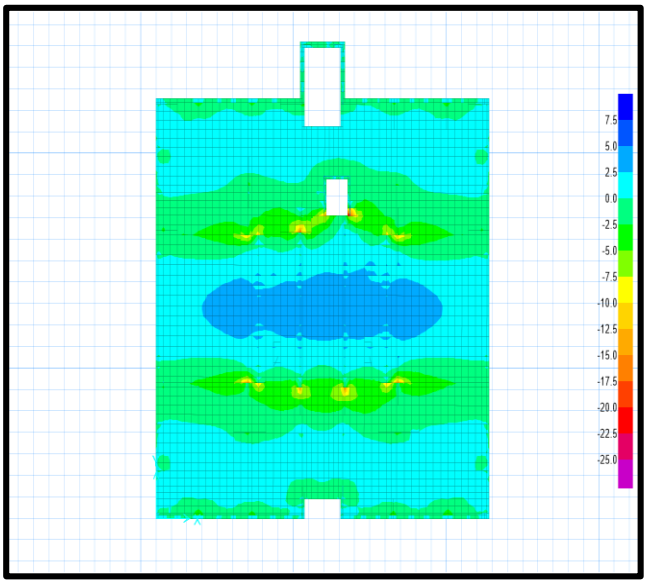
Inner wall\m2

Walls height= 3.00 m , walls density =550 kg/m3 , walls thickness=0.12m
loads of walls without plastering \m'=3.00×0.55×0.12=0.198 t\m'
weight of plastering=0.04×1.8×3=0.21 t\m'
Total quantity of inner walls in floor around 30 m3 , total area of floor without opening=365 m2
Total wall loads/square meter without plastering=30*0.550/365=0.45 t/m2
Total wall loads/square meter with plastering=85 kg/m2 assumed as 100kg

M1-1

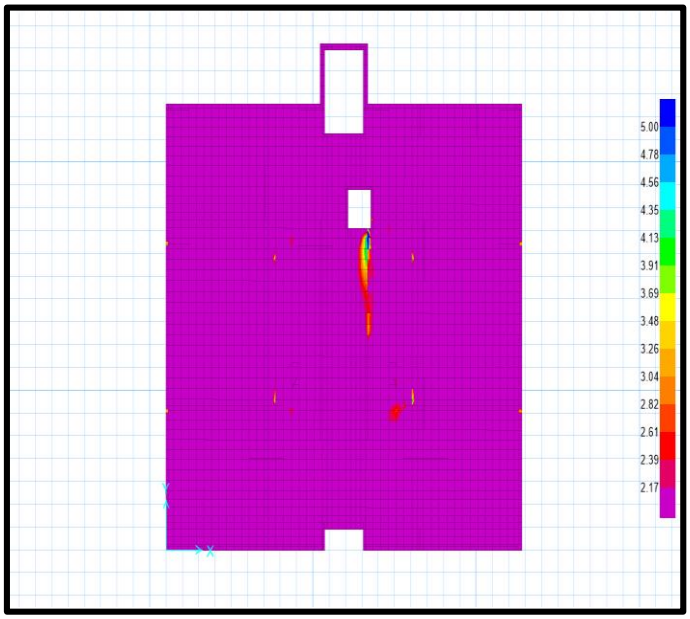


M2-2

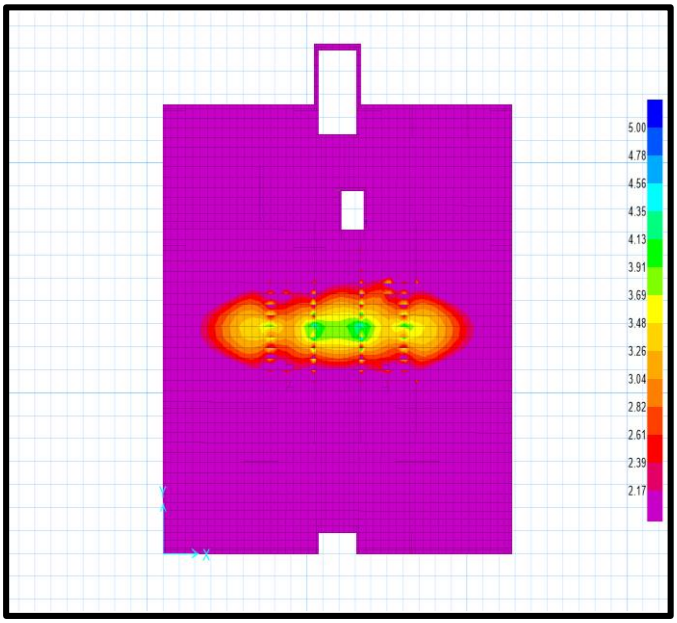


REINFORCMENT WITH TOP&BOTTOM MESH T10@165 mm

+ve M1-1

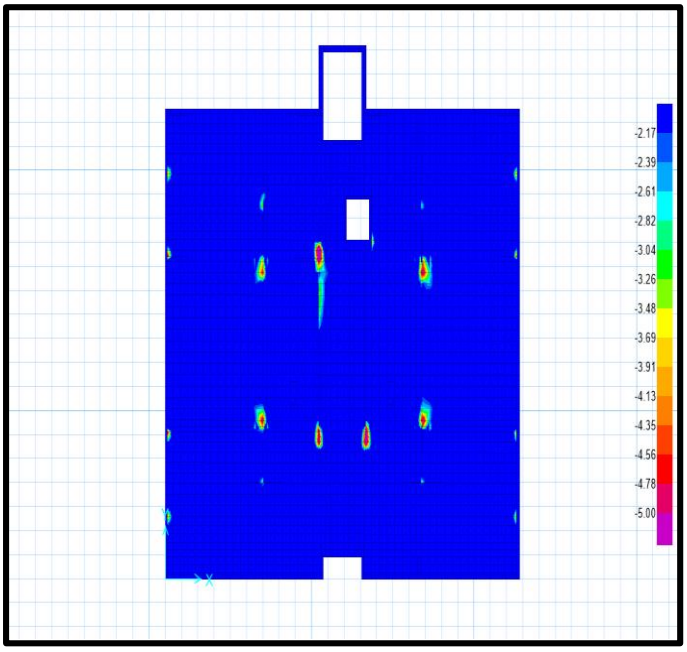


+ve m2-2

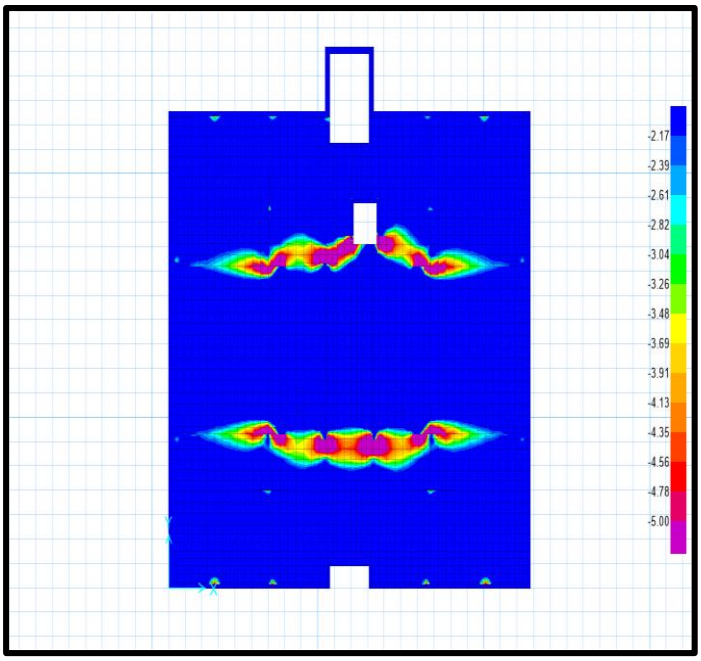


Different colures need add reinforcement as the showing in drawing

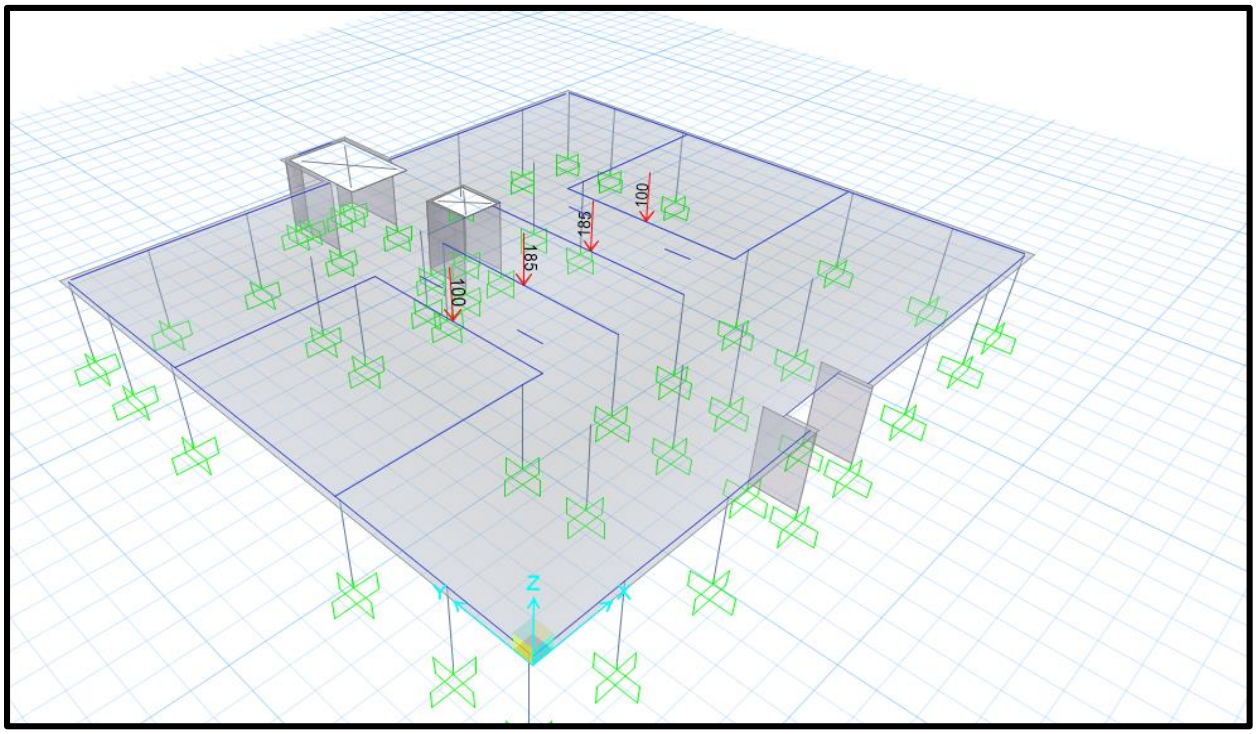
-ve M1-1



-ve M2-2

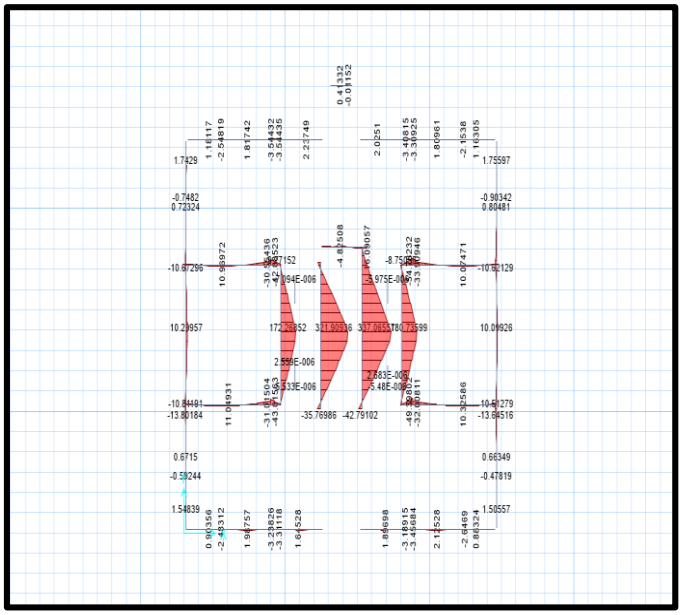


Beams assign loads (planted columns)

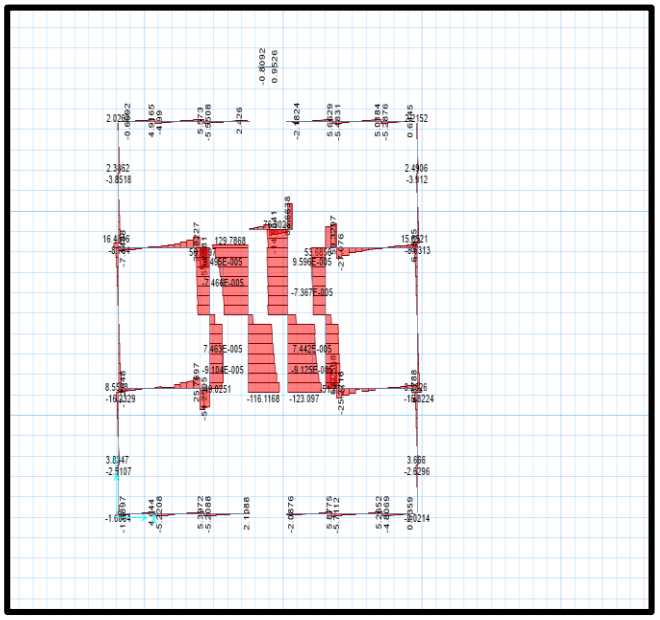


Beams stresses

Moment

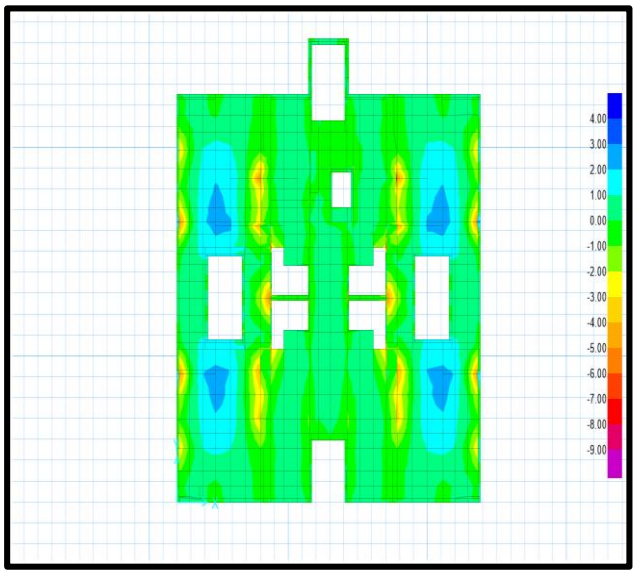


shear

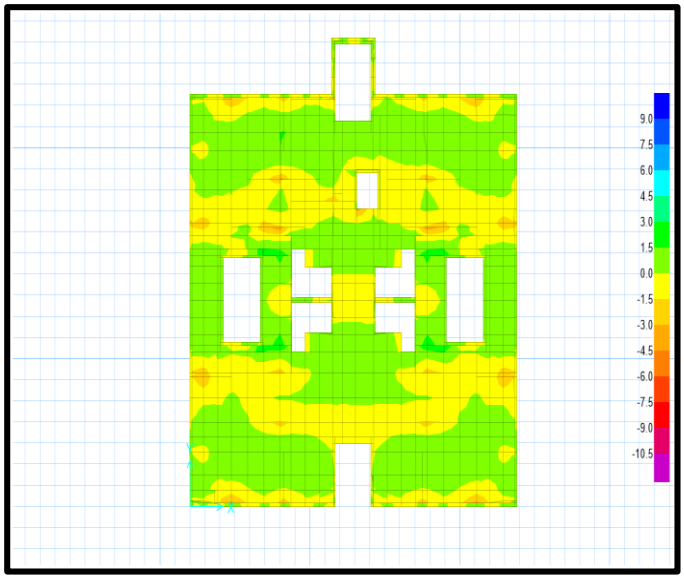


Ground floor:-

M1-1

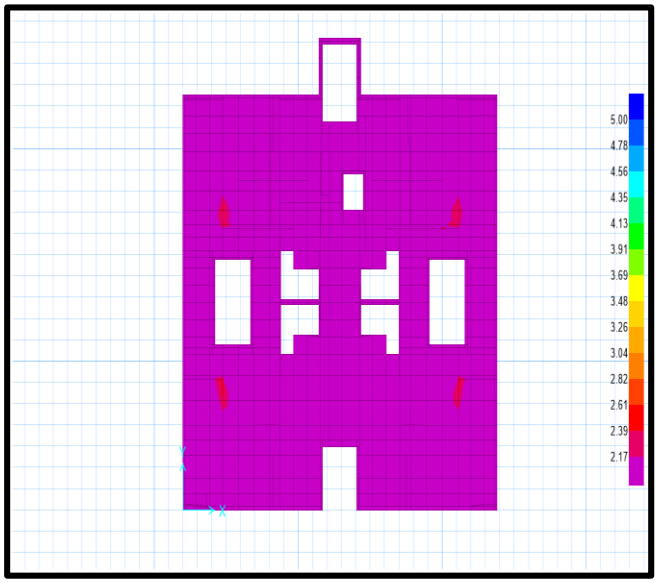


M2-2

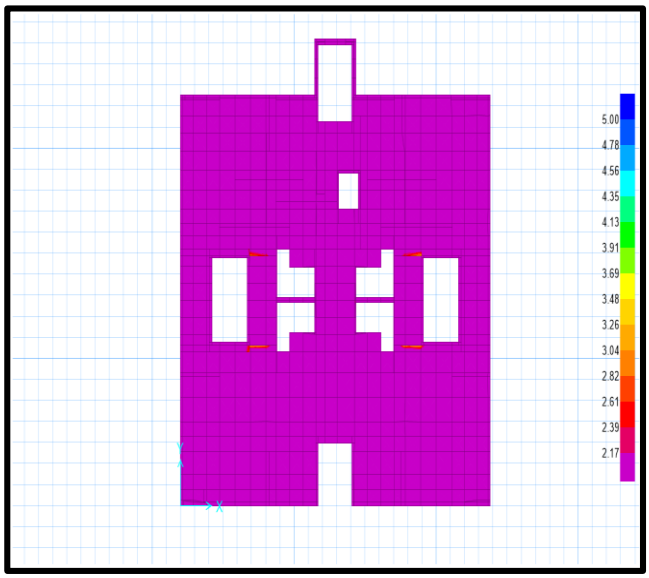


REINFORCMENT WITH TOP&BOTTOM MESH T10@165 mm

+ve M1-1

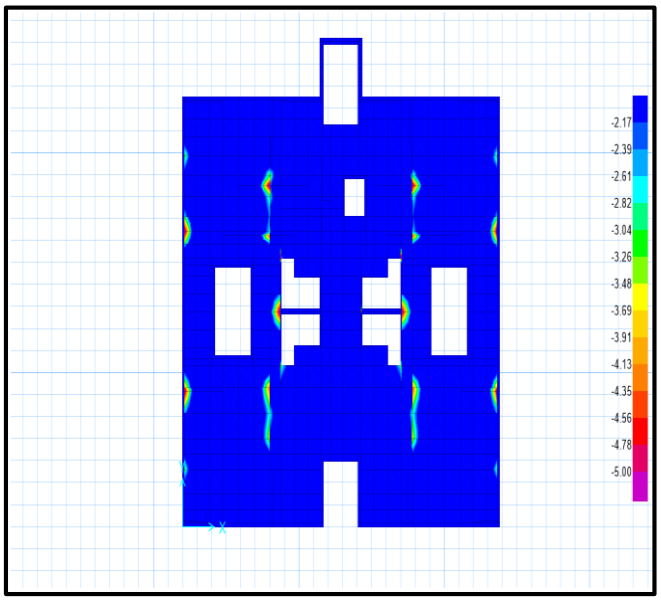


+ve M2-2

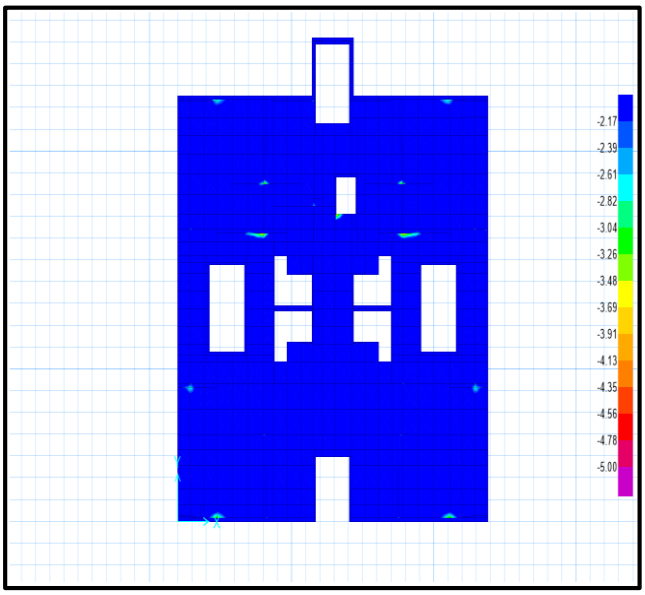


Different colures need add reinforcement as the showing in drawing

-ve M1-1

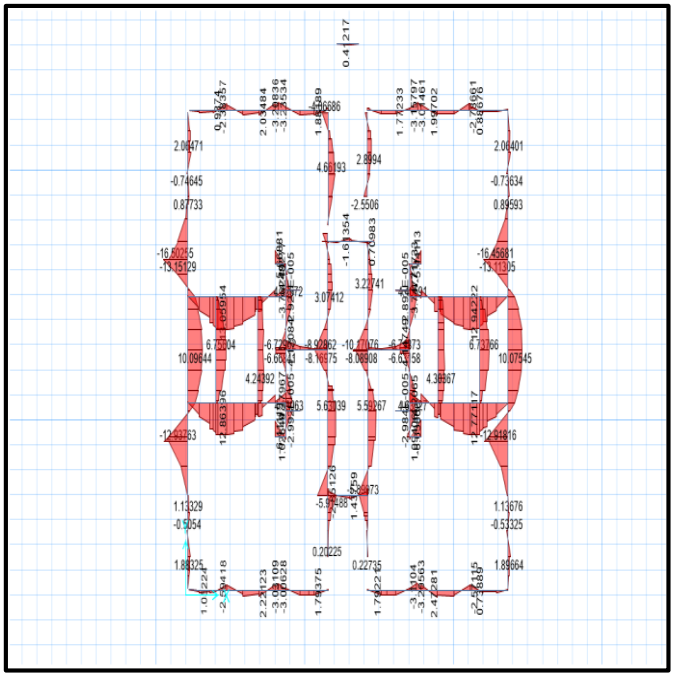


-ve M2-2

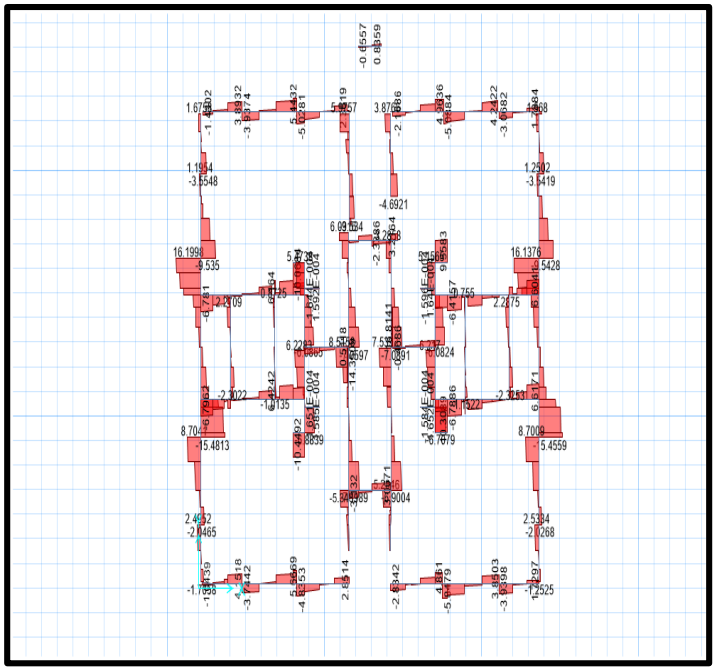


Beams stresses

Moment

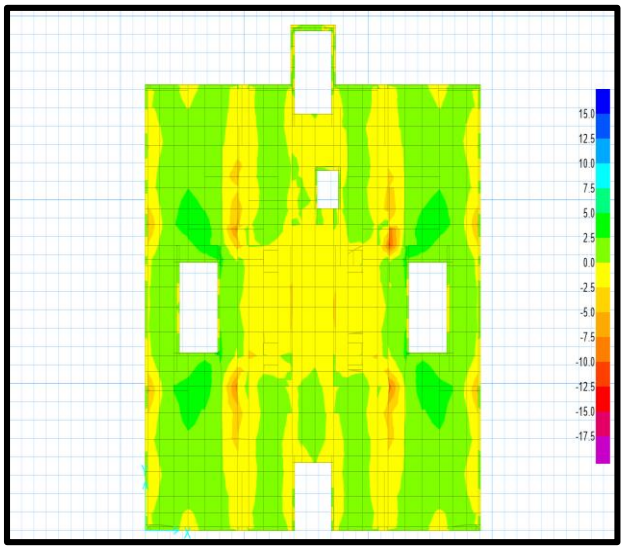


shear

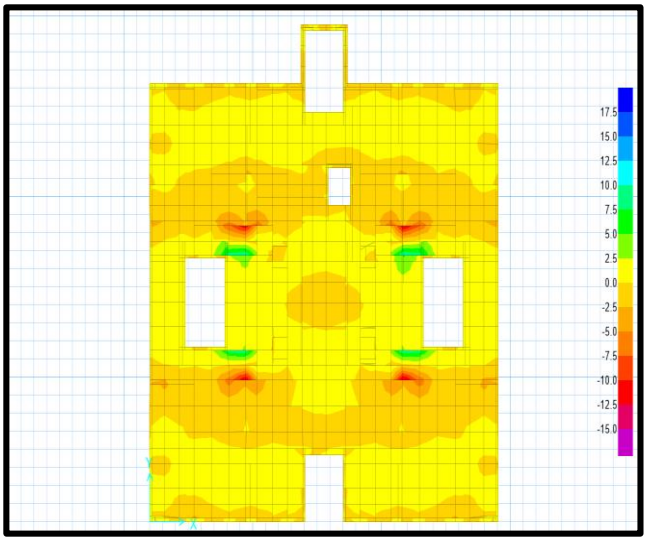


Third floor

M1-1

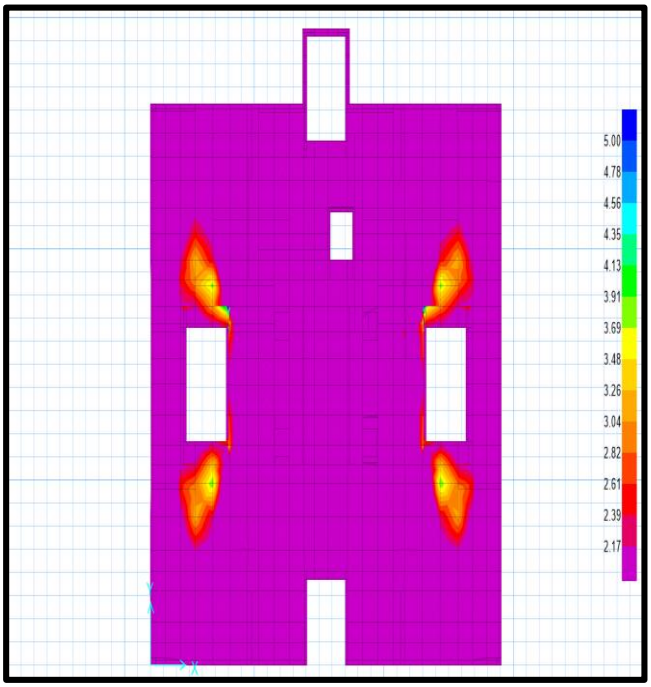


m2-2

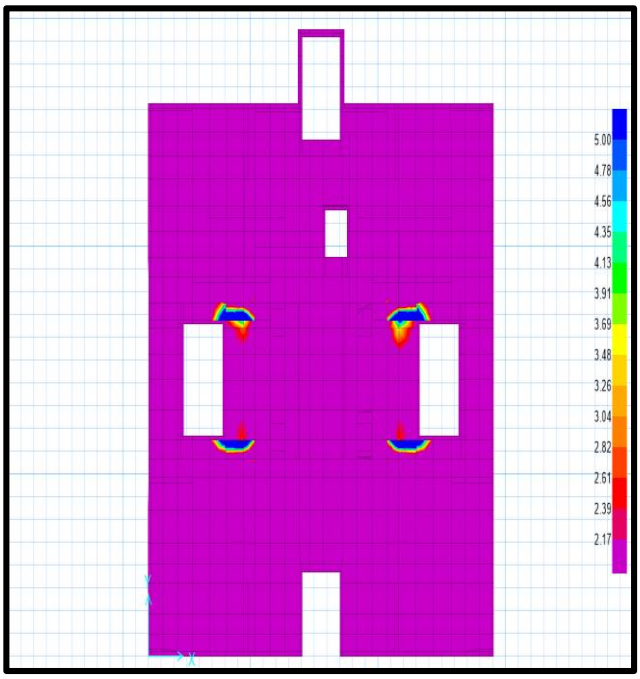


REINFORCMENT WITH TOP&BOTTOM MESH T10@165 mm

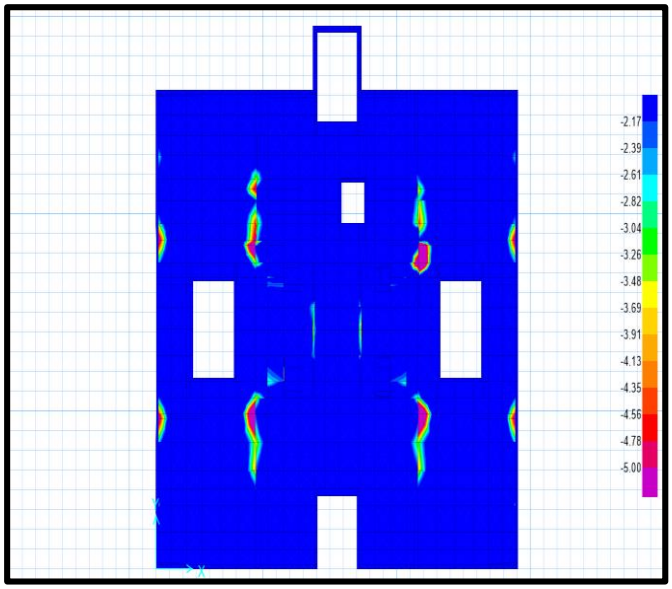
+ve M1-1



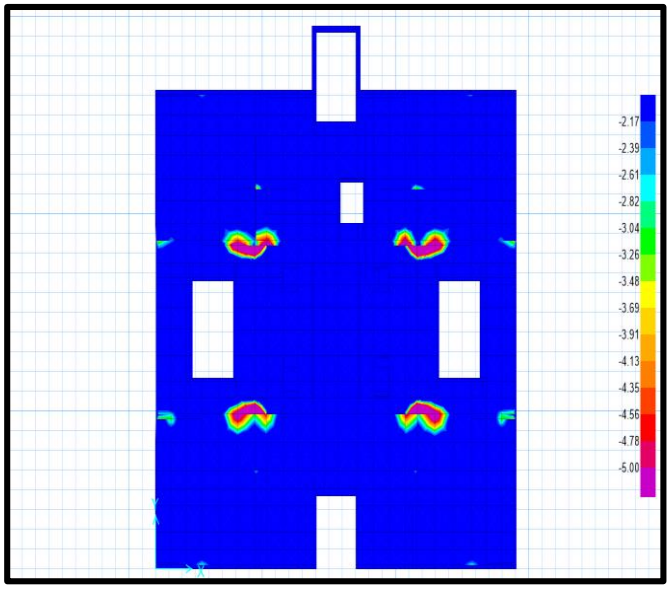
M2-2



-ve M1-1

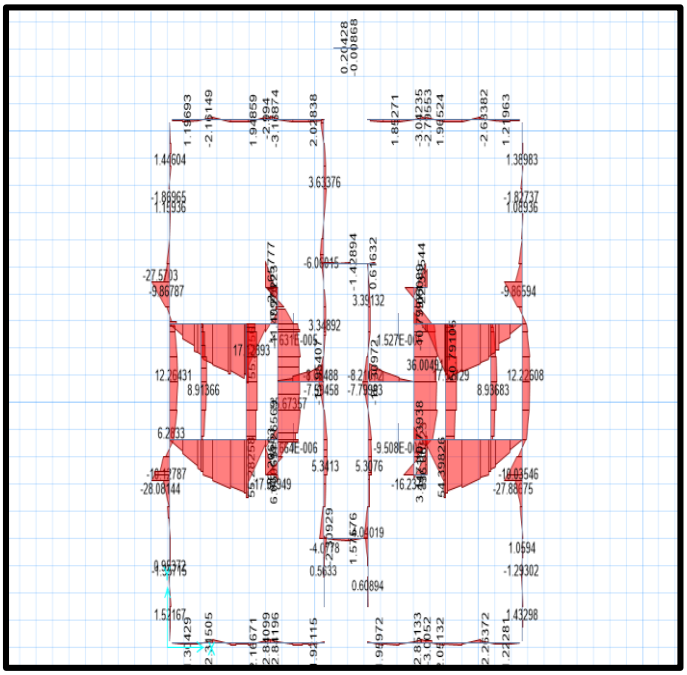


-ve M2-2

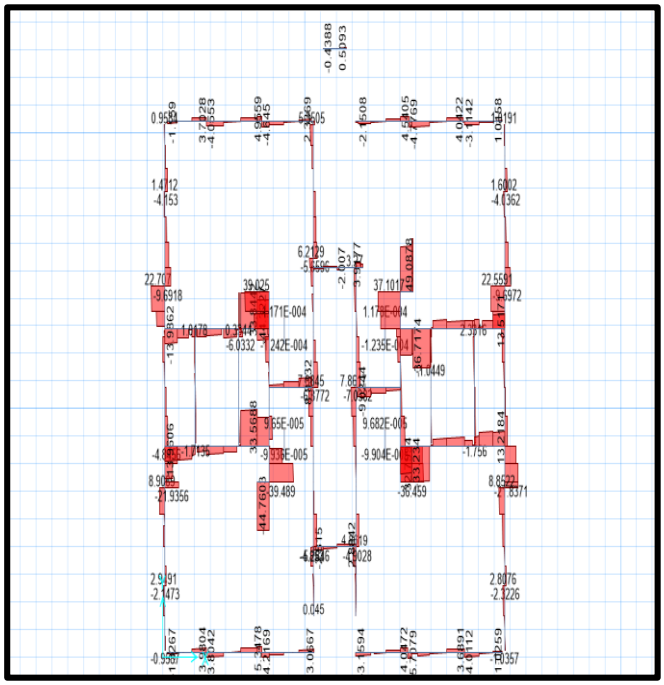


Beams stresses

Moment

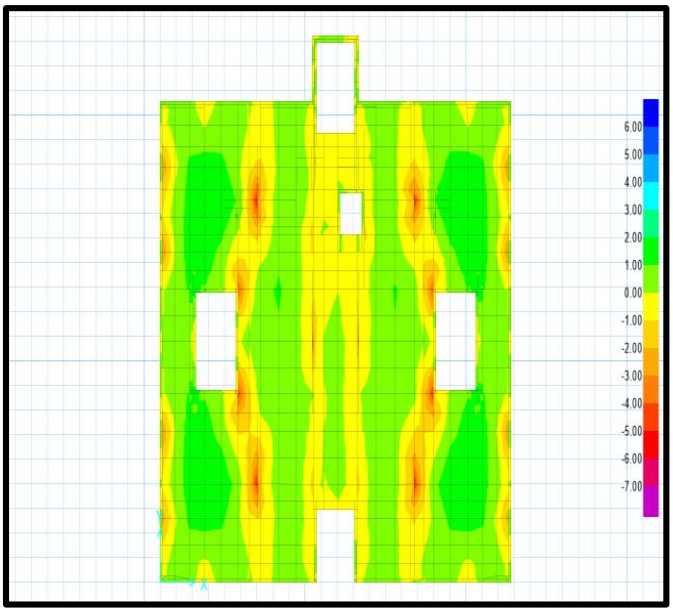


SHEAR

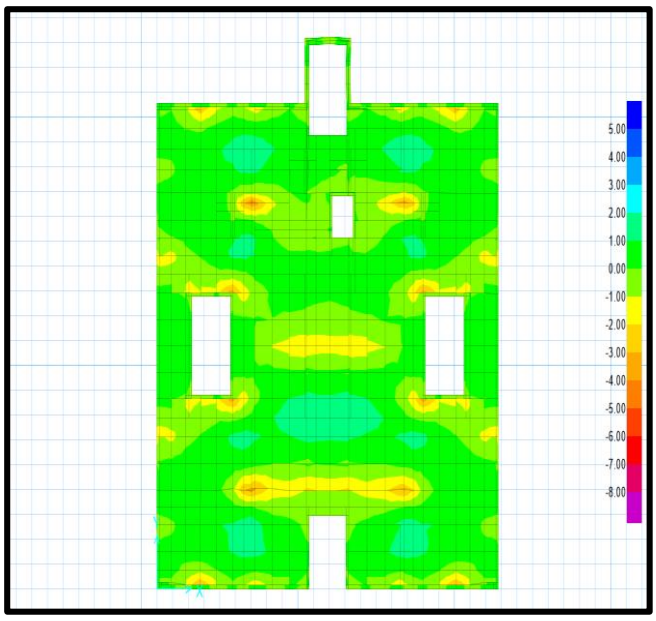


FORTH FLOOR

M1-1

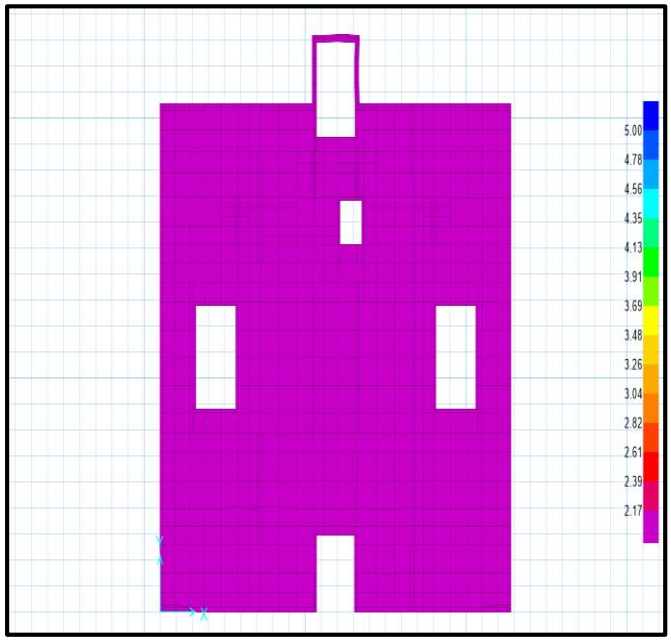


M2-2

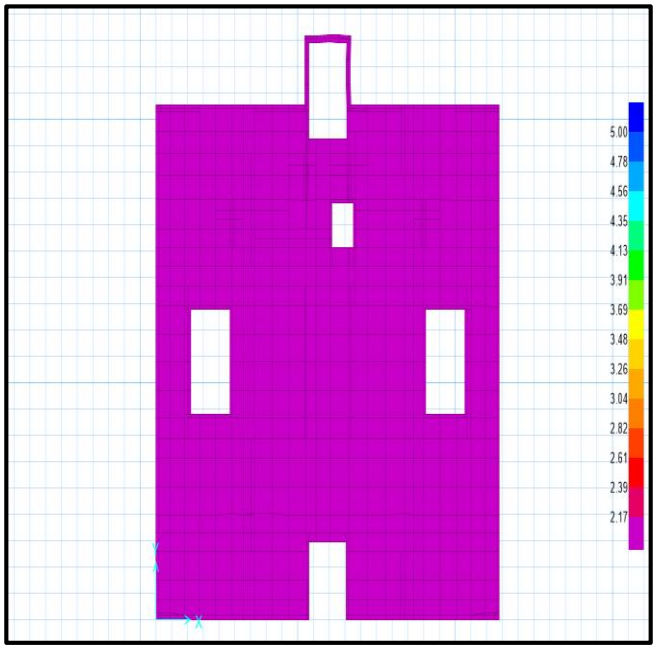


REINFORCMENT WITH TOP&BOTTOM MESH T10@165 mm

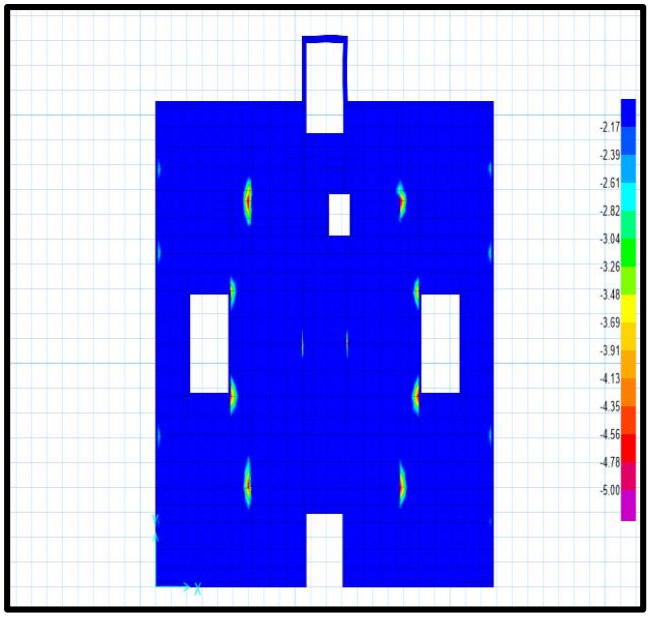
+VE M1-1



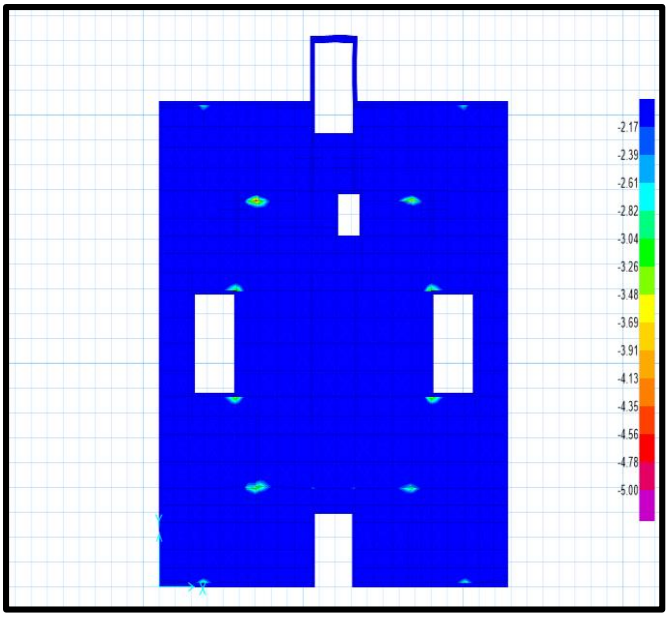
+VE M2-2



-VE M1-1

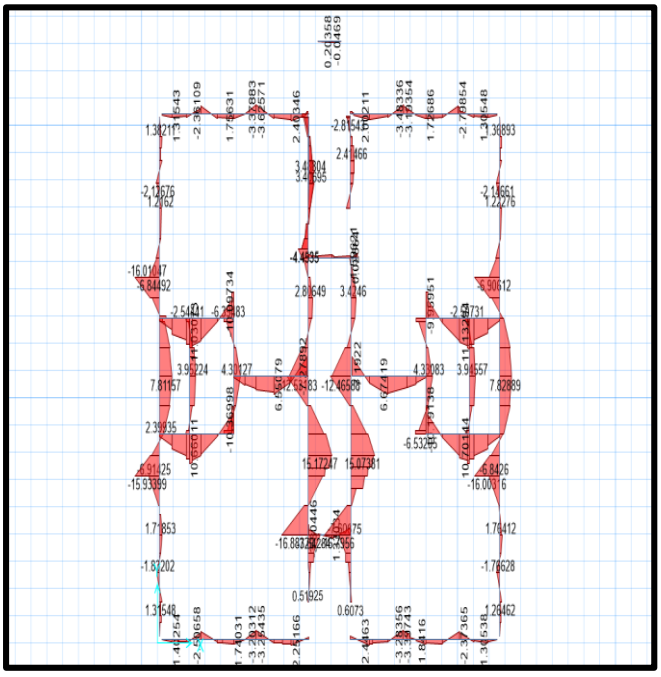


-VE M2-2

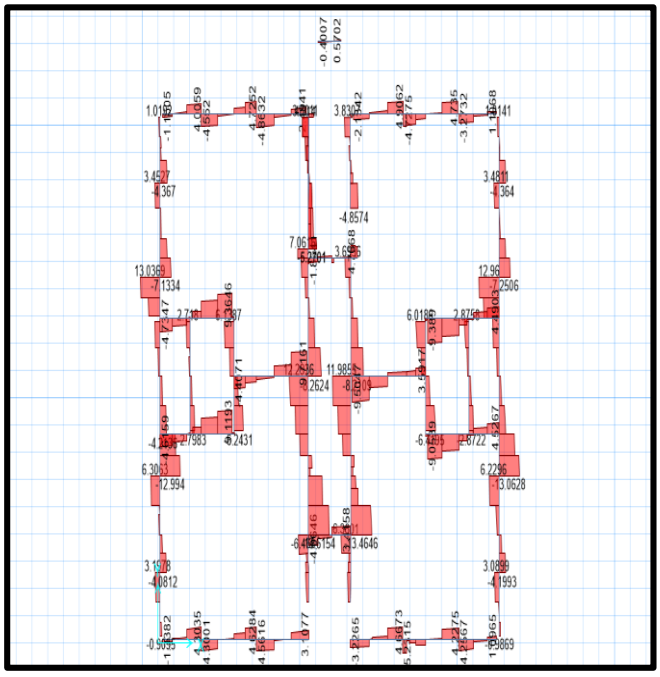


Beams stresses

moment

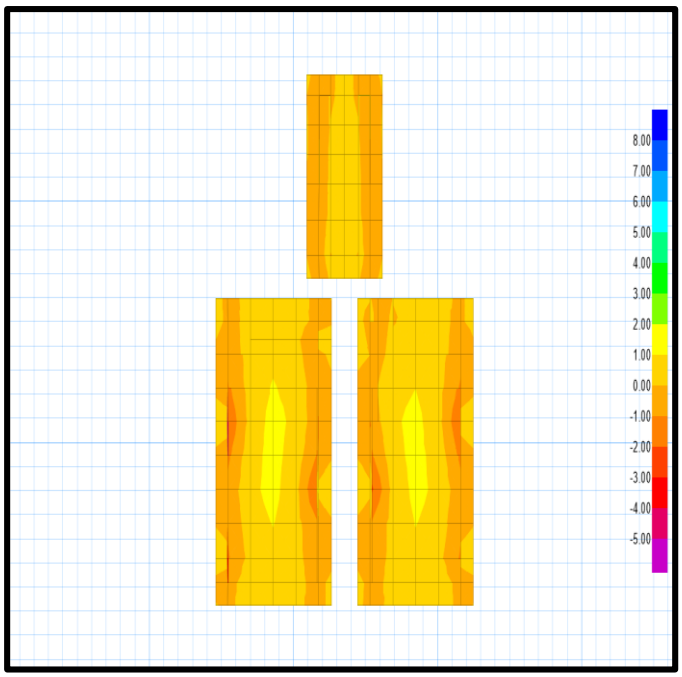


shear

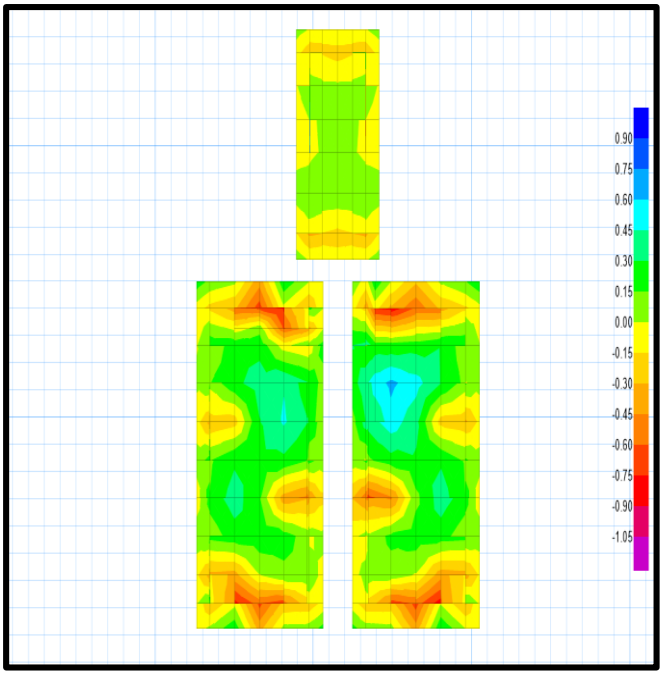


ROOF

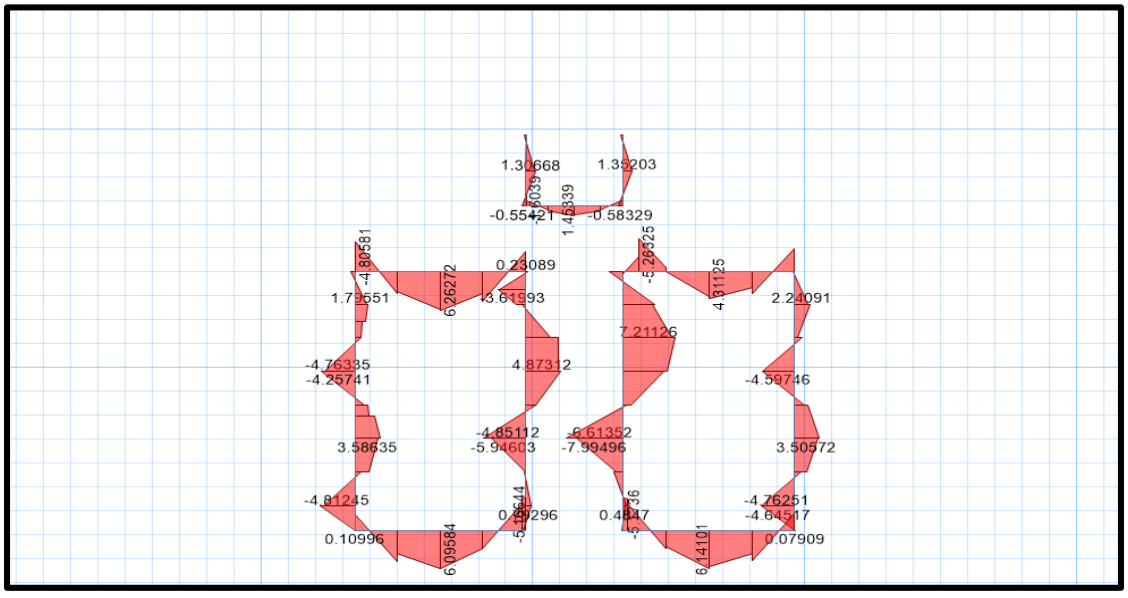
M11



M2-2



BEAM STRESSES



- **Design of slabs and beams**

1. **CONCRETE DIM**

ASSUMED Ts= 18 cm

Fcc=300kg/cm2

The bigger span length is not exceed 6 m , 6/36 =16.6 cm

The concrete depth satisfied code conditions.

2. **REINFORCEMENT**

Reinforcement	Area of steel cm2	Coverage moment m.t
T10@165 mm	**3.702**	**2.17**
T10@330 mm	**3.085**	**1.085**
T12@165 mm	**6.78**	**3.12**
T12@330 mm	**3.39**	**1.56**
T16@165 mm	**12**	**5.52**
T16@330 mm	**6**	**2.76**

According to the pervious table and values , the reinforcement of different floors was according to it

3. **CHECK DEFLECTION**

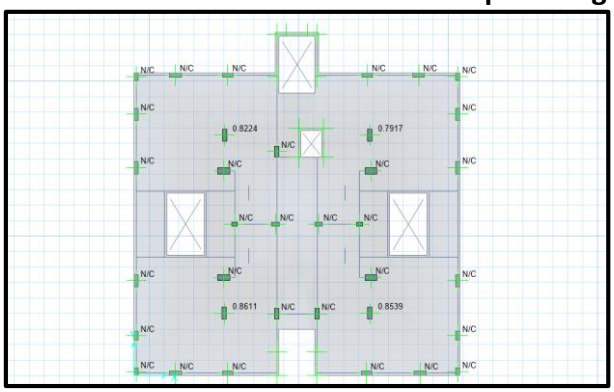
MAXIMUM SPAN LENGTH = 6 meter

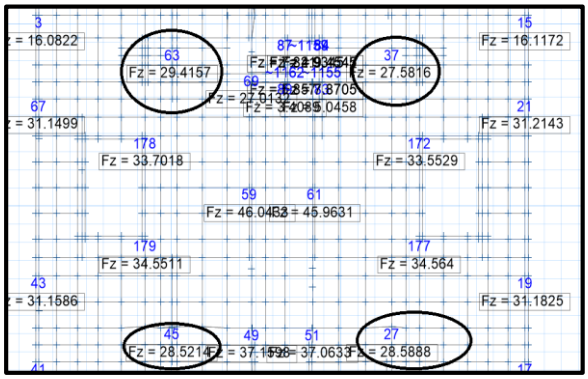
Allowable deflection=6/250=2.40 cm

Maximum actual deflection due to vertical loads= 1.6 cm

And it is satisfied code conditions.

4. **Check punching**

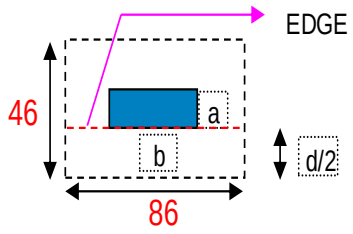




CHECK PUNCHING SHEAR [flat slab]

R-col

F_{cu}	300	kg/cm^2
Q_{up}	30	ton
d_{slab}	16	cm
a_{col}	30	cm
b_{col}	70	cm



q_{cup} 13.13 kg/cm^2

RESULT

INTERIOR COLUMNS	q_{up}	8.2 kg/cm^2	SAFE
EDGE COLUMNS	q_{up}	15.0 kg/cm^2	UN SAFE
CORNER COLUMNS	q_{up}	24.2 kg/cm^2	UN SAFE

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name	:	TRIO GARDENS
Location	:	NEW CAIRO
Beam no	:	B1

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 3.50 m.t. Qu = 10 ton Mt = 0.0 m.t. b = 25 cm d = 55 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 As min = 1.3 As r 0.0020

$$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}} = 19.0 \text{ cm}$$

d = 55 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 = 29.39 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γs * (d - d') = 38.01 m.t.

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

$$As = \frac{Mu}{Fy/\gamma s * d * (1 - 0.4*c/d)} = 2.14 \text{ cm2}$$

$$As' = \frac{0.15*As}{} = 0.32 \text{ cm2}$$

Tension reinforcement

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

As actual = 2.26 cm2

μ = As/(b*d) = 0.002

Compression reinforcement

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

As' actual = 1.57 cm2

μ' = As'/(b*d) = 0.0011

Check μmin < μ < μmax ⟹ Decrease d

Check 0.1μ < μ' < 0.004 ⟹ Increase d

Check of Shear

qu = Qu / (b*d) =	7.27 kg/cm2	
qt = 3*Mtorsion / (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	
qcu = 0.75 * δsi *(Fcu/γc)^.5 =	10.61 kg/cm2	
qumax = 2.2* δsi *(Fcu/γc)^.5 =	30.00 kg/cm2	≤ 30 kg/cm2
qtu = 0.75 * δti *(Fcu/γc)^.5 =	10.61 kg/cm2	
qtumax = 2.2 * δti *(Fcu/γc)^.5 =	31.11 kg/cm2	

If qu < qcu and qtu < qtcu ⟹ Use min stirrups 5Φ8 / m'

Closed stirrups for Shear & Torsion

Shear		Torsion	
qsteel = qu - 0.5*qcu =	0.00 kg/cm2	qsteel = tu - 0.5*qtcu =	0.00 kg/cm2
μ = n*Ast1 / (b * s) = qsteel / (Fystr/γs)		x1 , y1 are stirrup dimensions	Y1= 50 X1 = 20
b < 40 cm take n = 2	2 Branches	α = 0.66 + 0.33* (y1 / x1) =	1.485
Ast/Ss =	0.000 cm	$Ast/St = \frac{(qsteel * (b^2*t)/3)}{\alpha t*x1*y1*(Fystr/\gamma s)}$ =	0.000 cm

Choose $\Phi_{stirrups}$ #DIV/0!

No. of stirrups = 100/St + 100/Ss = #DIV/0!

Use Stirrups #DIV/0! #DIV/0! 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 : TRIO GARDENS
Location : NEW CAIRO
Beam no : B2

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 6.50 m.t. Qu = 10 ton Mt = 0.0 m.t. b = 25 cm d = 55 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

$$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}} = 25.9 \text{ cm}$$

d = 55 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 = 29.39 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γs * (d - d') = 38.01 m.t.

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

$$As = \frac{Mu}{Fy/\gamma s * d * (1- 0.4*c/d)} = 3.97 \text{ cm2}$$

$$As' = \frac{0.15*As}{} = 0.60 \text{ cm2}$$

Tension reinforcement

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

As actual = 4.02 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) = 0.0011

Check μmin < μ < μmax ⟹ Decrease d

Check 0.1μ < μ' < 0.004 ⟹ Safe

Check of Shear

qu = Qu / (b*d) =	7.27 kg/cm2	
qt = 3*Mtorsion / (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 qu < qcu and qtu < qtcu ⟹ Use min stirrups 5Φ8 / m'

Closed stirrups for Shear & Torsion

Shear		Torsion	
qsteel = qu - 0.5*qcu =	0.00 kg/cm2	qsteel = tu - 0.5*qtcu =	0.00 kg/cm2
μ = n*Ast1 / (b * s) = qsteel / (Fystr/γs)		x_1 , y_1 are stirrup dimensions	Y1= 50 X1 = 20
b < 40 cm take n = 2	2 Branches	α = 0.66 + 0.33* (y_1 / x_1) =	1.485
Ast/Ss =	0.000 cm	$Ast/St = \frac{(qsteel * (b^2*t)/3)}{\alpha_t*x_1*y_1* (Fystr/\gamma_s)}$ =	0.000 cm

Choose $\Phi_{stirrups}$ #DIV/0!

No. of stirrups = 100/St + 100/Ss = #DIV/0!

Use Stirrups #DIV/0! #DIV/0! 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 : TRIO GARDENS
Location : NEW CAIRO
Beam no : B3

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 9.50 m.t. Qu = 10 ton Mt = 0.0 m.t. b = 25 cm d = 55 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

$$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}} = 31.3 \text{ cm}$$

d = 55 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 = 29.39 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γ_s * (d - d') = 38.01 m.t.

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

$$As = \frac{Mu}{Fy/\gamma s * d * (1- 0.4*c/d)} = 5.81 \text{ cm2}$$

$$As' = \frac{0.15*As}{} = 0.87 \text{ cm2}$$

Tension reinforcement

Choosen Φ_{main} = 16 mm ⟹ no. of Bars = 3

As actual = 6.03 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) = 0.0011

Check μmin < μ < μmax ⟹ Safe

Check 0.1μ < μ' < 0.004 ⟹ Safe

Check of Shear

qu = Qu / (b*d) = 7.27 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 qu < qcu and qtu < qtcu ⟹ Use min stirrups 5Φ8 / m'

Closed stirrups for Shear & Torsion

Shear		Torsion	
qsteel = qu - 0.5*qcu =	0.00 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= 50 X1 = 20
b < 40 cm take n = 2	2 Branches	α = 0.66 + 0.33* (y_1 / x_1) =	1.485
Ast/Ss =	0.000 cm	Ast/St = (qsteel * (b^2*t)/3) / (α_t*x_1*y_1* (Fystr/γ_s)) =	0.000 cm

Choose $\Phi_{stirrups}$ #DIV/0!

No. of stirrups = 100/St + 100/Ss = #DIV/0!

Use Stirrups #DIV/0! #DIV/0! 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 : TRIO GARDENS
Location : NEW CAIRO
Beam no : B4

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 12.50 m.t. Qu = 10 ton Mt = 0.0 m.t. b = 25 cm d = 55 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

$$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}} = 35.9 \text{ cm}$$

d = 55 cm Check d'/d ≤ 0.15 ⟹ Fs' = Fy/γs

From d get c/d = 0.165 Check $c_{min}/d < c/d < c_{max}/d$ ⟹ Safe

Mumax1 (moment Capacity for single reinforced section) = Rmax * Fcu/γc * b * d^2 = 29.39 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γs * (d - d') = 38.01 m.t.

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

$$As = \frac{Mu}{Fy/\gamma s * d * (1- 0.4*c/d)} = 7.77 \text{ cm2}$$

$$As' = \frac{0.15*As}{} = 1.17 \text{ cm2}$$

Tension reinforcement

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

As actual = 8.05 cm2

μ = As/(b*d) = 0.006

Compression reinforcement

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

As' actual = 1.57 cm2

μ' = As'/(b*d) = 0.0011

Check μmin < μ < μmax ⟹ Safe

Check 0.1μ < μ' < 0.004 ⟹ Safe

Check of Shear

qu = Qu / (b*d) = 7.27 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 qu < qcu and qtu < qtcu ⟹ Use min stirrups 5Φ8 / m'

Closed stirrups for Shear & Torsion

Shear		Torsion	
qsteel = qu - 0.5*qcu =	0.00 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= 50 X1 = 20
b < 40 cm take n = 2	2 Branches	α = 0.66 + 0.33* (y_1 / x_1) =	1.485
Ast/Ss =	0.000 cm	Ast/St = $\frac{(qsteel * (b^2*t)/3)}{\alpha_t*x_1*y_1*(Fystr/\gamma_s)}$ =	0.000 cm

Choose $\Phi_{stirrups}$ #DIV/0!

No. of stirrups = 100/St + 100/Ss = #DIV/0!

Use Stirrups #DIV/0! #DIV/0! 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	:	TRIO GARDENS
Location	:	NEW CAIRO
Beam no	:	B5

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 181.00 m.t. Qu = 70 ton Mt = 0.0 m.t. b = 80 cm d = 80 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

$$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}} = 76.3 \text{ cm}$$

d = 80 cm Check d'/d ≤ 0.15 ⟹ Fs' = Fy/γs

From d get c/d = 0.391 Check $c_{min}/d < c/d < c_{max}/d$ ⟹ Safe

Mumax1 (moment Capacity for single reinforced section) = Rmax * Fcu/γc * b * d^2 = 199.00 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γ_s * (d - d') = 259.13 m.t.

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

$$As = \frac{Mu}{Fy/\gamma s * d * (1 - 0.4*c/d)} = 85.63 \text{ cm2}$$

$$As' = \frac{0.15*As}{} = 12.84 \text{ cm2}$$

Tension reinforcement

Choosen Φ_{main} = 25 mm ⟹ no. of Bars = 18

As actual = 88.39 cm2

μ = As/(b*d) = 0.014

Compression reinforcement

Choosen $\Phi_{secondary}$ = 22 mm ⟹ no. of Bars = 4

As' actual = 15.21 cm2

μ' = As'/(b*d) = 0.0024

Check μmin < μ < μmax ⟹ Safe

Check 0.1μ < μ' < 0.004 ⟹ Safe

Check of Shear

qu = Qu / (b*d) = 10.94 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		Torsion	
qsteel = qu - 0.5*qcu =	5.63 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= 75 X1 = 75
n = (b-cover)/25 + 1 =	4 Branches	α = 0.66 + 0.33* (y_1 / x_1) =	0.99
Ast/Ss =	0.054 cm	$Ast/St = \frac{(qsteel * (b^2*t)/3)}{\alpha_t * x_1 * y_1 * (Fystr/\gamma_s)}$ =	0.000 cm

Choose $\Phi_{stirrups}$ Ø10

No. of stirrups = 100/St + 100/Ss = 6.8720

Use Stirrups 7 Ø10 4 Branches

Longitudinal bars for torsion

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

Choosen $\Phi_{secondary}$ = 22 mm ⟹ no. of Bars = 0

Shrinkage bar

t > 70 cm Use shrinkage side bars

As shrinkage = 0.008 * As = 0.71 cm2

bar spacing = 26.667 cm ≤ 30 cm

Φ shrinkage = Ø08 no. of bars = 4

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Project name :TRIO GARDENS
Location NEW CAIRO
Beam no : B6

Given Data

Fcu = 300 kg/cm2 Fy = 3600 kg/cm2 Mu = 380.00 m.t. Qu = 100 ton Mt = 0.0 m.t. b = 100 cm d = 85 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

$$d_{min} = \sqrt{\frac{Mu}{Rmax * Fcu/\gamma c * b}} = 98.9 \text{ cm}$$

d = 85 cm Check d'/d ≤ 0.15 ⟹ Fs' = Fy/γs

From d get c/d = 0.440 Check $c_{min}/d < c/d < c_{max}/d$ ⟹ Safe

Mumax1 (moment Capacity for single reinforced section) = Rmax * Fcu/γc * b * d^2 = 280.81 m.t.

Mumax2 (moment Capacity for double reinforced section) = Rmax * Fcu/γc * b * d^2 + 0.004 * b * d * Fy /γs * (d - d') = 366.00 m.t.

Check Mu > Mumax2 =======> Increase section dimensions

$$As = \frac{Mumax1}{Fy/\gamma s * d * (1- 0.4*cmax/d)} + \frac{Mu - Mumax1}{Fy/\gamma s * (d -d')} = 167.60 \text{ cm2}$$

$$As' = \frac{Mu - Mumax1}{Fy/\gamma s * (d - d')} = 39.59 \text{ cm2}$$

Tension reinforcement

Choosen Φ_{main} = 25 mm ⟹ no. of Bars = 35

As actual = 171.88 cm2

μ = As/(b*d) = 0.020

Compression reinforcement

Choosen $\Phi_{secondary}$ = 22 mm ⟹ no. of Bars = 11

As' actual = 41.83 cm2

μ' = As'/(b*d) = 0.0049

Check μmin < μ < μmax ⟹ Increase d

Check 0.1μ < μ' < 0.004 ⟹ Increase d

Check of Shear

qu = Qu / (b*d) = 11.76 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	Torsion
qsteel = qu - 0.5*qcu = 6.46 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= 80 X1 = 95
n = (b-cover)/25 + 1 = 6 Branches	α = 0.66 + 0.33* (y_1 / x_1) = 0.9379
Ast/Ss = 0.034 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 = 6.8411

Use Stirrups 7 Ø8 6 Branches

Longitudinal bars for torsion

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

Choosen $\Phi_{secondary}$ = 22 mm ⟹ no. of Bars = 0

Shrinkage bar

t > 70 cm Use shrinkage side bars

As shrinkage = 0.008 * As = 1.38 cm2

bar spacing = 28.333 cm ≤ 30 cm

Φ shrinkage = Ø12 no. of bars = 4

DELTA BUILDING SYSTEMS
MEMBER OF PLENA

Tables of quantities & CONSLOSION

ONE BUILDING (QUATTRO STANDARD, BASMENT+GROUND +4 MUILTI STORIES + ROOF)

1. COLUMNS AND WALLS

	DELTA BLOCK	CLAY
TOTAL QUANTITY OF RC IN M3/FLOOR	37.04	46.48
QUANTITY OF SAVING	9.44	
% OF SAVING	20.03%	

2. FLOORS AND BEAMS

	DELTA BLOCK	CLAY
Total quantity of concrete/Basement	106.48	116.59
Total saving	10.11	
% of saving	8.67%	
Total quantity of concrete/ground	94.08	100.24
Total saving	6.16	
% of saving	6.14%	
Total quantity of concrete/First	94.08	100.24
Total saving	6.16	
% of saving	6.14%	
Total quantity of concrete/Second	94.08	100.24
Total saving	6.16	
% of saving	6.14%	
Total quantity of concrete/third	95.84	102.67
Total saving	6.56	
% of saving	6.39%	
Total quantity of concrete/forth	94.08	108.36
Total saving	14.28	
% of saving	13.2	
Total quantity of concrete/Roof	25.72	27.1
Total saving	1.38	
% of saving	5.1%	
Total quantity of saving/floors	59.73	
TOTAL % OF SAVING IN FLOORS	7.59%	

3. REINFORCEMENT

	DELTA BLOCK	CLAY
TOTAL QUANTITY OF STEEL IN WALLS & COL TON	6.78	9.458
% OF REINFORCEMENT IN COLUMNS &WALLS	183.04 KG/M3	203.5 KG/M3
QUANTITY OF SAVING	2.678	
% OF SAVING	28.31%	
TOTAL QUANTITY OF STEEL IN BASMENT TON	16.1	18.69
% OF REINFORCEMENT IN BASMENT TON	158KG/M3	160KG/M3
QUANTITY OF SAVING	2.59	
% OF SAVING	13.85%	
TOTAL QUANTITY OF STEEL IN GROUND FLOOR TON	10.98	12.28
% OF REINFORCEMENT IN GROUND FLOOR	116.7KG/M3	123KG/M3
QUANTITY OF SAVING	1.3	
% OF SAVING	10.58%	
TOTAL QUANTITY OF STEEL IN FIRST FLOOR TON	10.98	12.28
% OF REINFORCEMENT IN FIRST FLOOR	116.7KG/M3	123KG/M3
QUANTITY OF SAVING	1.3	
% OF SAVING	10.58%	
TOTAL QUANTITY OF STEEL IN second FLOOR TON	10.98	12.28
% OF REINFORCEMENT IN second FLOOR	116.7KG/M3	123KG/M3
QUANTITY OF SAVING	1.3	
% OF SAVING	10.58%	
TOTAL QUANTITY OF STEEL IN third FLOOR TON	11.82	13.48
% OF REINFORCEMENT IN third FLOOR	123.3KG/M3	131.12KG/M3
QUANTITY OF SAVING	1.66	
% OF SAVING	12.3%	
TOTAL QUANTITY OF STEEL IN forth FLOOR TON	11.12	12.65
% OF REINFORCEMENT IN forth FLOOR	118.2kg/m3	116.69KG/M3
QUANTITY OF SAVING	1.53	
% OF SAVING	12.1%	
TOTAL QUANTITY OF STEEL IN roof FLOOR TON	2.45	4.89
% OF REINFORCEMENT IN roof FLOOR	95.25kg/m3	180.44
QUANTITY OF SAVING	2.44	
% OF SAVING	49.89	
TOTAL QUANTITY OF SAVING	14.798	
TOTAL % OF SAVING	15.41%	

4. walls

	DELTA BLOCK	CLAY
TOTAL OF QUANTITY 25 CM M3	**126**	126
TOTAL OF QUANTITY 12 CM M3	98	**19.6**
TOTAL OF QUANTITY M3	224	**224**
PRICE/M3 AFTER SALE TAX INCLUDED &TRANSPORTATION	783.47	**446**
TOTAL PRICE	175497.28	**99904**
TOTAL QUANTITY OF DELTA MORTER	224 PAG	**24.7 ton**
TOTAL PRICE OF DELTA MORTER	9990	**19760**
TOTAL SAVING in	**9770**	
%OF TOTAL SAVING	**49.44 %**	

TOTAL COST OF ONE BUILDING QUATTRO STANDARD

	DELTA BLOCK	CLAY
TOTAL QUANTITY OF FLOORS AND COLUMNS IN M3	**826.8**	**943.17**
COST OF M3 INCLUDED CON. &FORMERS WITHOUT REIN.	**950**	
TOTAL COST OF RC OF SLABS AND COLUMNS	**785403**	**896011.5**
TOTAL COST OF MASONARY /BLOCKS	**175497.28**	**99904**
TOTAL QUANTITY OF STEEL	**81.21**	**96.01**
TOTAL COST OF STEEL	**974520**	**1152096**
TOTAL COST OF DELTA MORTER	**9990**	**19760**
TOTAL COST OF BUILDING	**1945410.3**	**2167771.5**
TOTAL SAVING	**222361.2**	
% OF SAVING IN BUILDING	**10.26%**	

The percentage of saving for one building only in block , 10.26% excluding foundations =222,361.2 EGP

***the prices of Delta block after discount 7% depended on quantities and According to attached financial offer.**

	% OF SAVING
TOTAL % OF SAVING QUANTITY OF CONCRETE IN COLUMNS	20 %
TOTAL % OF SAVING QUANTITY OF CONCRETE IN FLOORS	7.6%
TOTAL % OF SAVING QUANTITY OF CONCRETE IN REINFORCEMENT	15.41%
TOTAL % OF SAVING IN MORTER	49.44%
IMPACT OVER ALL BUILDING	**10.26%**

Technical Department

Eng.Essam Samy