# *Tower isntalling on Roof buidling For ( 25 m) height*

**Prepared by :**

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# ***Building Analysis***

Based on my practical experiences on the field in the last ( 6) years of my duties, I would like to state one of the cases that we have executed. This is to be my search report as our calculation & formula is calculated in hereunder report.

## ***Site topology:***

* Roof top site

* Building (2) story with 3m height for each floor

* Skeleton building

* Installed (25m) tower (Matis type)

* Applying reduction factor by (80%) for additional tower loading to minimize its height & antennas mounting

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## Commerical building checking to support ٣٠ m Steel Tower

The commerical building located at Erbil city-with two stories

### ١ – Check thickness of the slab:

maximum panel size ( ٥.٢٠ x ٧.٩٠ m c/c )

$t_{min}$ = [Ln ( ٠.٨ + ( fy / ١٤٠٠ ))] / [ ٣٦ + ٩ β] , ACI ٢٠٠٨, Chap.٩, Eq. ٩.١٣

Ln = ٧.٩ – ٠.٤ = ٧.٥ m

fy = ٤١٤ Mpa ( Grade ٦٠ ),

β = Ln١ / Ln٢ = ٧.٥ / ٤.٨ = ١.٥٦٢٥

$t_{min}$ = [ ٧.٥ ( ٠.٨ + ( ٤١٤ / ١٤٠٠ ))] / [ ٣٦ + ٩ (١.٥٦٢٥)] = ٠.١٦٤ m

For this panel thickness to be not less than ١٧ cm

For the panel which steel tower to be supported on, is ٥.٢ x ٣.٣ m c/c as shown in Fig.(١).

β = ٤.٨ / ٢.٩ = ١.٦٥٥

$t_{min}$ = ٠.١٠٤ m

Thickness of ١٥ cm is adequate for this panel.

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## ٢ - Load Calculations :

The building is consist of two – stories , Ground and Roof , the load can be calculated as follows :

a – Ground Floor :

- Dead Loads.
- slab, ٠.١٥ x ٢٤ = ٣.٦ kN/ m$^{٢}$
- tile + mortar = ١.٦٢ kN/ m$^{٢}$
- finishing = ٠.٣ kN/ m$^{٢}$

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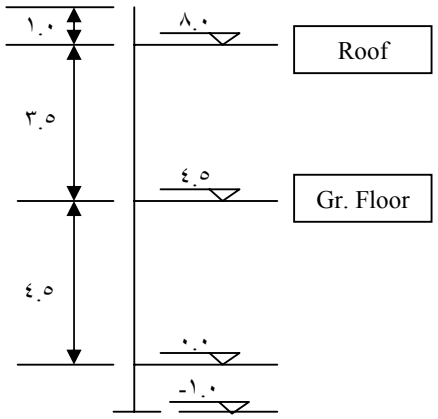
٥.٥٢ kN/ m$^{٢}$




Live Load = ٣.٠ kN/ m$^{٢}$

Wu = ١.٢ D.L + ١.٦ L.L

= ١.٢(٥.٥٢) + ١.٦(٣) = ١١.٤ kN/ m$^{٢}$

b – Roof

Dead Loads

- slab, ٠.١٥ x ٢٤ = ٣.٦٠ kN/ m$^{٢}$
- Roofing system ( Future ) ≈ ٢.٠٠ kN/ m$^{٢}$
- finishing ≈ ٠.٣٠ kN/ m$^{٢}$

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٥.٩٠ kN/m$^{٢}$

Live Load = ١.٥ kN/ m$^{٢}$

Wu = ١.٢ D.L + ١.٦ L.L

= ١.٢(٥.٩) + ١.٦(١.٥) = ٩.٤٨ kN/ m$^{٢}$

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**-Beam Cross – Sections:**

٤٠٠ x ٥٥٠ mm  Ground

٤٠٠ x ٤٥٠ mm  Roof

$h_{min}$ required according to ACI Code chap. ٩

For span ٧.٩ m , $h_{min}$ = L / ١٨.٥ = ٧.٩ / ١٨.٥ = ٠.٤٣ m

For span ٥.٢ m , $h_{min}$ = L / ١٨.٥ = ٥.٢ / ١٨.٥ = ٠.٢٨ m

Section sizes provided greater than required by ACI Code , there is no need for check of deflection for beams.

## Transmission of loads from the slab to B١ and B٢:

١ – load from the slab

a – roof slab , Wu = ٩.٤٨ kN / $m^{٢}$

Area bounded by beam B١ & B٢ shown in Fig.(٢)

Area bounded by B١ = ١٢.٦٢ $m^{٢}$

Area bounded by B٢ = ٥.٤٥٠ $m^{٢}$

Ultimate load from slab,  for  B١ = ( ١٢.٦٢ / ٥.٢ ) x ٩.٤٨ = ٢٣ kN / m

for  B٢ = ( ٥.٤٥ / ٣.٣ ) x ٩.٤٨ = ١٥.٦ kN / m

Beam stem = ٠.٤ x ٠.٣ x ٢٤ x ١.٢ = ٣.٥ kN / m

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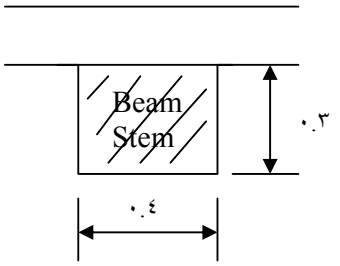
B١ , Wu = ٢٣.٠ + ٣.٥ = ٢٦.٥ kN / m

B٢ , Wu = ١٥.٦ + ٣.٥ = ١٩.١ kN / m




b – Ground Floor slab , Wu = ١١.٤ kN / m$^{٢}$

Load from slab to B١ = ( ١٢.٦٢ / ٥.٢ ) x ١١.٤ = ٢٧.٧ kN / m

B١ , Wu = ٢٧.٧ + ٣.٥ = ٣١.٢ kN / m

Load from slab to B٢ = ( ٥.٤٥ / ٣.٣ ) x ١١.٤ = ١٨.٨ kN / m

B٢ , Wu = ١٨.٨ + ٣.٥ = ٢٢.٣ kN / m

## Load calculations for Colums:

First the load of beams supported by C١ & C٢ calculated and shown in Fig.(٣), for both ground and roof slab.

Load from roof to C١ = ٣٠.٥ x ٢.٦ + ١٩.١ x ١.٦٥ + ٢٦.٥ x ٤.٨ = ٢٣٨ kN

Load from ground to C١ = ٣٦.٦ x ٢.٦ + ٢٢.٣ x ١.٦٥ + ٣١.٢ x ٤.٨ = ٢٨٢ kN

Col. load = ٠,٤ x ٠,٤ x ٨ x ٢٤ x ١,٢ = ٣٧ kN

Pc١ = ٥٥٧ kN

Load from roof to C٢= ٣٠.٥ x ٢.٦ + ١٩.١ x ١.٦٥ + ٢٦.٥ x ٦.٥٥ = ٢٨٤.٤ kN

Load from ground to C٢= ٣٦.٦ x ٢.٦ + ٢٢.٣ x ١.٦٥ + ٣١.٢ x ٦.٥٥ = ٣٣٦.٣kN

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Col. load = ٠,٤ x ٠,٤ x ٨ x ٢٤ x ١,٢ = ٣٧ kN

Pc٢ = ٦٥٨ kN ( Ultimate factored load )

## Applied moments to the Columns

Columns above ground slab

$$Pc_{٢} = ٢٨٤.٤ + ١٨.٥ = ٣٠٣ \text{ kN}$$

$$Mx = ( ١ / ١٠ ) \times ٣٠.٥ \times ( ٥.٢٥ - ٠.٤ )^{٢} - ( ١ / ١١ ) \times ١٩.١ \times ٢.٩^{٢} = ٥٧ \text{ kN. m}$$

$$My = ( ١ / ١٠ ) \times ٢٦.٥ \times ٧.٥^{٢} - ( ١ / ١١ ) \times ٢٦.٥ \times ٤.٨^{٢} = ٩٤ \text{ kN. m}$$

$$Pc_{١} = ٢٣٨ + ١٨.٥ = ٢٥٧ \text{ kN}$$

$$Mx = ٥٧ \text{ kN. m}$$

$$My = ( ١ / ١٠ ) \times ٢٦.٥ \times ٤.٨^{٢} - ( ١ / ١١ ) \times ٢٦.٥ \times ٣.٦^{٢} = ٣٠ \text{ kN. m}$$

# Design of the slab, beam, column and Footings

١ – Check the structural design of the slab.

For the shaded area :

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$Wu = ١١,٤\ kN/m^{٢}$ $fy = ٤١٤\ Mpa$ $fc' = ٢١\ Mpa$

$t = ١٥٠\ mm \Longrightarrow d = ١٥٠ - ٢٥ - ١٢/٢ = ١١٩\ mm$

$b = ١.٠\ m$

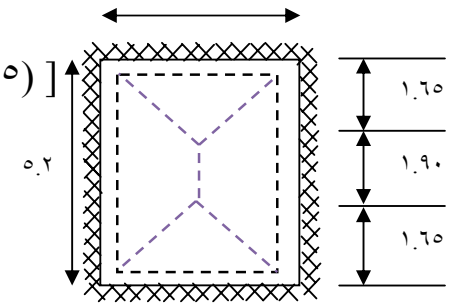
Calculate $m_{neg}$ and $m_{pos}$ by YLT or other methods:

$\Sigma W\delta = ١١.٤ ( ٠.٥ \times ٣.٣ \times ١.٦٥ \times \delta/٣ + ٠.٥ \times ١.٦٥^{٢} \times \delta/٣ \times ٢ + \delta/٢ \times ١.٩ \times ١.٦٥ )$

٣.٣

$\Sigma W\delta = ٣٩\ kN$

$\Sigma M\square = (m_n + m_p) [ ٣.٣ \times \delta/(١.٦٥) + ٥.٢ \times \delta/(١.٦٥) ]$




$\Sigma M\square = \Sigma W\delta$

$m_n = ٥.١ \times ٢$ ( safety ) $= ١٠.١\ kN.\ m/m$

$R = Mu / \Phi\ b\ d^{٢} = ٠,٧٩\ MPa$

$m = fy / ٠.٨٥\ fc' = ٢٣.٢٠$

$\rho = ١/m ( ١ - \sqrt{١ - ٢mR/fy}) = ٠.٠٠١٩٥$

$\rho$ calculated $= ٠.٠٠١٩٥ > \rho$ min.$= ٠.٠٠١٨$ ( ACI Code ٧.١٢ )

As required $= \rho \times b \times d = ٢٣٢\ mm^{٢}/m$

$\Phi$ ١٠ @ ٢٥٠ mm c/c required.

**Comment: Provided reinforcement more than required i.e the slab is safe and there is no additional loads from steel tower to the slab.**

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٢ – Check the structural design of beams:

more critical beam is B١ , L = ٥.٢ m c/c

Mneg. = ١/١١ Wu $ln^{٢}$ = ١/١١ x ٢٦,٥ x ( ٥,٢ – ٠,٤ )$^{٢}$ = ٥٥,٥ kN. m

( ACI Code ٢٠٠٨ chap. ٨ )

b = ٤٠٠ mm

d = ٤٥٠ – ٤٠ – ١٠ – ١٦/٢ = ٣٩٢ mm

R = Mu / Φ b $d^{٢}$ = ١.٠ MPa

$\rho$ = ١/m ( ١-$\sqrt{١-٢mR/fy}$) = ٠.٠٠٢٥ < $\rho$ min

Use $\rho$ min

$\rho$ min = ٠.٢٥ $\sqrt{fc'}$ / fy = ٠.٠٠٢٨ < ١.٤ / fy = ٠.٠٠٣٣٨

$\rho$ min = ٠.٠٠٣٣٨

As = $\rho$ b d = ٠.٠٠٣٣٨ x ٤٠٠ x ٣٩٢ = ٥٣٠ $mm^{٢}$

Privide reinf. ٤Φ ١٦ mm , As = ٨٠٤ $mm^{٢}$ > ٥٣٠ $mm^{٢}$ O.K

**Comment: ١ – Beam B١ resisting applied load safely.**

**٢ – When additional loads applied from the steel tower , the additional loads to be resisted by Other Beam shown in Fig.(٤) from analysis by STAAD Pro ٢٠٠٧ Software to transmit the loads to the Columns.**

٣ – Check structural design of the Columns :

Applied load from slab and Beam to Pc٢ (more critical column )

a – C٢ ( Roof Column )

Pc٢ = ٣٠٣ kN

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Mx = ٥٧ kN. m

My = ٩٤ kN. m } greater than $M_{min}$ , i.e to be considered

Design the Column as biaxial column

ex = My / P = ٣١٠ mm , ex / h = ٠.٧٧٥

ey = Mx / P = ١٨٨ mm , ey / h = ٠.٤٧

Columns ٤٠٠ x ٤٠٠ mm , As = ٨ x ٢٠١ = ١٦٠٨ $mm^2$

$\rho_g$ = ١٦٠٨ / ( ٤٠٠ x ٤٠٠ ) = ١ %

$\gamma$ = ( ٤٠٠ – ٦٢ x ٢ ) / ٤٠٠ = ٠.٧

From charts given in the text book by Arthur H. Nilson " Design of concrete structures " ٢٠٠٤.

Pu = ٠.١٤ fc' Ag = ٤٧٠.٤ kN > ٣٠٣ kN O.K

Mx = ٠.١٣ fc' Ag h = ١٧٦.٥ kN > ٩٤ kN O.K

My = ٠.١٥ fc' Ag h = ٢٠١ kN > ٥٧ kN O.K

**Comment: ١- Columns are adequate for holding the building safely**

**٢- Additional load comes from the Tower is less than**

**( ٤٧٠.٤ – ٣٠٣ ) = ١٦٧.٤ kN , O.K safe**

**No Additional treatment reqd. ( Detail calculation given in the output of the Program.**

٤ – Check for Footing :

maximum applied load from C٢ to foundation is $Pc^2$ = ٦٥٨ kN

Note: Based on soil investigation for other building in Gulan & Ainkawa Site, Allowable bearing capacity , $q_{all} \approx$ ١٥٠ – ٢٠٠ kN / $m^2$

For calculations, $q_{all} \approx$ ١٧٥ kN / $m^2$

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Unfactored load, Pc٢ = ٦٥٨ / ١,٤ = ٤٧٠ kN

Area reqd. = ٤٧٠ / ١٧٥ = ٢.٦٩ $m^{٢}$

Area Provided ١,٨ x ١,٨ = ٣,٢٤ > ٢.٦٩ O.K

**Check punching shear strength and calculate thickness of footing:**

Required thickness based on the applied load:

٦٥٨ = ( ٠,٧٥ / ٣ ) $\sqrt{fc'}$ x d x ( ٠,٤ + d ) x ٤

d = ٢٤ cm

t = ٢٧ cm on Lean Conctere

thickness privided > t reqd. O.K

As = ٠.٠٠١٨ x ١٠٠٠ x ٤٠٠ = ٧٢٠ $mm^{٢}$ ( Φ ١٦ @ ٢٥٠ mm c/c )

**To prevent punching shear failur, ٢٧ cm thickness required.**

**Comment :**

**١- Footing dimensions & reinf. is adequate for the existing Building.**

**Check structural design when steel tower loads applied.**

١- slab , no need for check, since the loads goes directly to beams & columns.

٢- Beams, provided beams not adequate to resist additional loads, other sections added as shown in the detail drawings and mentioned earlier.

٣- Columns with ٤٠٠ x ٤٠٠ and ٨ Φ ١٦ mm reinforcement.

٤- Provided Area of Footing **more** than reqd. after additional loads applied.

Note: Aditional loads from steel tower provided by Asia Cell with reduction factor of %٨٠ ( According to Instructions of Mr. Rebware ).

Thanks

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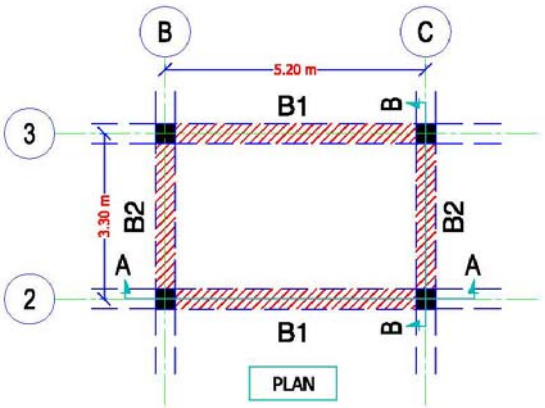
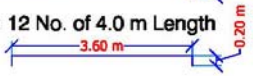



Note :

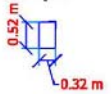
Amount of Steel required :

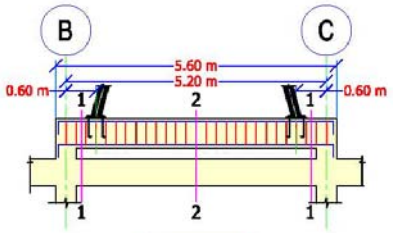
1- Ø 25 mm ------> 16 No. of 6.0 m Length

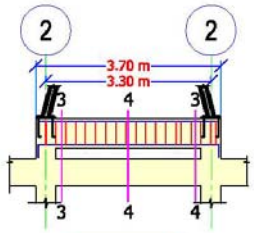

2- Ø 25 mm ------> 12 No. of 4.0 m Length

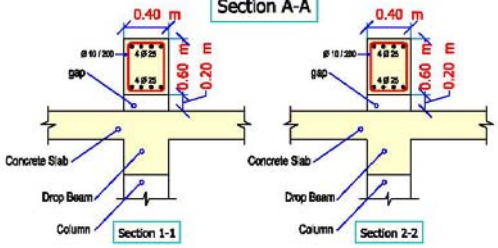


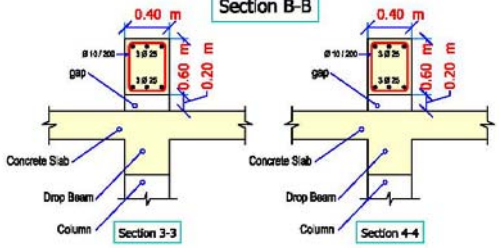

3- Ø 10 mm for stirrups 90 Stirrups




TOWER
installing

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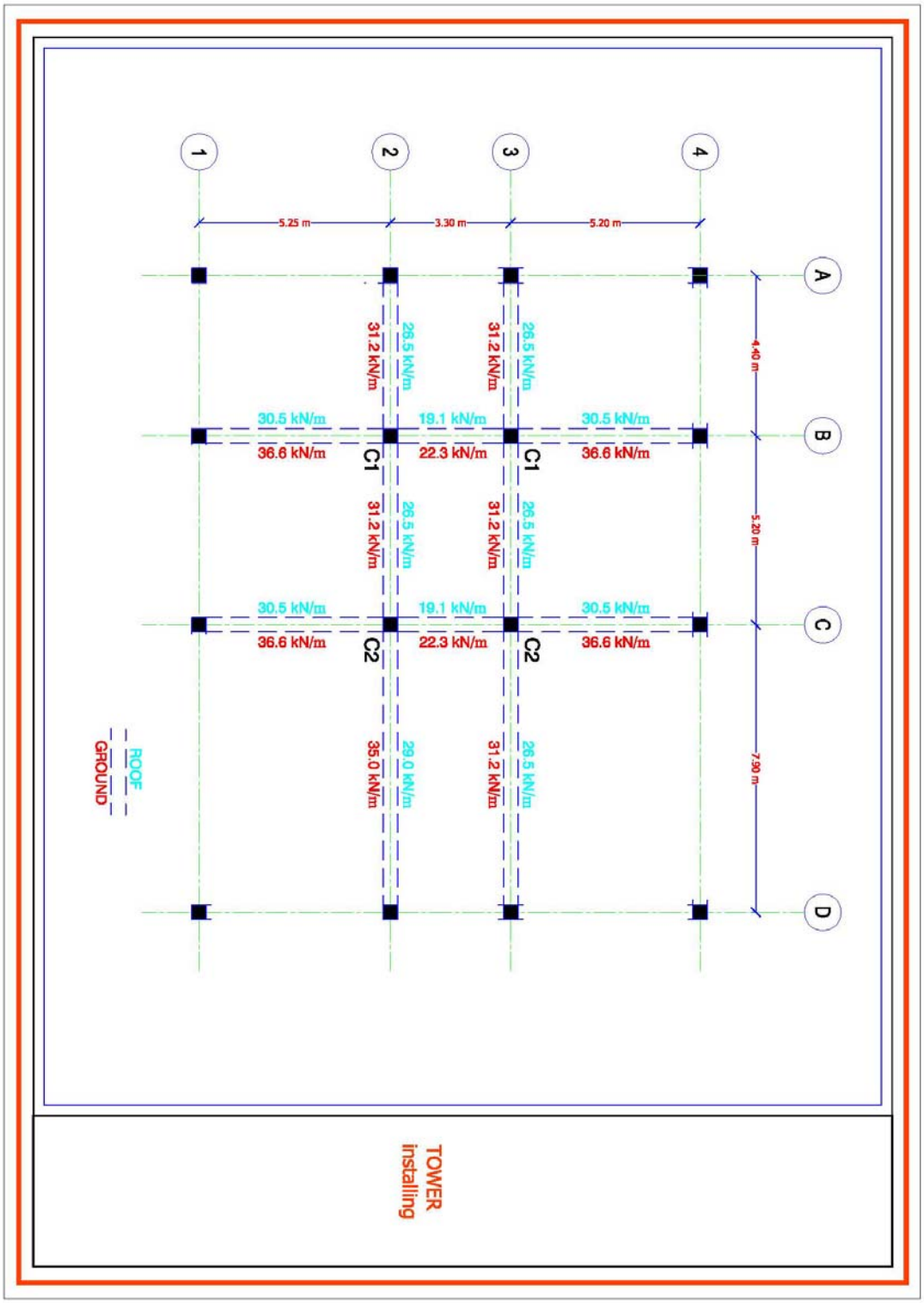
1
2
3
4
5.25 m
3.30 m
5.20 m
A
B
C
D
4.40 m
5.20 m
7.90 m
31.2 kN/m
26.5 kN/m
30.5 kN/m
19.1 kN/m
36.6 kN/m
22.3 kN/m
C1
C2
35.0 kN/m
29.0 kN/m
ROOF
GROUND
TOWER
installing

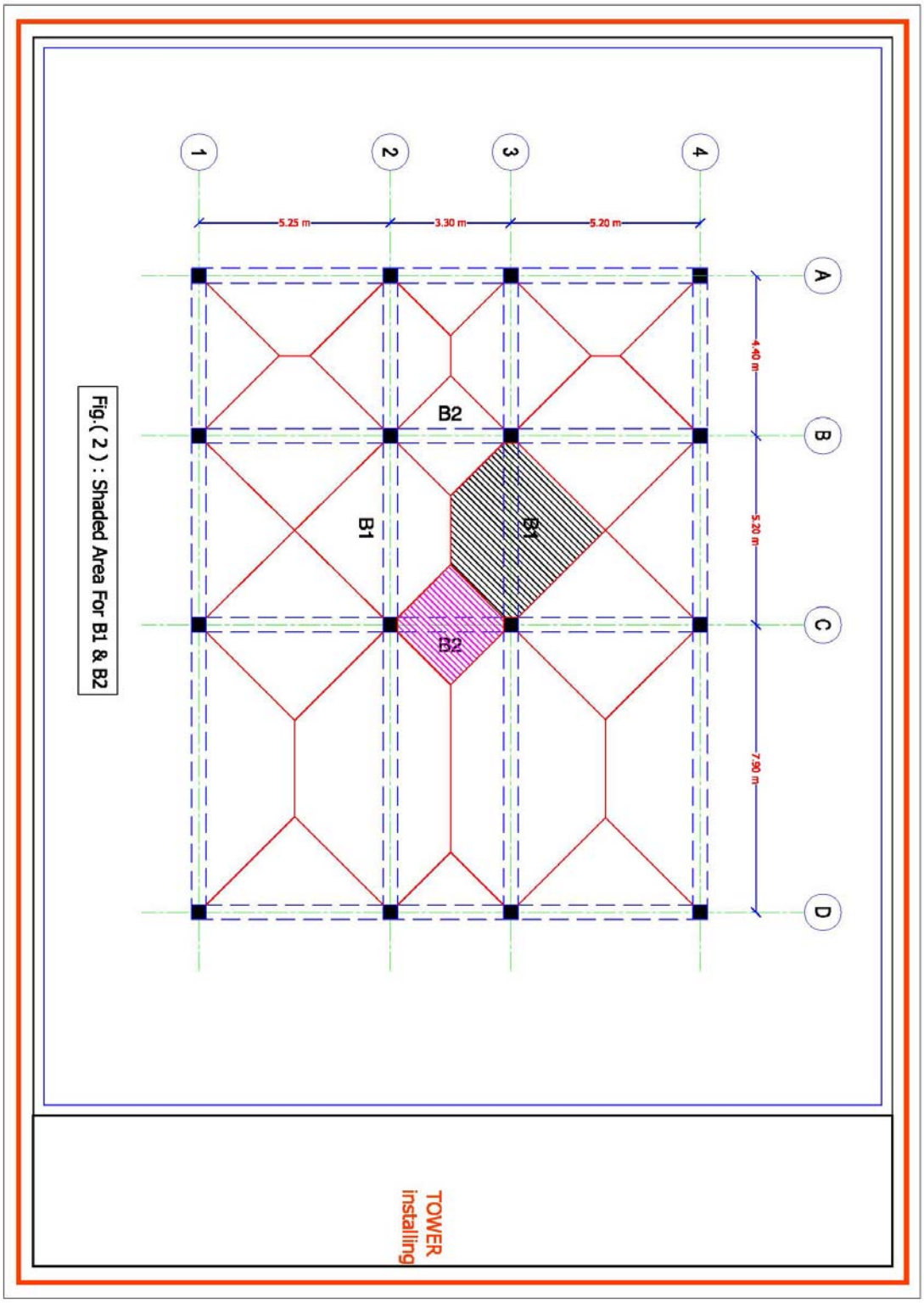


Fig.( 2 ) : Shaded Area For B1 & B2

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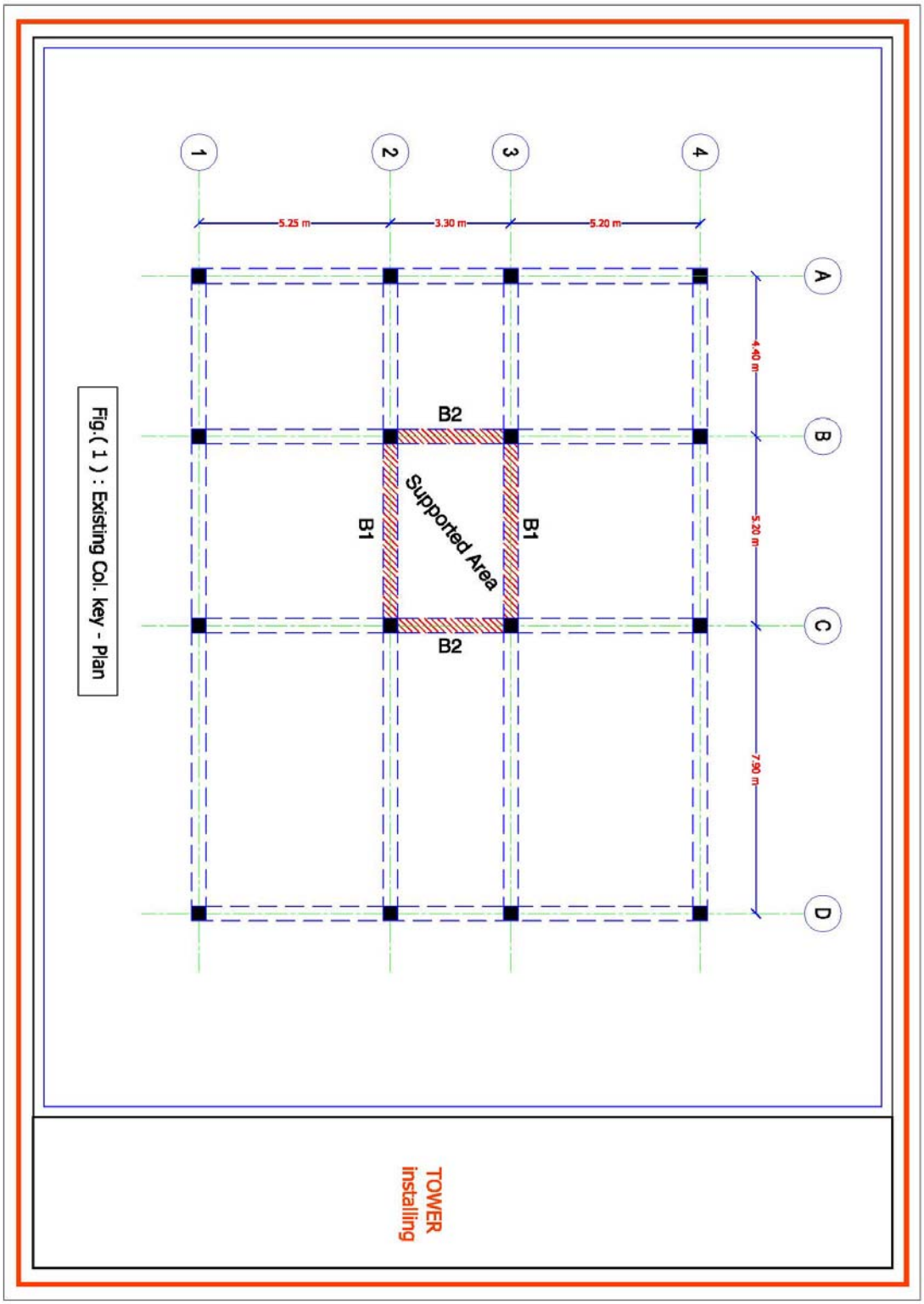


Fig.( 1 ) : Existing Col. key - Plan