iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** V **Month of publication:** May 2020

DOI: http://doi.org/10.22214/ijraset.2020.5075

Investigation of Load Transfer Mechanism in Building Strucutre with Analysis and Design of Biaxially Loaded Column & its Isolated Slope Footing - A Case Study at Silchar Airport

Abdul Aziz[1], A Ramakrishnaiah[2]
[1]*M.Tech. scholar of Structural Engineering and Construction Management, Department of Civil Engineering, Golden Valley Integrated Campus, Angallu, Andhra Pradesh, INDIA*
[2]*Associate Professor cum HOD, Department of Civil Engineering, Golden Valley Integrated Campus, Angallu, Andhra Pradesh, INDIA,*

Abstract: The mechanism in a construction work of building where the building floor system consists of reinforeced concrete slab which is supported on a rectangular grid of beams. The grid of beams takes load from slab and transfer it towards column. Hence, slab thickness can reduce by a structural designier, depending upon on the geometric configuration of grid forming beams. The structural elements of a building such as slab, beam, column and footing bearing their own loads and imposed load i.e. dead load and live load and transfers from roof to floor beam, floor beam to column and finally from footing to soil. So, all the structural elements are interelated to each other for providing the structural stability in a building. Without geotechnical survey of soil condition, footing can not be design, because without proper bearing capacity of soil, the whole structure may fail at any condition due to earthquake load, wind load, snow load, hydrostatic pressure, low soil bearing capacity, etc. There are several restriction must follows while designing any structural element.
The purpose of the study is to aid structural designers while designing the structrual elements of building. This study investigates how the structural elements transfer loads from top level to bottom of the building. In this research work, a small portion of building frame has considered which is constructed in modification of terminal building (G+3) storey at Silchar Airport. As well, the various aspects and manually designing procedure for Biaxially Loaded Column with Isolated Slope Square Footing as per IS codel provisions where as few datas are taken from S.T. Enterprise consultant's report.
Keyword: Soil-structure interaction, load transfer mechanism, Beam-column joint, structural elements, failure mechanism, structural design, buildng systems, biological design in Structural Engineering, structural optimization.

I. INTRODUCTION

Structural Engineering started from ancients Egyptions & "Imhotep" (2700 BC) constructed step pyramid for Pharaoh Djoser known the first Structural Engineer. In the structural engineering field, the main aspect to investigate, design & develop low budget economical structure with more functional facilities, durabilities and shear & moments and strengtheing of structural elements in a proper manner. While designing of buildings, bridges, offshore and industrial structures- a set of planning and controlling of various elements design is necessary for performing the imagination intro real world. Proper load transformation and functions of each elements are necessary to form a building strcture, otherwise building many collapse with heavily self loaded, external forces, and other unwanted aspects. So, structural optimization, soil-structure interaction studuies is necessary while analysis of structural elements for design . External loads like seismic forces, wind load, etc. are to be considered in each and every structural elements with maintaining proper safety factors, as per codel provisions.

The load-transfer mechanism of building tells us about load configuration exerct by each element through its geometrical as well as structural aspects. In case of slab, depending upon the ration of longer span and shorter span-designer has consider to follow one-way or two-way load carrying slab. In case of beam, it has consider to check natural axis's position for balancing the load with proper reinforecement as well for proper maintaining of development length for smooth transfering of load towards column at beam-column junction. While in footing case- depending upon on load capacity and column positioning as well as soil conditions, it could design in several type like- Isolated footing, eccentrically loaded footing, pile foundation, etc. majorly in rectangular, square or circular form. So, soil-structure interaction occures and is required to investigate all datas for performing a better structural health of a building. Shear calculation is required to check the amount of shear exerts by particular element from external and internal

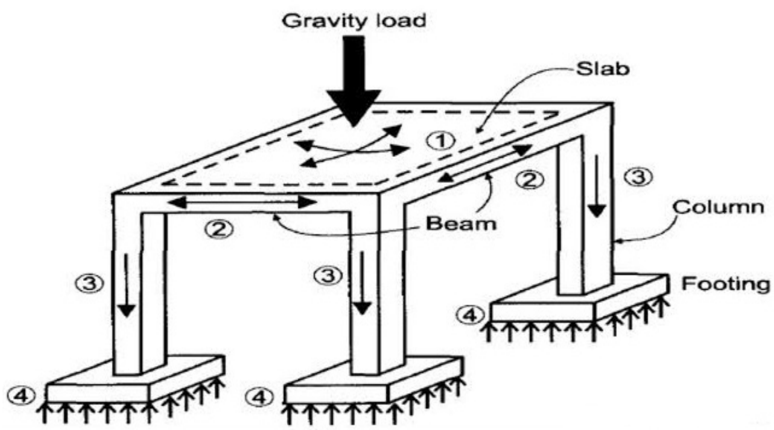
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

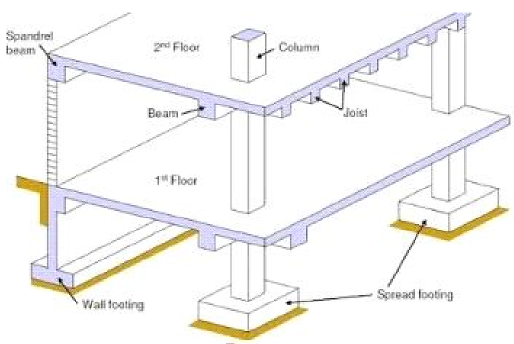
loads while resulting shear failure at its own position or shears small away and to balance the shear force through shear reinforcement. Moment calculation is necessary to design the element which could bear its own & overburden load. Otherwise elements could fail due to compression or tension resulting flexural failure or modulus of rupture, and overburder failure or buckling from compression or brittle failure.

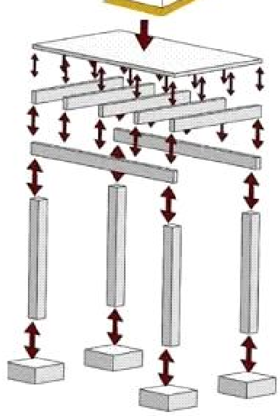
Besides on all failure configuration of structural elements, Structural Engineers design all the elements with special care. There are several softwere package has developed to design the structural components easily with consideration of safety factors, like- Staad Pro, ANSYS, SAFE, RISA, Autodesk Revit, SAP2000, 3D Max, Navisworks, etc. The present study was carried out while construction of Modification of Terminal Building (G+3) storey at Silchar Airport where as we will see how structural elements transfers loads from one stage to another and later on in this paper- a structural element-Footing (Isolated sloped square) for rectangular column will design manually.

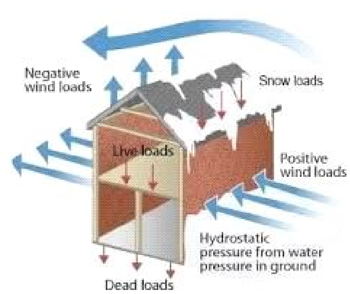
II. STRUCTURAL ELEMENTS

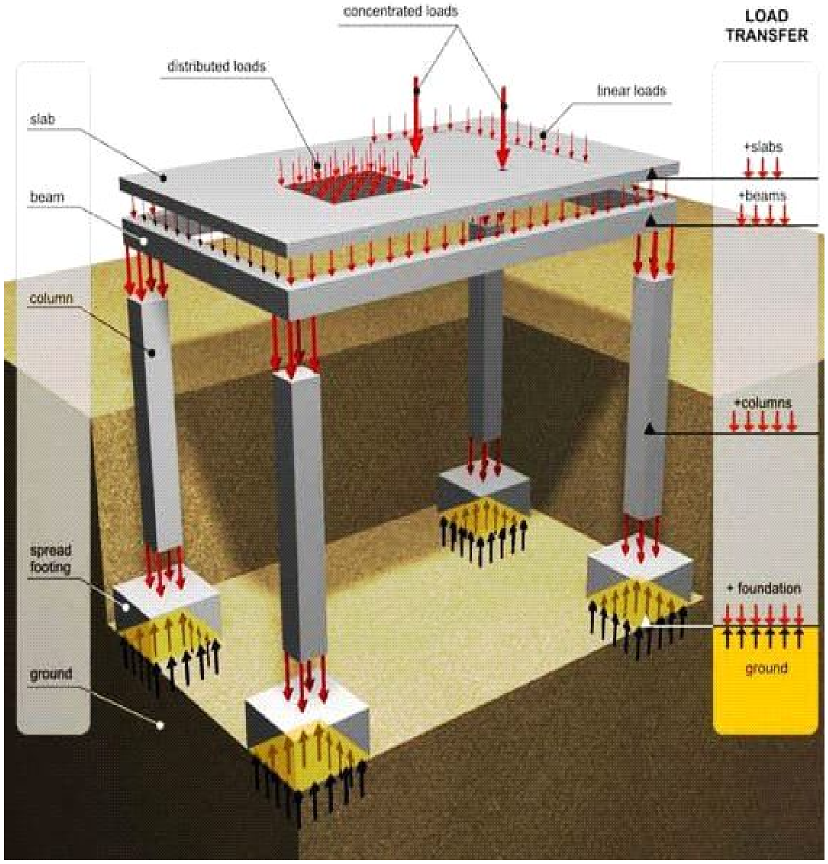
Major elements of building structure are Slab, Beam, Column, Foundation, Stair etc. where they carry loads and transfer to downgrade to surve support, enclose and protect the building structure.

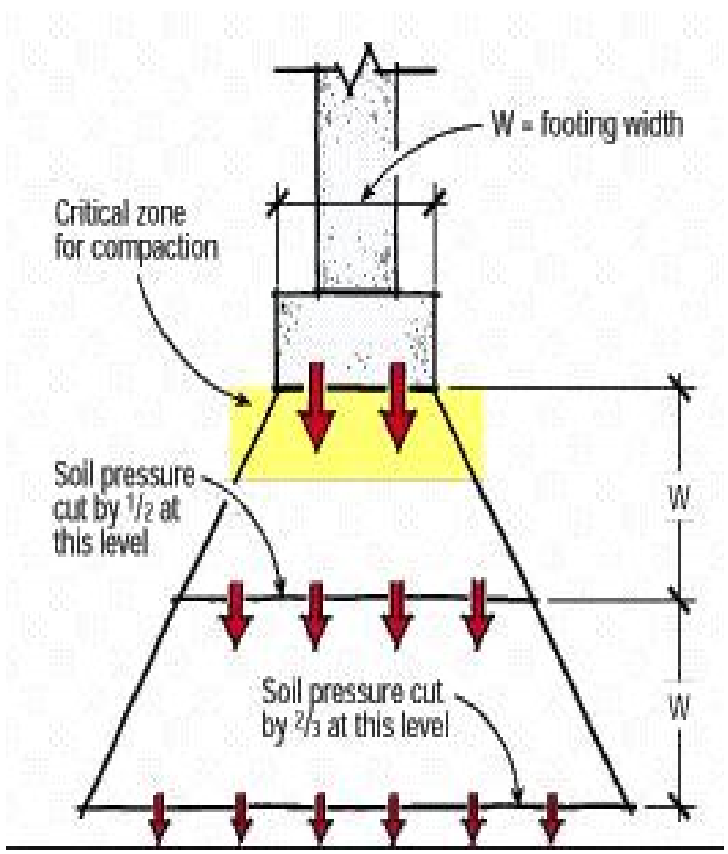








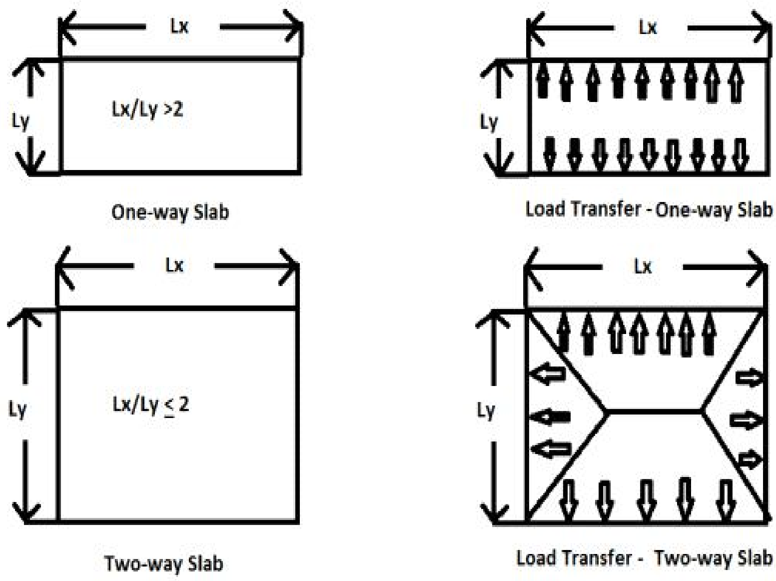

concentrated loads
LOAD TRANSFER
distributed loads
linear loads
slab
+slabs
beam
+beams
column
+columns
spread footing
+ foundation
ground
ground

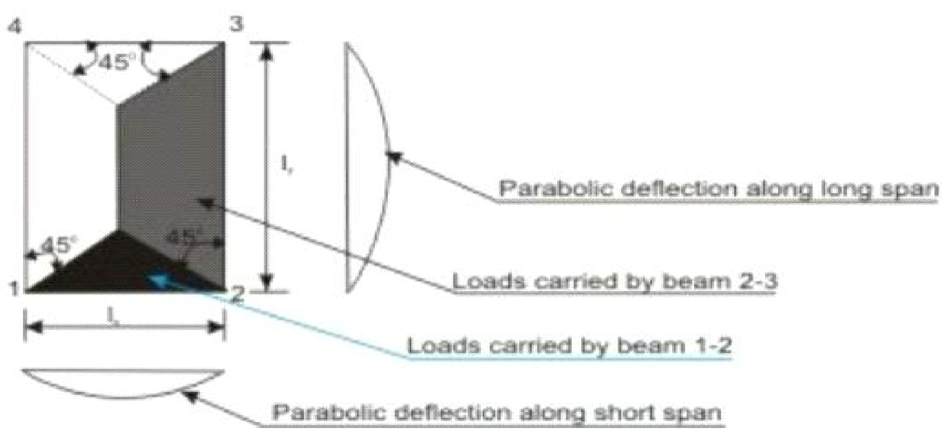

W = footing width
Critical zone for compaction
Soil pressure cut by 1/2 at this level
W
Soil pressure cut by 2/3 at this level
W

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

III. BENDING BEHAVIOUR ON SLAB

Depending upon of load bearing capacity on each span of a slab, it may design mainly in One-directional or two directional slab. In here, the load bears by each span are discuss elaborately.





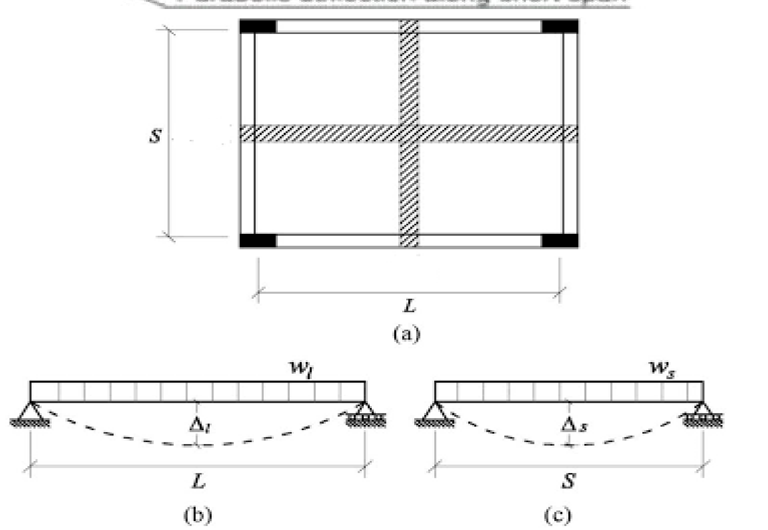
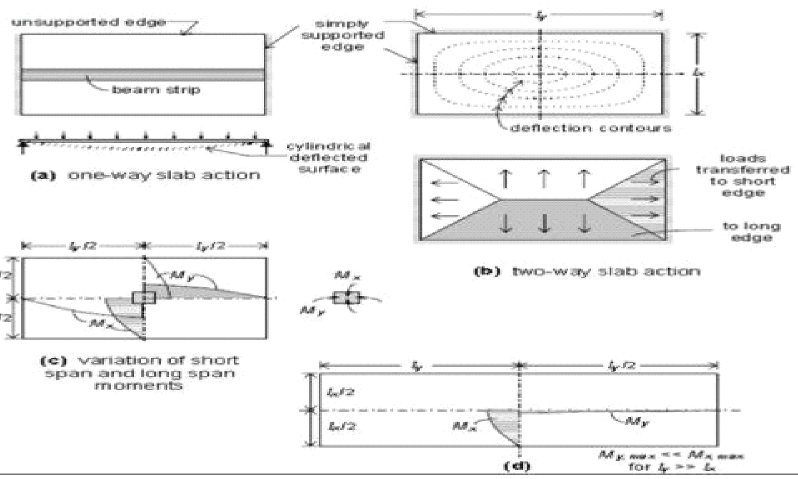


Figure : (a) Strips in the short and long directions; (b) deflection in the long direction; (c) deflection in the short direction

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

Consider, W = Udl on slab, L_y = Longer span & L_x = Shorter span
W_x = Load carried by strip AC along X direction,
W_y = Load carried by strip BD along Y direction,
Therefore, Total Load, $W = W_x + W_y$,..............................eq.1.
$d_c = (5/384) \times (WL^4/EI)$,.................................eq.2
d_c = deflection at centre, W = UDL, L = length of Area/Beam/Strip.
$(d_p)_x$ along X direction = $(5/384) \times (W_xL_x^4/EI)$,.........eq.3
$(d_p)_y$ along X direction = $(5/384) \times (W_yL_y^4/EI)$,.........eq.4
when $(d_p)_x = (d_p)_y$
& $W_x = L_y * (L_y/L_x)^4$
Putting the value of W_x in eq.1, we get $W_y = W/\{1 + (L_y/L_x)^4\}$,
and $W_x = \{W * (L_y/L_x)^4\}/\{1 + (L_y/L_x)^4\}$
Finally, $W = W_x + W_y = \{W * (L_y/L_x)^4\}/\{1 + (L_y/L_x)^4\} + W/\{1 + (L_y/L_x)^4\}$,........eq.5



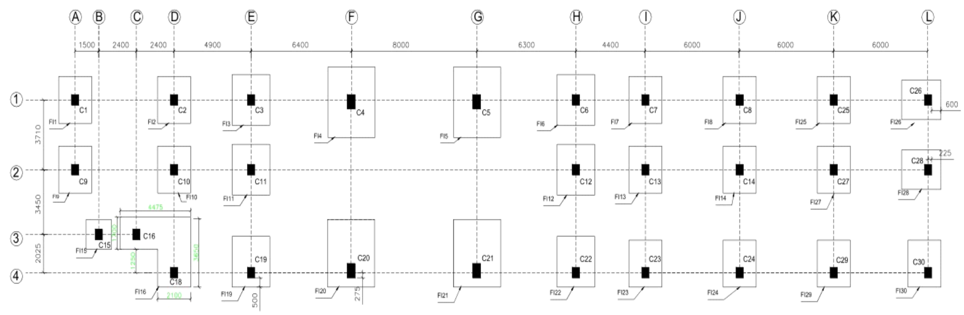
1) For CASE-1 - One way slab
When $L_y/L_x >= 2$, say $L_y/L_x = 2$, Then $W_y = W/(1+ 2^4) = 0.05$ W
and $W_x = W * (2)^4/ (1 + 2^4) = 0.95$ W
i.e., Load carried by strip BD along Y direction is only 5% of total udl & by strip AC along X direction is 95% of total load i.e. almost all loads. Thats why, Bending will happens only in one direction i.e, along Shorter direction- called One way slab. Also, Main Reinforcement provided along Shorter span of slab.
Here from Case-1 figure, Each of B1 & B2 carries = Half of the rectangular load = $(WL_X)/2$

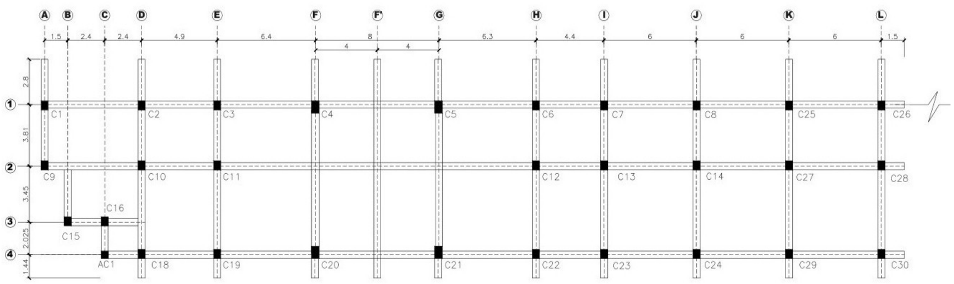
2) For CASE-2 - Two way slab
When $L_y/L_x < 2$, say $L_y/L_x = 1.2$,Then $W_y = W/(1+ 1.2^4) = 0.33$ W
and $W_x = W * (1.2)^4/(1 + 1.2^4) = 0.67$W.
i.e., Load carried by strip BD along Y direction by 33% of total udl & strip AC along X direction is 67% of total load. So, bending will happens only in both directions - called Two way slab. Also, Main Reinforcement provided along both direction of slab.
Here from Case-2 figure, Each of B1 & B3 carries = Trapezoidal Load
= $(WL_x)/2$ [1- $(1 / 3b^2)$] , $b = L_y/L_X$
& Each of B1 & B3 carries = $(WL_X)/3$

3) When $L_y/L_x = 1$, Then $W_y = W/(1+ 1^4) = 0.5$ W
and $W_x = W * 1^4/ (1 + 1^4) = 0.5$ W.
i.e., Load carried by both strip BD along Y direction & strip AC along X direction by 50% of total udl on each span as shown in Case-3. So, bending will happens only in both directions - also called Two way slab. Also, Main Reinforcement provided along both the span.

IV. AN APPROACH FOR LOAD-DISTRIBUTION SYSTEM (METHOD-1)

FOOTING LAYOUT

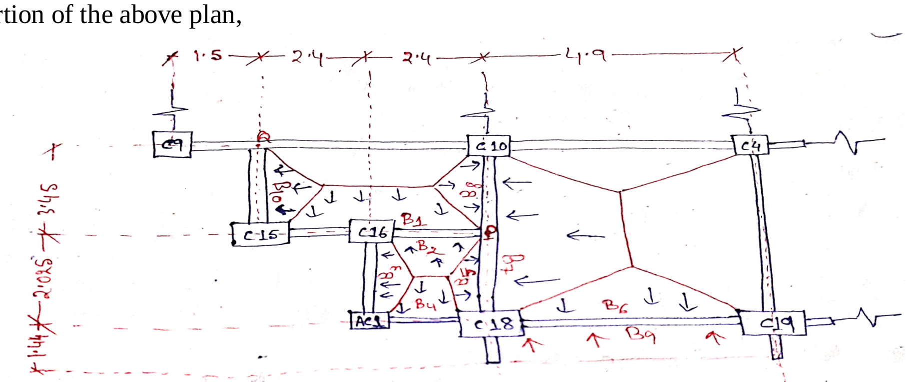




BEAM AND COLUMN LAYOUT

A. *Nomanclature of Beam and Column*

Considering a small portion of the above plan,



Distribution of loads from slab to footing:

From above plan,

slab thickness= 130 mm, Beam size= 450 mm X 600 mm

Size-1 type column= 450 mm X 550 mm (Columns are C9, C10, C11, C15, C16, C18, C19)

Size-2 type column= 300 mm X 450 mm (Column AC1)

Column Height= 4.1 m

width of wall (including plastering)=250 mm and neglecting parapet wall.

Factor of safety = 1.5

M25 grade of concrete & Fe 500 grade of steel.

From I.S 875-1987 Code, considering-

Density of concrete= 25 KN/m^3

Unit weight of Brick masonry= 20 KN/m^3

Live load on Roof= 1.5 KN/m^2

Live load on Floor= 5.75 KN/m^2

Floor Finish= 2 KN/m^2 (Including other finishes)

1) Load of Roof Slab

Self weight of Roof = 0.13 m x 25 KN/m^3 = 3.25 KN/m^2

Live Load on Roof = 1.5 KN/m^2

Floor Finishing (Including Water proofing) = 2 KN/m^2

Total Load = 6.75 KN/m^2

Total Factored Load on Roof slab = 1.5 x 6.75 = 10.125 KN/m^2

2) Load of Floor Slab

Dead Load of slab= 0.13 m X 25 KN/m^3 =3.25 KN/m^2

Live Load on Floor = 5.75 KN/m^2

Floor Finishing (Including other finishes) = 2 KN/m^2

Total load= = 11 KN/m^2

and Factored Load of slab= 1.5 X 11 =16.5 KN/m^2

3) Load of Beam per meter length (Each Floor)

Self weight of Beam per meter length = B x H x Density of concrete

= 0.45 X 0.60 X 25 = 6.75 KN/m.

Factored Load on Beam per meter length = 1.5 x 6.75 = 10.125 KN/m

4) Load of Column (floor to Floor)

Load on each size-1 type column = L x B x H x Density of concrete

= 0.45 x 0.55 x 4.1 x 25 = 25.37 KN.

Factored load on each size-1 type column = 1.5 x 25.37 = 38.05 KN

Similarly, factored load on size-2 type column= 1.5 x (0.3 x 0.45 x 4.1 x 1.5)

= 20.76 KN.

5) Load of Wall in Each Floor

Height of wall = centre to centre at Floor to Floor Height - depth of Beam.

= 4.1-0.6 = 3.5 m

Weight of brickwork per meter length = B x H x Unit weight of brick masonry

= 0.25 x 3.5 x 20 = 17.5 KN/m.

Factored wall load = 1.5 x 17.5 = 26.25 KN/m.

Factored wall load on C18 Column = (WL/2) + (WL)

= (26.25 X 12.125/2) + (26.25 X 1.165) = 190.51 KN

Factored wall load on C16 Column = (WL/2) = (26.25 X 5.425) = 71.2 KN

Factored wall load on AC1 Column = (WL/2) = (26.25 X 3.55)= 46.60 KN

Factored wall load on C15 Column = (WL/2) = (26.25 X 4.9) = 64.31 KN

B. Distribution of Load from Slab to Beam

Grouping B2 & B4 in ---- Group-1,beause of similar load condition.

Similarly, Grouping B5 & B5 in ---- Group-2 and Grouping B8 & B10 in ---- Group-3.

At B1- From drawing (column C15 towards C16 to P)->

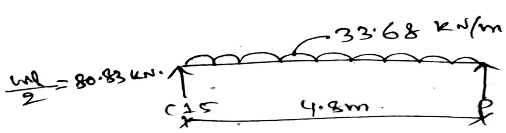
One trapezoidal load + self wt. of Beam

= {(W L_x^2)/2 } x [1- {1/(3 x b^2)}] + Self weight of Beam

= {(16.5 x 3.45)/2} x [1-{1/(3 x 1.39^2)}] + 10.125 ,.......

b= L_y /L_x = (2.4+2.4) / 3.45 = 1.3913, L_x= Shorter span and L_y = Longer span

= 33.68 KN/m.



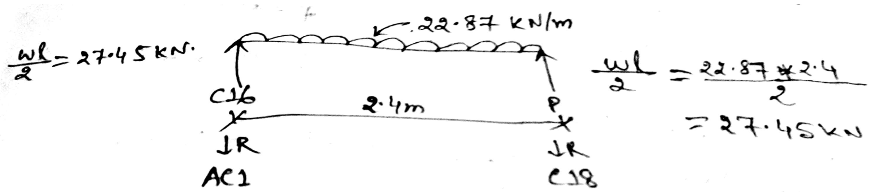
$$\frac{wl}{2} = \frac{33.68 \times 4.8}{2} = 80.83\ KN.$$

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

Since, C16 is at mid-length of C15 & P. So here, C16 will take = (WL/2) load =80.83 **KN** alone.
and, C15 and P will take a load of = 1/2 x (WL/2) = 40.42 **KN** seperately.

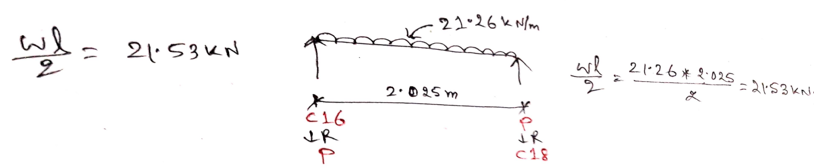
1) At Group-1,-- B2 and B4

One trapezoidal load + self wt. of Beam
= {(16.5 x 2.025)/2} x [1-{1/(3 x 1.1852^2)}] + 10.125 = 22.87 **KN/m.**

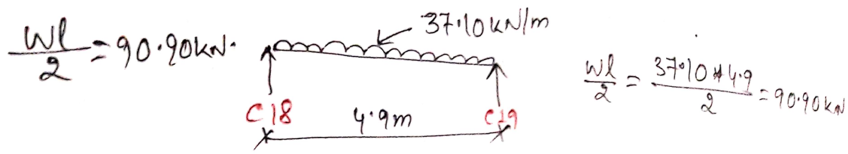


2) At Group-2,-- B3 and B5

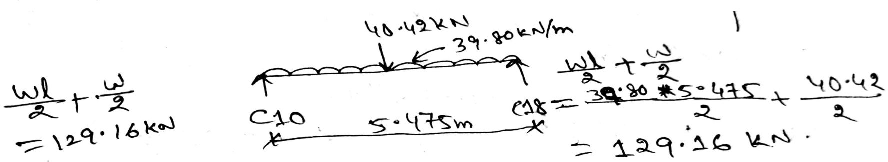
One triangular load + self wt. of Beam
= (WL$_x$)/3 + 10.125 = (16.5 X 2.025)/3 + 10.125 = 21.26 KN/m



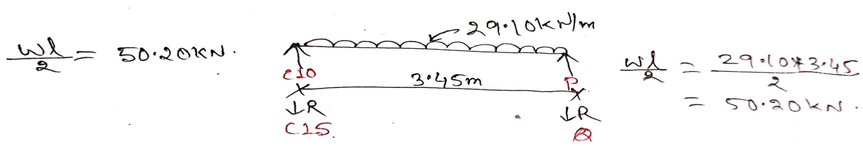
a) At B6 : one triangular load + self weight of Beam = (16.5 x 4.9)/3 + 10.125 = 37.10 KN/m



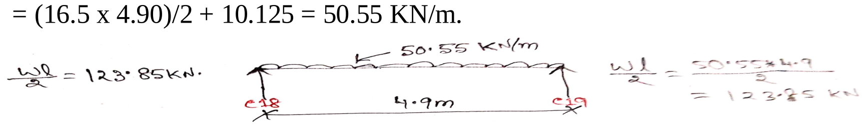
b) At B7: One trapezoidal load + Point load + Self weight of Beam
= {(16.5 x 4.90)/2} x [1-{1/(3 x 1.12^2)}] KN/m + 40.42KN + 10.125
39.80 KN/m + 40.42 KN.



3) At Group-3,-- B8 and B10 : One triangiular load + self weight of Beam
= (16.5 x 3.45)/3 + 10.125 = 29.10 **KN/m**



a) At B9 : Cantilever Portion of C18 & C19 :
Half rectangular load + self weight of Beam = (WL/2) + 10.125
= (16.5 x 4.90)/2 + 10.125 = 50.55 KN/m.



C. Distribution of Load from Floor slab to Beam

At B1- From drawing (column C15 towards C16 to P)->
One trapezoidal load + self wt. of Beam
= {(W L$_x^2$)/2 } x [1- {1/(3 x b^2)}] + Self weight of Beam
= {(10.125x3.45)/2} x [1-{1/(3 x 1.39^2)}] + 10.125 = 24.58 KN/m.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

Reeaction at each end = (24.5x 4.8)/2 = 59 KN
at column C16 = 59 KN
at C15 & P. Each one take load=(WL/2) = 29.5 KN alone.
At Group-1,-- B2 and B4 : Each of C16, P, AC1 & C18 takes load = 21.53 KN
At Group-2,-- B3 and B5 : Each of C16, P & C18 takes load =17.17 KN
At B6 : Each of C10 & C19 takes load =65.32 KN
At B7: Each of C10 & C18 takes load =77.48 + 14.75 = 92.23 KN.
At Group-3,-- B8 and B10 : Each of C10, P, Q & C15 takes load =37.55 KN
At B9 : Cantilever Portion of C18 & C19 : Each of C18 & C19 takes load =85.58 KN

D. Total Factored Load on Each Column

For Column C16, C18, AC1 & C15 at Plinth Beam level.
No of Floor slab = 3 Floor slab + 1 Roof slab.
Total load on Each columnm =(No. of floor x total factored load on each column) + Roof Floor + Total self weight of column + Total load from wall on each column**.**

1) Load at C16 at plinth Beam level = {3 x floor load from (B1 + B2 + B3)} + {1 x Roof load from (B1 + B2 + B3)} + (4 x self weight of C16 column from floor to floor) + (4 x wall load from floor wall to floor wall at C16 column).

= {3 x (80.83 + 27.45 + 21.53) + { 1 x (59 +21.53 + 17.17) + (4 x 38.05) + (4 x 71.2)
= 924.16 KN.

2) Load at C18 at plinth Beam level = {3 x floor load from (B4 + B5 + B6 + B7 + B8 + B9)+ {1 x Roof load from (B4 + B5 + B6 + B7 + B8 + B9)} + (4 x self weight of C18 column from floor to floor) + (4 x wall load from floor wall to floor wall at C18 column).

= {3 x (27.45 + 21.53 + 90.90 + 129.16 + 50.20 + 123.85)}+ { 1 x (21.53 + 17.17 + 65.32 + 92.23 + 37.55 + 85.58) + (4 x 38.05) + (4 x 175.22) = 2501.76 KN

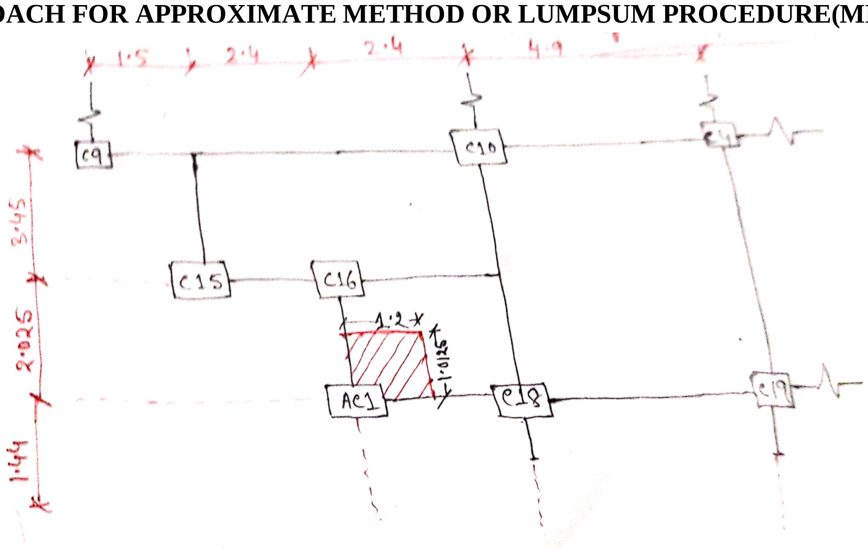
3) Load at AC1 at plinth Beam level = {3 x floor load from (B3 + B4)}+ {1 x Roof load from (B3 + B4)}+ (4 x self weight of AC1 column from floor to floor) + (4 x wall load from floor wall to floor wall at AC1 column).

= {3 x (21.53 + 27.45)} + { 1 x (17.17 + 21.53)} + (4 x 20.76) + (4 x46.60) = 455.08 KN.

4) Load at C15 at plinth Beam level = {3 x floor load from (B1 + B10)} + {1 x Roof load from (B1 + B10)} + (4 x self weight of C15 column from floor to floor) + (4 x wall load from floor wall to floor wall at C15 column).

= {3 x (40.42 + 50.20)} + { 1 x (29.5 + 37.55) + (4 x 38.05) + (4 x 64.31)= **748.35 KN.**

V. AN APPROACH FOR APPROXIMATE METHOD OR LUMPSUM PROCEDURE(METHOD-2)



The highlighted area or the elements surrounded by this column AC1 in all side are considered at a distance of 'half' portion from column in X & Y direction.

We have already calculated the following details-
Factored load of Roof slab = 10.125 KN/m^2
Factored load of Floor slab = 16.5 KN/m^2
Factored load of walls = 26.25 KN/m
Factored load of Beam = 10.125 KN/m
Factored load of Column AC1 = 5.06 KN/m

From the highlighted portion of column AC1-
Floor Area = 1.2 m x 1.0125 m = 1.215 m^2
Length of Beam = 1.2 + 1.0125 = 2.2125 m
Length of wall =wall length - duduction of column portion= (1.0125 +1.2) - 0.2 =2.0125 m
Total Height = 4 x 4.1 = 16.4 m.

A. Load on Column AC1

1) Load from Roof to Third Floor

Total Roof Load = 10.125 KN/m^2 x Highlighted area surrounded by Column AC1.
= 10.125 X 1.215 = 12.30 KN
Load on Beam = 10.125 KN/m x length of Beam = 10.125 x 2.2125 = 22.40 KN.
Load on wall = 26.25 KN/m x length of wall = 26.25 x 2.0125 = 52.83 KN
Total load = 87.53 KN.

2) Load from third Floor to Second Floor

Floor load = 16.5 x 1.215 = 20.05 KN
Load on Beam = 10.125 x 2.2125 = 22.40 KN
Load on wall = 26.25 x 2.0125 = 52.83 KN.
Total Load = 95.28 KN.
Similarly, Load from second floor to first floor = 95.28 KN
& Load from First floor to Ground floor = 95.28 KN.
Therefore, Total load on Column AC1 at Plinth Beam Level
= Total Floor Load from Roof to G.F + Self weight of column in total floor.
= 87.53 + 95.28 +95.28 + 95.28 + (5.06 x 16.4) =456.4 KN.

Thus, it conclude that from the above both methods, Loads on each column are approximately same in each case. So, the mechanism of load transformation & its behaviour in each and every structural element has done on such manner from top level to ground.

VI. DESIGN OF BIAXIALLY LOADED COLUMN C15

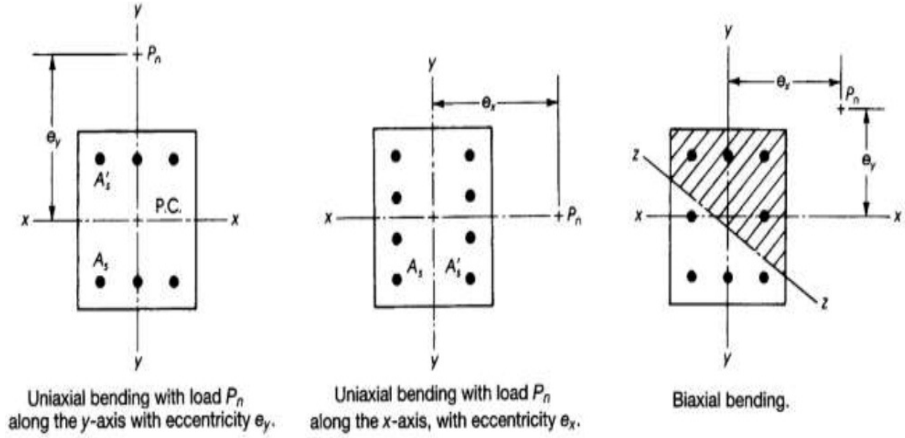
From the plan, the rectangular column C15 carrying biaxially load subjected to biaxial bending properties. Bending moment coming from both axes may be transfered from attached beam or caused by axial load being applied eccentrically to one axis or both axes rather than through the centre of the column.
Here, Size of column, (bxd) = 450 mm x 550 mm
Ultimate load, P_u= 455.08 KN.
Floor to floor height = 4.1 m
Moment of Resistance along X direction, M_{ux}= 27 KN.m
and M.O.R along Y direction, M_{uy}= 30 KN.m
So, Effective Length , L_{eff} = 0.65L (take both side restrained)
= 0.65 x 4.1 = 2.67 m.

A. Slenderness Ratio of Column (l)

l = (L_{eff} /Least Lateral Dimension) = (2.67/0.45) = 5.93 < 12.
Therefore, It is a short column.
In other words, Depth,
D = maximum of {not less than 400 mm, (or) not less than 0.12 L = 0.12 x 4100 = 492 mm
Since, Depth, D= 550 mm > 492 mm. **OK.**

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

B. For Loading Condition, Eccentricity on Both Direction



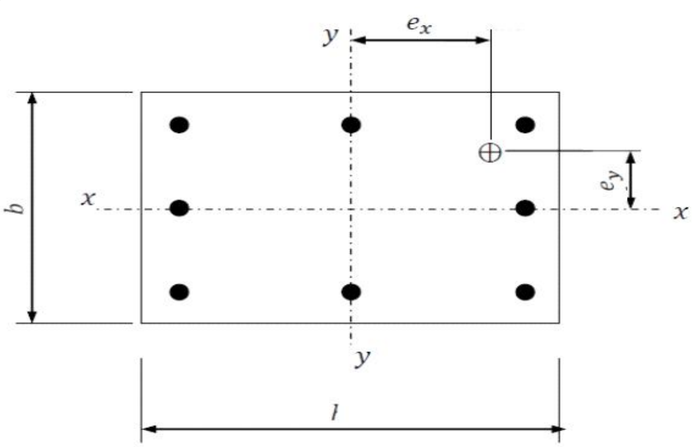
e = {(L/500) + (D/30), (or) 20 mm.

For X direction, e_x = {(4100/500) + (55x0/30), (or) 0.05D

= { 26.53 mm (or) 27.5 mm

For Y direction, e_y = {(4100/500) + (450/30), (or) 0.05b

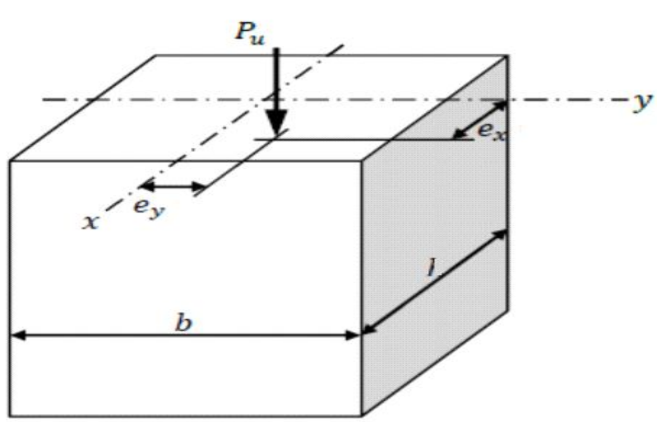
= { 23.20 mm (or) 22.5 mm

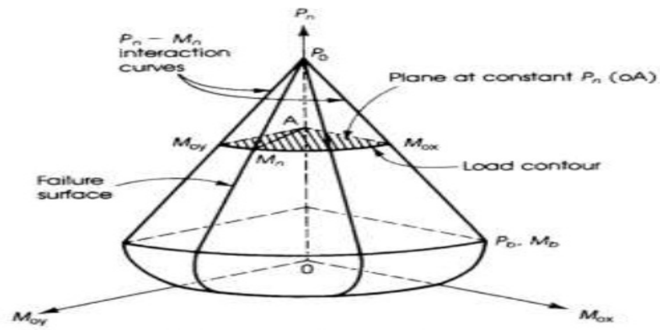


Since, $e_x > 0.05D$ & $e_y > 0.05b$

Therefore, It is designed as Short Biaxially loaded Column.

C. Calculation of Moment due to Eccentricity along X & Y Direction





Biaxial interaction surface.

Moment along X direction, $(M_u)_x = P_u \times e_y = 455.08 \times 0.0232 = 10.56$ KN.m
Moment along Y direction, $(M_u)_Y = P_u \times e_X = 455.08 \times 0.02653 = 12.07$ KN.m
Consider 40 mm of effective cover.
From SP-16, I.S:456:1980, Chart-48,
$(d' / D) = (40/550) = 0.07$ & $(d' / b) = (40/450) = 0.089$
Therefore, $(P_u / f_{ck} \times b \times D) = \{(455.08 \times 10^3) / (25 \times 450 \times 550) = 0.074$
Assume, percentage of steel, Pt = 1 %, & $Pt/f_{ck} = (1/25) = 0.04$
$(M_{ux} / f_{ck} \times b^2 \times D) = 0.03$, So, $M_{ux} = 25 \times (450)^2 \times 550 \times 0.03 = 83.53$ KN.m
& $(M_{uy} / f_{ck} \times b \times D^2) = 0.03$, So, $M_{uy} = 25 \times 450 \times (550)^2 \times 0.03 = 102.10$ KN.m
From IS:456-2000, Cl. 39.6,
$(M_{ux} / M_{ux,1})^{a}{}_{n} + (M_{uy} / M_{uy,1})^{a}{}_{n} <= 1$
So, $(27 / 83.53)^{a}{}_{n} + (30 / 102.10)^{a}{}_{n} <= 1$, ...eq.1
For ${}^{a}{}_{n}$ = (Axial Force / Pure Compressive Force) = (P_u / P_{uz})
and, $P_{uz} = 0.45 f_{ck} A_c + 0.75 f_y A_{sc} = 0.45 \times 25 \times (A_g - A_{sc}) + 0.75 \times 500 \times A_{sc}$,
Where A_c = Area of concrete = Gross area - Area of steel= $A_g - A_{sc}$ = (bxD) -(1 % of bD)
= (450 x 550) - (0.01 x 450 x 550) = 247500 - 2475 = 245025 mm^2
Therefore, $P_{uz} = (0.45 \times 25 \times 245025) + (0.75 \times 500 \times 2475) = 3684.66$ KN.
So, $(P_u / P_{uz}) = (455.08 / 3684.66) = 0.124$
For value of (P_u / P_{uz}) = 0.2 to 0.8, the values of $({}^{a}{}_{n})$ very linearly from 1 to 2.
Interpolating, ${}^{a}{}_{n} = 0.873$
So, From eq. (1),
$(0.323)^{0.873} + (0.294)^{0.873} <= 1$, Finally, 0.72 < 1, OK.
nearer to 1 is more economical.

D. Reinforcement Detailing

A_{st} = 1 % bD = 2475 mm^2
Considering 20 mm f bars, $a_{st} = (p / 4) \times 20^2 = 314$ mm^2
No. of bar = (A_{st}/a_{st}) = (2475/314) = 7.88, say 8 No.
$(A_{st})_{provided}$ = 8 x 314 = 2512 mm^2
For transverse reinforcement,
Diameter of lateral ties or link, f_t = maximum { (1/4) f_L or, 6 mm
= maximum { (1/4) x 20 = 5 mm, or, 6 mm
= 6 mm.
Consider, 10 mm f of transverse reinforcement & Pitch
= minimum of {least lateral dimension, (or) 16 f_L , (or) 300 mm
= minimum of { 450 mm , or (16 x 20)= 320 mm , or 300 mm
= 300 mm.
Take Pitch upto 0.25L of column at support @ 100 mm c/c < 300 mm, **OK.**
& at mid section @ 200 mm c/c < 300 mm , **OK.**

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

E. Check for Extra Stirrups Requirement

Along X direction, spacing of bar = {(B- Cover on both side)/3} = (450-40-40)/3
= 123.33 mm > 75 mm

So, extra stirrup is required.

Spacing between cover bar = 450-40-40 > 48f_t
= 370 mm **< (48 X 10 =480 mm)**.

So, there is no requirement of Close type stirrup.

Provide open type of extra stirrup along X direction.

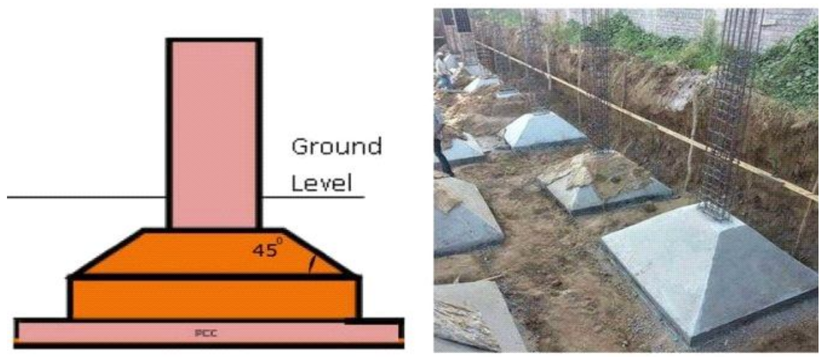
Similarly, Along Y direction, spacing of bar = {(L- Cover on both side)/3} = (550-40-40)/3
= 156.67 mm > 75 mm

& 550-40-40 > 48f_t
= 470 mm **< 480 mm.**

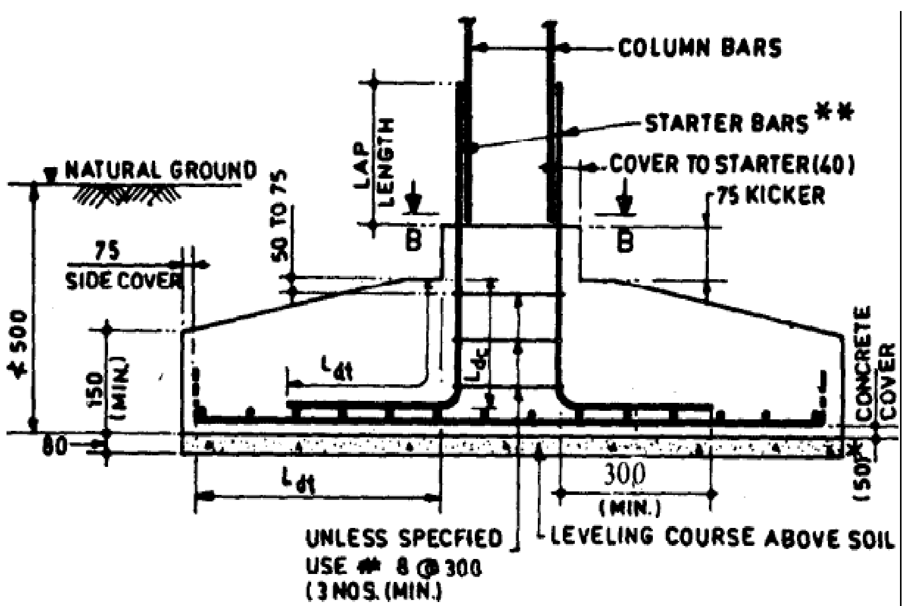
Provide open type of extra stirrup along Y direction.

VII. DESIGN OF ISOLATED SLOPE SQUARE FOOTING FOR C15 COLUMN

Footing which provides under a column independently called Isolated footing. With high bearing capacity of soil in general cases, Isolated footing introduce which comprise of thick slab in flat or sloped or stepped form. It is most economical when compair with other footings. Isolated slope footings are trapezoidal footings with top slope at 45 degree is maintained from all sides.



SLOPED FOOTING



International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

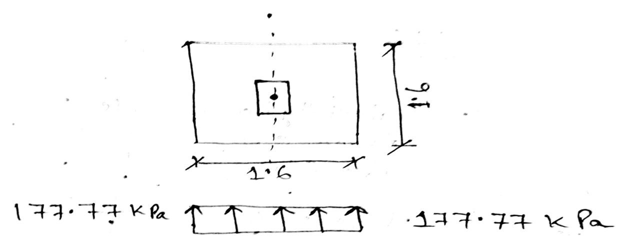
In here, the designing aspect for isolated slope square footing of column C15 has discussed below.
From soil investigation report at Silchar Airport from S.T. Enterprise Consultant-
Unit weight of soil = 16.5 KN/m^3
Bearing Capacity of soil, S.B.C = 225 KN/m^2
Cohesion, C = 8 KN/m^2
Factor of safety against Sliding = 1.5
F.O.S against overturning = 1.5
Coefficient of friction = 0.15
From Plan, Size of C15 column = 450 mm x 550 mm
Factored load on Column at Plinth level = 455.08 KN.
Working l oad on column at .plinth load = 455.08/1.5 = 303.4 KN.
Since, C15 column is subjected to biaxial .bending (and for biaxial bending or corner column, increment of load for bending due to effect of fixity can done 16% to 33%).
Adding @ 30% of self weight of footing = 91.02 KN.
So, Total Load = 303.4 + 91.02 = 394.42 KN.

A. Area of Footing

= Total working load/ S.B.C = (394.42/225) = 1.753 m^2
Since, it is a rectangular column, differce in column dimension, d = L-B = 0.55 - 0.45 = 0.1 m
So, L = B + 0.1 m and **Area, A** = (B + 0.1) X B = 1.753 m^2 So, B= 1.28 m and L= 1.28 + 0.1 = 1.38 m
Therefore, minimum size of rectangular footing = 1.38 m X 1.28 m
Considering a square footing for rectangular column,
Area, A = 1.753 m^2 = B X B => B = 1.33 m
So, minimum size of squre footing required = 1.33 m X 1.33 m
Introducing a squiare footing with size= 1.6 m X 1.6m > (1.38 m X 1.28 m) or (1.33 m X 1.33 m)
Satisfy.

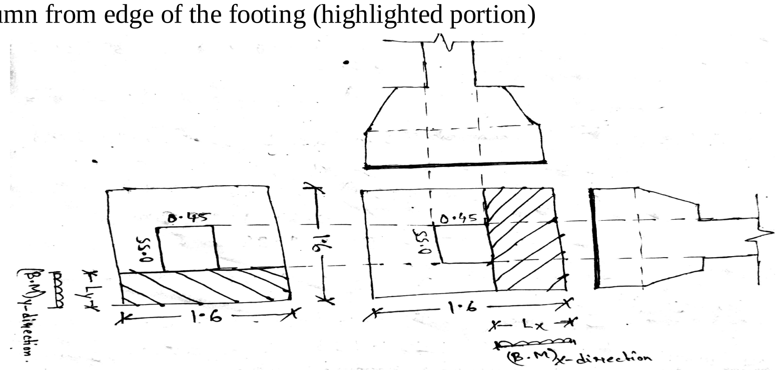
B. Net Upward Soil Pressure(s_u)

s_u = (Total Factored Load / Area of Footing)
= {455.08 / (1.6 x 1.6)} = 177.77 KN/m^2



C. Calculation of Bending Moment at Critical Section of the Footing

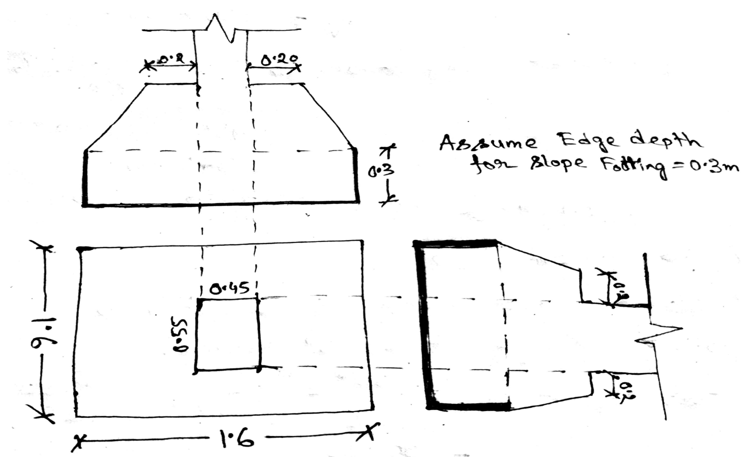
Udl along both direction, **W = s_u** X **B = 177.77** X **1.6** = 284.43 KN/m.
Critical section @face of column from edge of the footing (highlighted portion)



B.M about any direction, $M = (WL^2 /2)$
Maximum B.M. about X direction, $M_x = (WL_y^2 / 2)$
$L_y = \{(B-b)/2\} = (1.6 - 0.55)/2 = 0.525$ m
$M_x = (284.43 \times 0.525^2 / 2) = 39.20$ KN.m
Maximum B.M. about Y direction, $M_y = (WL_x^2 / 2)$
$L_x = \{(L-a)/2\} = (1.6 - 0.45)/2 = 0.575$ m
$M_y = (284.43 \times 0.575^2 / 2) = 47.02$ KN.m

D. Calculate Depth of Footing

Minimum offset with the column to be 50 mm.
Consider 200 mm of offset at all sides.



For M25 grade of concrete and Fe 500 steel,
Moment of Resistance, M.O.R, $M_u = 0.136 f_{ck} bd^2$
M.O.R along X direction, $(M_u)_x = 39.20 \times 10^6 = 0.136 \times 25 \times 850 \times d^2$,
b= width of resisting section along X direction = 450 + 200 + 200 = 850 mm
Calculating, d = 116.46 mm
Similarly, M.O.R along Y direction, $(M_u)_y = 47.02 \times 10^6 = 0.136 \times 25 \times 950 \times d^2$,
b= width of resisting section along X direction = 550 + 200 + 200 = 950 mm
Calculating, d = 120.65 mm
Consider overall depth, D = 450 mm, 50 mm of effective cover, 16mm f bars use in both direction.
Effective depth,
along Y direction, d_y = Overall depth - Cover - j/2 = 450 - 50 - (16/2) = 392 mm
along X direction, d_x = Overall depth - Cover - j - j/2 = 450 - 50 - 16 - (16/2) = 376 mm
Avg. depth = (392 + 376)/2 = 384 mm.

E. Reinforcement

Reinforcement along X direction->
M.O.R, $(M_u)_y = 47.02 \times 10^6$ N.mm
Percentage of steel, Pt% = $(50 f_{ck}/f_y) [1- [1 - \{4.6 (M_u)_y/f_{ck} \times b \times d^2\}]^{1/2}]$
$= (50 \times 25/500) \times [1- [1 - \{(4.6 \times 47.02 \times 10^6)/(25 \times 1600 \times 384^2)\}]^{1/2}] = 0.05$ %
Reinforcement along Y direction,
M.O.R = $(M_u)_x = 39.20 \times 10^6$ KN.m, and Pt% = 0.04 %
But, as per I.S: 456: 2000, minimum reinforcement shouble be = 0.12 %
taking 0.12% of Pt, A_{st} = (Pt/100) x bd = (0.12/100) x 1600 x 384 = 737.28 mm^2
Take 16mm j bars, $a_{st} = 200.96\ mm^2$
No of bars = A_{st}/a_{st} = (737.28/200.96) = 3.67, say 4 nos.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

F. Check for Clear Spacing

As per I.S:456-2000, Table-15,

For Fe500 steel, clear distance between bars should not be greater than 150 mm

c/c spacing = (**L**-cover on both sides - j/2 - j/2)/(No. of bar -1)

= (1600 - 50 -50 -16/2 -16/2)/(4-1) = 494.67 mm

and clear spacing between bars = 496.67 - j/2 - j/2 = 478.67 mm > 150 mm

Not Satisfy.

Considering , c/c spacing between bar = 110 mm

so, clear spacing between bar = 110 - j/2 - j/2 = 94 mm < 150 mm, Satisfy.

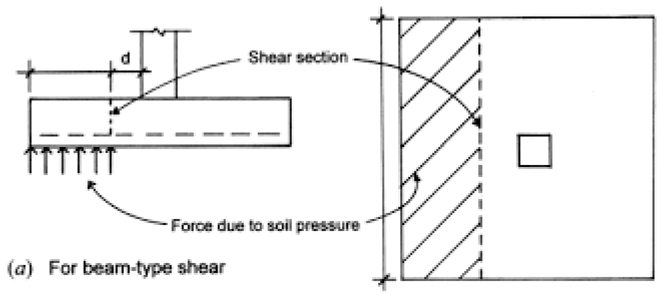
& No of bars = {(1600 -50 -50 - 8 -8)/110} + 1 = 14.49, say 15 Nos.

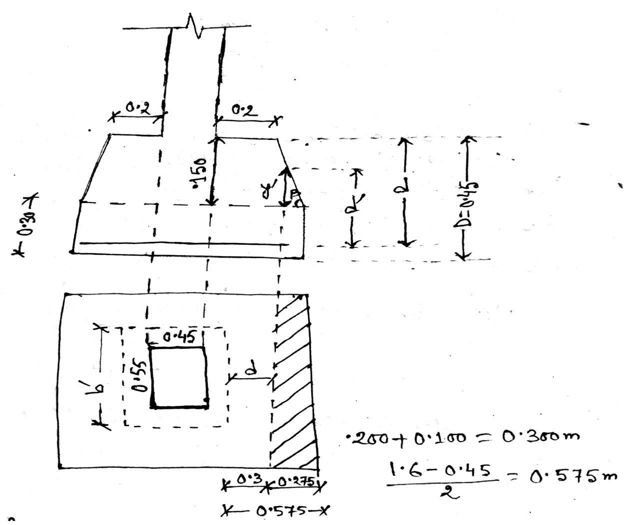
Therefore, Provide 15 Nos. of 16mm j bars @ 110 mm c/c in both direction.

$(A_{st})_{provide}$ = no. of bar x area of one bar = 15 x 200.96 = 3014.4 mm^2 > 737.28 mm^2 , OK.

Pt% = 100 A_{st} /bd = (100 x 3014.4)/ (1600 x 384) = 0.49 %

G. Check for One-way Shear





Depth @ face of column = (450-300) = 150 mm

For calculating y' ,

at depth 575 mm -> get depth = 150 mm

so at depth 275 mm -> get depth upto = (150/575) x 275 = 71.74 mm

Therefore, Y' = 71.74 mm

d' =depth of y' +egde depth - effective cover - j/2 = 71.74 + 300 - 50 - (16/2)= 313.74 mm

Resisting width along Y direction, b' = 450 + 2d = 450 + (2x 384) = 1218 mm.

Critical section at 'd' distance from the face of column.

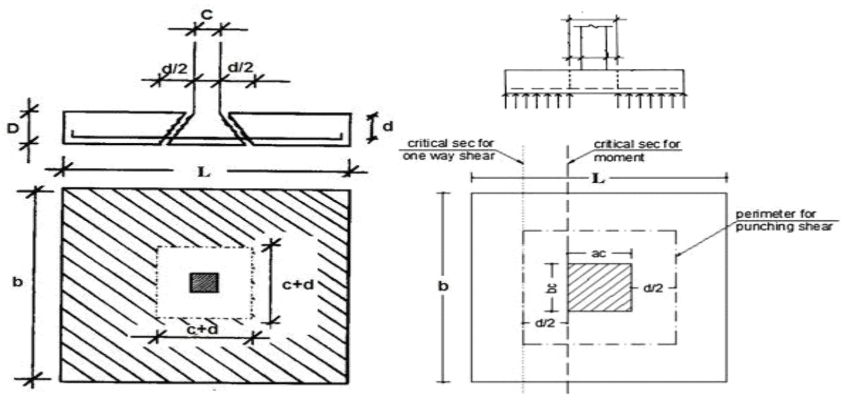
Max. shear stree, u_u = shear stress at critical section x Area of Highlighted portion

= 177.77 x (0.275 x 1.6) = 78.22 KN

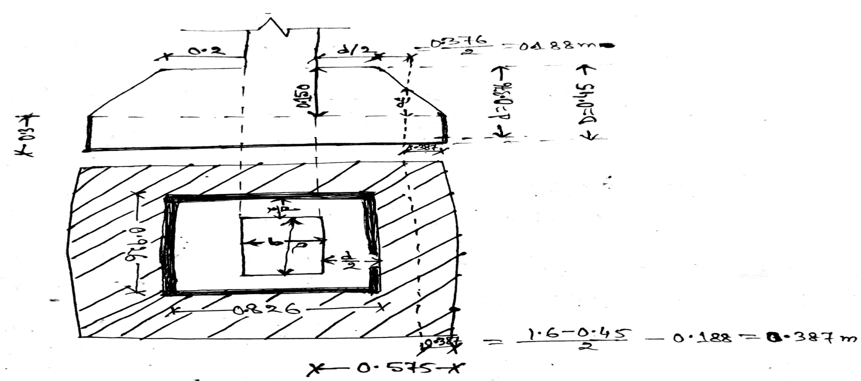
& Nominal shear stress, I.S :456-2000, Page-72,
z_v = [u_u - {(M_U/d') x tanb}]/ b'd'
From diagram, tanb = (150/575) = 0.26
Moment @ critical section at distance 275 mm from the edge of footing, $M_u = WL^2 / 2$
$= 284.43 \times 0.275^2 / 2 = 10.76$ KN.m
Therefore, Nominal shear stress, z_v = [78.22 - {(10.76/0.31374) x 0.26}]/ (1218 x 313.74)
$z_v = 0.18$ N/mm^2
& Pt% = 100 A_{st} /bd = (100 x 3014.4)/ (1218 x 313.74) = 0.79 %
From Table-19, I.S:456-2000,
For M25 grade of concrete, K = 1.32
& If Pt% is 0.25% , then $z_c = 0.36$
When Pt5 is 0.795, then z_c = (0.36/0.25) x 0.79 = 1.14 N/mm^2
Finally, $z_c > z_v$ and One-way shear check is satisfied.
For depth check, u_u /Bd = K z_c => d = u_u /(B x K x z_c) = (78.22 x 10^3)/ (1600 x 1.32 x 1.14)
= 32.49 mm < 384 mm on the basis of moment.
Hence, depth check is satisfied.

H. *Check for Two-way Shear*

Punching shear check @ critical section at pheripherial at 'd/2' distance from the face of column.



For punching shear

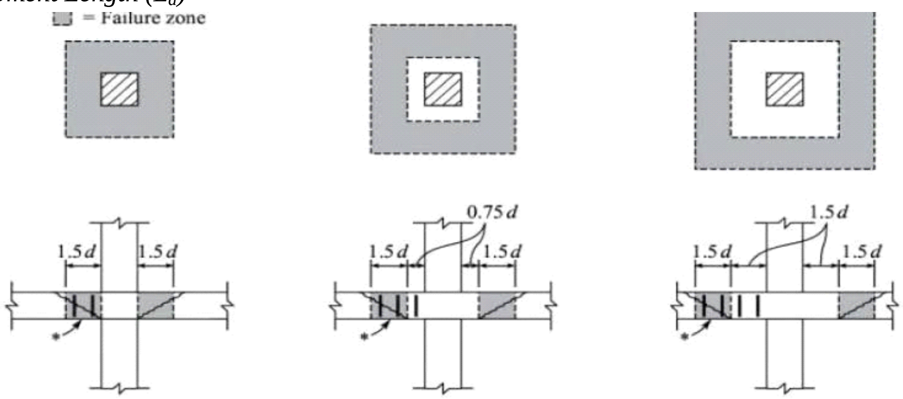


y' = (150/575) x 387 = 100.96 mm
d' = depth of y' + edge depth - eff. cover - j - j/2 = 100.96 + 300 - 50 -16 -16/2 = 326.96 mm
Length of Pheriphery, b_o = 2 x [(a + d/2 + d/2) + (b + d/2 + d/2)]
= 2 x [(550 + 188 + 188) + (450 + 188 + 188)] = 3504 mm
Maximum shear stress @ critical section,
u_u = shear stress at critical section x Area of Highlighted portion
= 177.77 x [(1.6 x 1.6) - (0.926 x 0.826)= 319.12 KN

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

Nominal shear stress, $z_v = u_u / b_o d' = (319.12 \times 10^3) / (3504 \times 326.96) = 0.28$ N/mm^2
From IS: 456-2000, $z_c' = K_s \times z_c$, where $K_s = 0.5 + b_c = 0.5 + (B/D) = 0.5 + (450/550)$
So, $K_s = 1.32$ & $z_c = 0.25 (f_{ck})^{1/2} = 0.25 \times (25)^{1/2} = 1.25$ N/mm^2
& $z_c' = K_s \times z_c = 1.32 \times 1.25 = 1.65$ N/mm^2
Finally, $z_c' > z_c$, Two-way shear check is satisfied.

I. Check for Development Length (L_d)

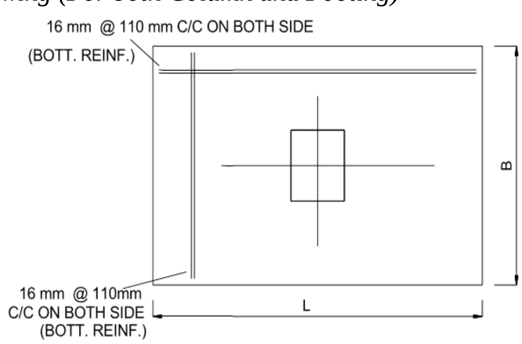


*At least 2 sets of reinforcement within a failure zone

(a) First failure zone (b) Second failure zone (c) Third failure zone

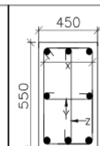
According to IS: 456-2000,
$L_d = (1/4) \times j \times (s_s / t_{bd})$
For M25 grade of concrete & Fe 500 steel,
Bond stress, $t_{bd} = 1.4$ N/mm^2
& Permisible stress for steel, $s_s = 0.55 f_y = 0.55 \times 500 = 275$ N/mm^2
$L_d = (1/4) \times 16 \times (275 / 1.4) = 785.71$ mm
(ix) Transfer of Load at Base of Column -
As per IS: 456-2000, Cl-76.4, Page-65,
Allowable Bearing stress = $0.45 f_{ck} = 0.45 \times 25 = 11.25$ N/mm^2
Alloawable Bearing Force =Alloawable Bearing stress x Area of column
= 11.25 x 450 x 550 = 2784.4 KN
Since, Actual load on column = 455.08 KN (Factored working load)
Therefore, Alloawable Bearing Force > Actaul factored working load.
Hence, the structure s safe.

J. Detailing of Drawing (For both Column and Footing)

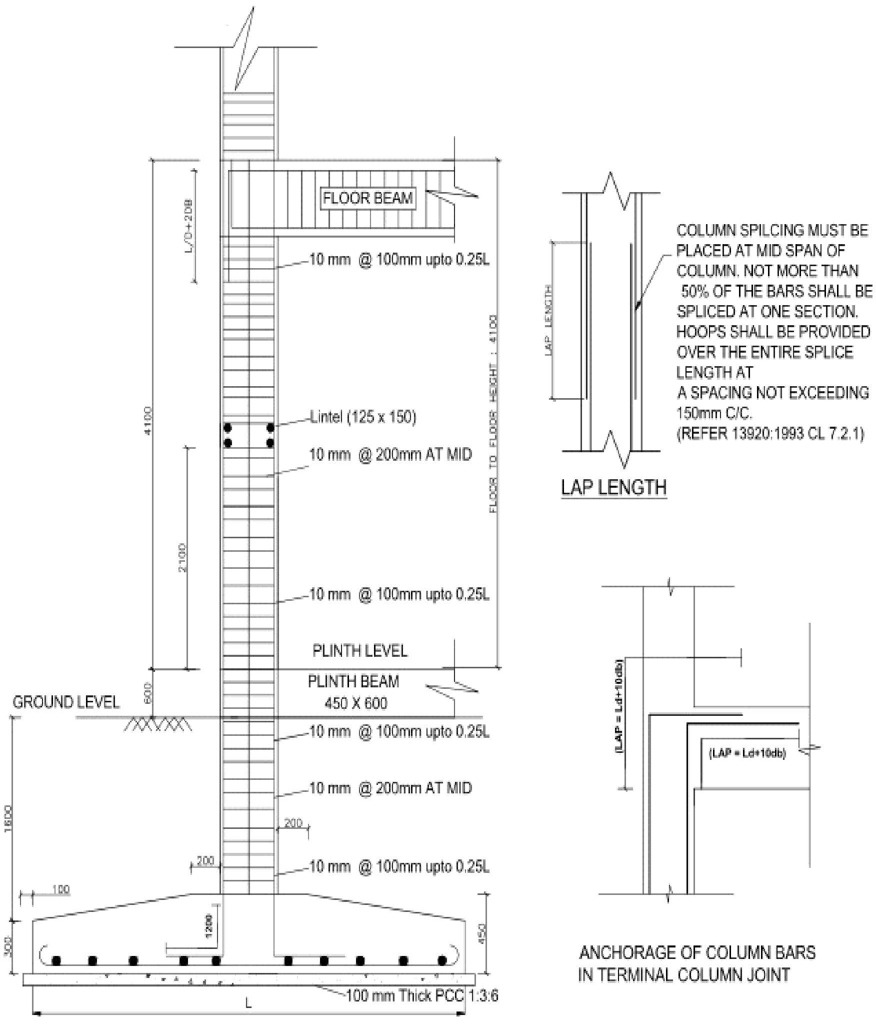


PLAN OF ISOLATED FOOTING

COLUMN SCHEDULE:

COLUMN SECTION FOOTING LVL. TO ROOF LVL.	
COLUMN SIZE	(450x550)
REINFORCEMENT	8-20Ø
STIRRUPS	10 Ø
SPACING SUPPORT UPTO 0.25L	@100 c/c(x,y,z)
SPACING MID	@200 c/c(x,y)
COLUMN MARKS	C15

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com



ISOLATED FOOTING ELEVATION

Foundation Mark	Column No.	Column			Foundation		Cover (m)	Reinforcement
		b (m)	l (m)	h (m) above GL	L (m)	B (m)		16 mm @ 110 mm
F I15	C15	0.550	0.450	4.100	1.600	1.600	0.050	16 mm @ 110 mm

ISOLATED FOOTING SCHEDULE

VIII. CONCLUSION

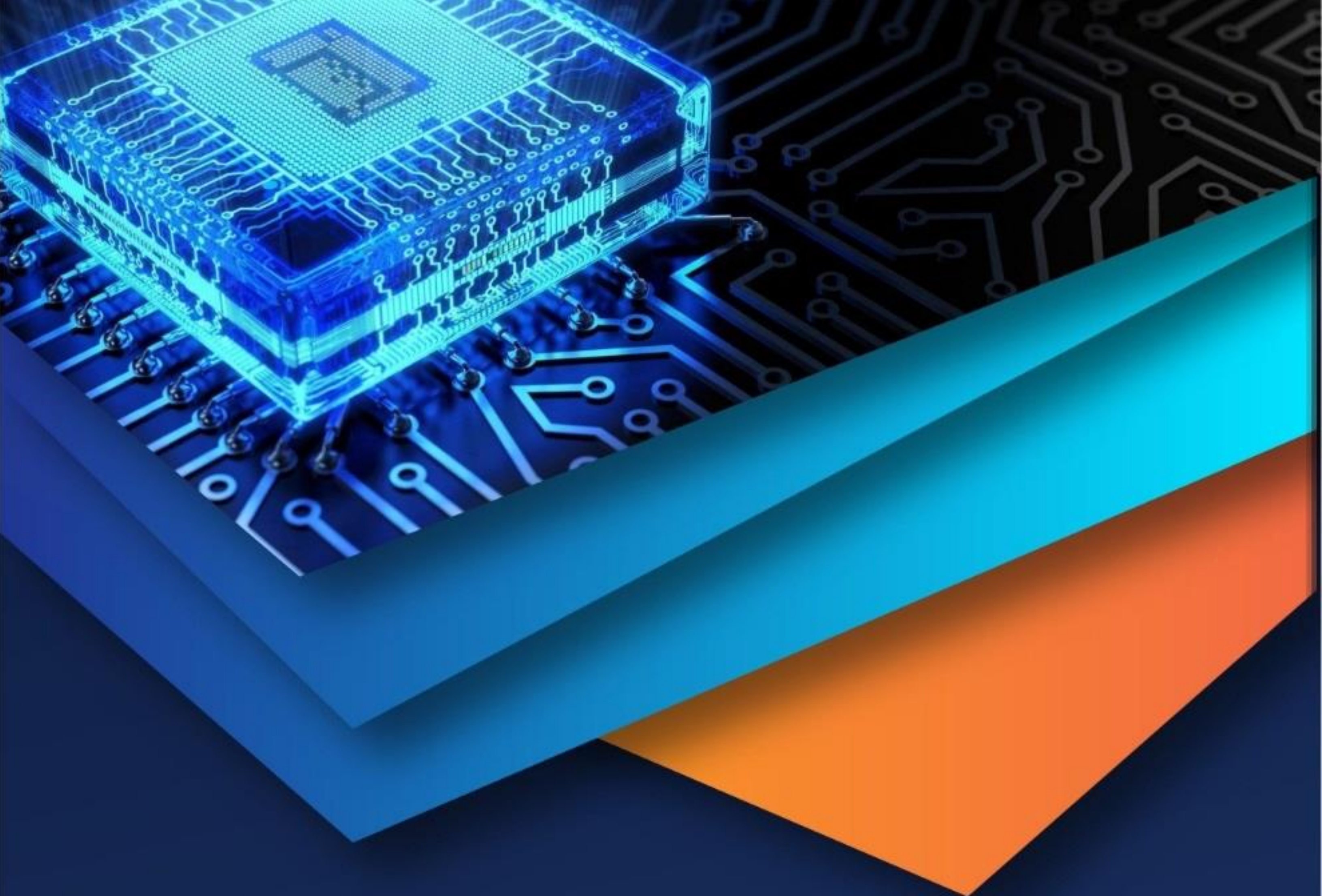
This study was undertaken for analysing the load transfer mechanism of structural elements and designing prospect of Biaxially Loaded Column with Isolated Slope Square Footing in building at construction of Modification of Terminal Building at Silchar Airport. The basic knowledge of structural elements design comes from its mechanism and analysis aspect which gives the better knowledge in this field. Structural footing plays a big rule in the construction industry. Few footing are easily design, few are in complex form depending on various demand comes from owner- in a small area with large prospect. While designing each and every structural elements in India, it is essential to follow up I.S codel provisions.

IX. ACKNOWLEDGMENT

Abdul Aziz was born at Nilambazar, Karimganj district of Assam. He pursed his bachelor degree in Civil Engineering from Holy Mary Institute of Technology under J.N.T. University, Hyderabad in 2017 and join continue in Master of Technology in Structural Engineering and Construction Management program from Golden Valley Integrated Campus, previously B.E.S Group of Institution, under J.N.T University, Ananatapur, A.P. He has join at Airports Authority of India and Service one year of Professional Training as an Graduate Apprentice Trainee (GAT) at Silchar Airport. He is connected with many Civil and Structural Engineering societies and Associations such as Student Member of International Association for Bridge and Structural Engineering (IABSE)-Zurich, Switzerland, Graduate Member of The Institution of Engineers (IStructE)-UK, Associate Member in Indian Association of Structural Engineers (IAStructE), Professional Member of Institute for Engineering Research and Publication (IFERP), Member of Structural Engineering Forum of India. He has published research papers, paper [1] entitled 'Analysis on mix design of M25 grade of Concrete- A case study on modification of terminal building at Silchar Airport', paper[2] entitled 'Earthquake Resistant Design of Building-A case study on modification of terminal building at Silchar Airport'. His thesis entitled 'A case study on modification of terminal building at Silchar Airport'. His research interest on Earthquake Engineering, Analysis and Design of various structure, Concrete Technology, Construction Materials and Management. His thesis entitled 'A case study on modification of terminal building at Silchar Airport'.

REFERENCES

[1] IS 456 :2000 – Code of Practice for Design of Plain and Reinforced Concrete.
[2] IS 875-1987: Code of Practice for Design Loads (Other than Earthquakes) for Building and Structures.
[3] IS: SP-7:2005- NBC (National Building Code of India).
[4] SP 6 (1) :1964- Handbook for structural Engineers.
[5] SP 34: 1987- Handbook on Concrete Reinforcement and Detailing.
[6] Seung Hun KIM, Sang Whan HAN, Li Hyung LEE.-Investigation on the Load Transfer Mechanism for the Joint of Reinforced Concrete Column and Steel Beam.
[7] Prof. V.S. Raju- Optimal Foundation for Tall Buildings with focus on National Capital Region- IAStructE.
[8] Utpal Kumar Nandy, Antara Nandy- Design Calculation & Analysis of Foundation & Column of Buildings: A Case Study at Gwalior.
[9] Charles Besjak, Alexandra Thewis, Raymond Sweeney, Preetam Biswas, Damayanti Chaudhuri, B.C. Roy: Chhatrapati Shivaji International Airport-Integrated Terminal Building- IABSE.
[10] Displacement-Based Design in Seismic Design Codes- by IABSE.
[11] Analysis and Design of Beams for Bending. (2001).
[12] Design standards for Architectural Building Components (2001). St. Louis: Washington University.
[13] Styles, K. (1995). Working Drawings' Handbook. Oxford: Architectural Press.
[14] Abdul Aziz: Earthquake Resistant Design of Building-A case study on modification of terminal building at Silchar Airport.
[15] Abdul Aziz, A. Ramakrishnaiah: Analysis on Mix Design of M25 Grade of Concrete- A case study on modification of terminal building at Silchar Airport.
[16] A.S. Boke, A.A. Avhad, A.A. Shelke- Comparative analysis of R.C.C & Steel Concrete Composite Residental Building Frame-IFERP.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY