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Design of G+10 Storey Residential Building using STAAD.PRO

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ABSTRACT: The basic objective of a structural engineer is to create a structure that is safe, useful, long-lasting, and cost-effective. The entire structural planning and design process calls for creative thinking and solid expertise. G+10 story residential building structure analysis and design using the IS Code technique. The entire structure's analysis and design were conducted manually, with STAAD.PRO software is being used for verification. Using AutoCAD, all of the drafting and detailing was completed. In this project, the "Limit State Method" is used to compute the beam, column, slab, staircase, and shear wall design. Different loads operating on the member are considered for seismic load by IS: 875-1987 (part 1, part 2) & IS: 1893-2005. Consequently, home construction is carefully planned in accordance.

KEYWORDS: Analysis, Design, AutoCAD, STAAD.PRO, Residential building, Dynamic load, Static load.

I. INTRODUCTION

India is a developing country, and there will be many large-scale development projects in the future because it has been so long since undeveloped cities needed to grow. In the twenty-first century, there are several ongoing projects all over the world. Time delays occur, which have an impact on the expansion of the building of large projects. Economic building methodologies should be used to prevent time delays and, consequently, growth. Techniques for structural optimization should be employed to reduce the structure's costs. Whether in terms of horizontal or vertical development, many metropolitan cities are dealing with enormous infrastructure growth. In high-rise buildings, we should be concerned with all the forces that act on the building, its weight, and the behavior of the earth. We chose deep holes for loose dirt.

1.1

AUTOCAD: AutoCAD is a drafting software used to develop 2-dimensional and 3-dimensional structures, developed and sold by Autodesk Inc. It is a vector graphics drawing program. AutoCAD's native file format DWG and to a lesser extent, its interchange file format, DXF.

1.2

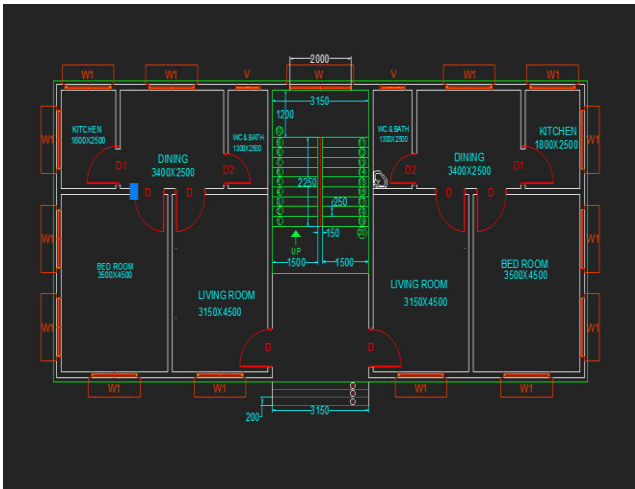
STAAD PRO: STAAD.PRO is a user-friendly software that is used for analyzing and designing structures by structural engineers. Staad Pro provides a lot of precise and correct results than manual techniques. STAAD.PRO software is used for both static and dynamic analysis for structures such as bridges, low-rise or high-rise buildings, stadiums, steel structures, etc. The first step in Staad Pro is to specify the geometry of the structures and then the properties of the members are mentioned, then the supports are generated and loadings are specified on the structure. Finally, the structure is analyzed.

II. BUILDING DESCRIPTION

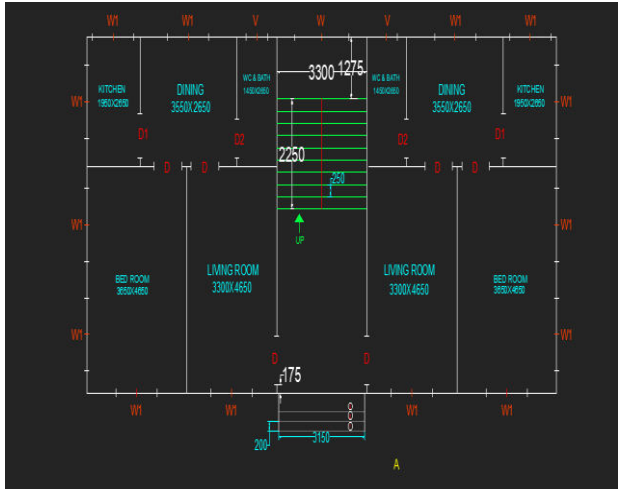
Purpose of Building	Residential
Shape of the Building	Regular (Rectangular)
No. of Stories	(G+10) Storey
Height of Stories	3 m (Similar)
Type of Wall	Brick Wall

Depth of Foundation	4 m
Area of Building	125.6 m ²
Beam Size	600 X 600 mm
Column size	400 X 600 mm
Slab Thickness	140

III. FLOOR PLAN OF BUILDING



Floor plan of building



Centre line plan

IV. MODEL DETAILS

Dead Load: Due to the self-weight of the slab
 Thickness of slab= 140mm
 Slab load per m = Thickness X unit weight = 0.140 x 25 = 3.5 KN/m²
 Wall load = 0.23 x (3-0.6) x 20 = 11.06 kN/m.
 Parapet load = 0.15 x 1 x 20 = 3 kN/m.

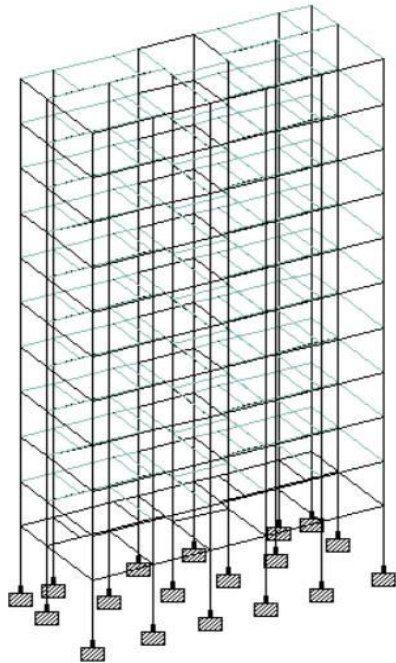
Live Load: Live load on floor 2 kN/sq. m. (Table 1 as per IS 875(part2):1987)

Wind Load: Probability factor or risk co-efficient (K1): 1.05 (clause 3 as per IS 875:1987(part 3))
 Terrain, Height, and Structure six factor (K2): Terrain category 3 and building class-C (clause 5.3.2.1 as per IS875:1987(part 3))
 Topography factor (K3): 1.0 (clause 5.3.3.1 as per IS 875:1987(part 3))
 Design wind speed (Vb): 33 m/s for Zone II; 39 m/s for Zone III; 46 m/s for Zone IV; 50 m/s for Zone V (clause 5.2 as per IS 875:1987(part 3))

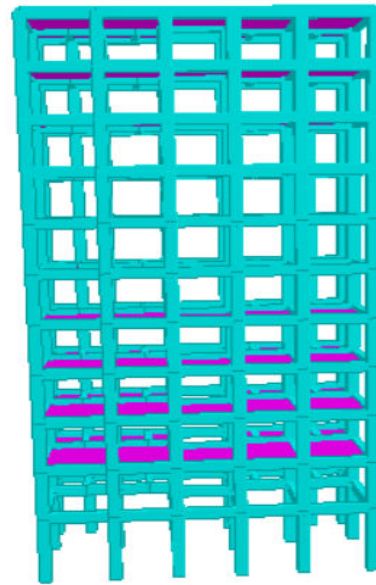
Seismic Load: Seismic Zone: Zone-II; Zone-III; Zone-IV; Zone-V (As per IS 1893:2002(part1)) Type of structure: Special RC moment-resisting frame (SMR) (Table 7 as per IS 1893:2002(part1))
 Seismic Zone factor: 0.16 for Zone II; 0.20 for Zone III; 0.30 for Zone IV; 0.36 for Zone V (Table 2 as per IS 1893:2002(part1))
 Importance factor: 1.5 (Table 6 as per IS 1893:2002(part1))

Response reduction factor: 5.0 (Table 7 as per IS 1893:2002(part1))

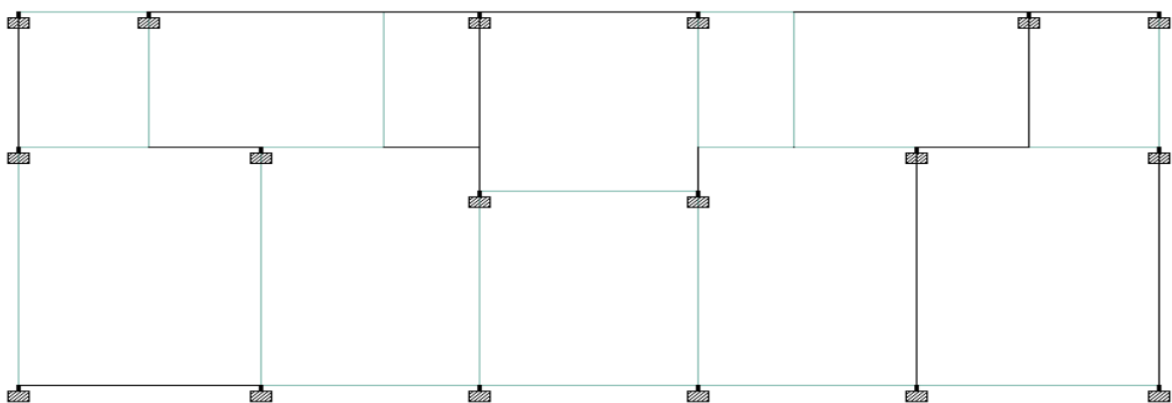
V. MODEL OF STRUCTURE



3-D View Model



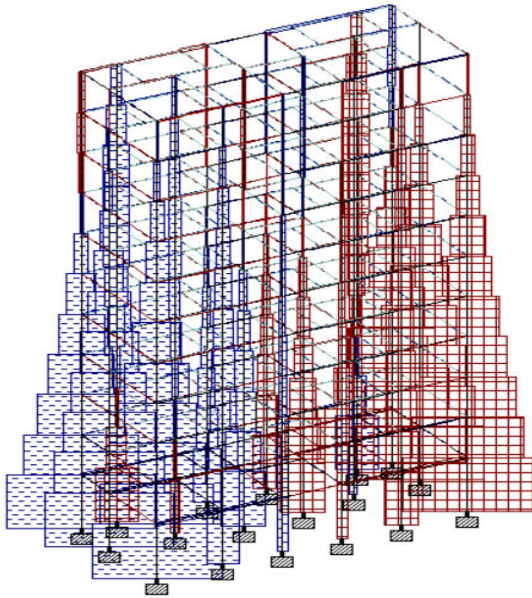
3-D Rendered View



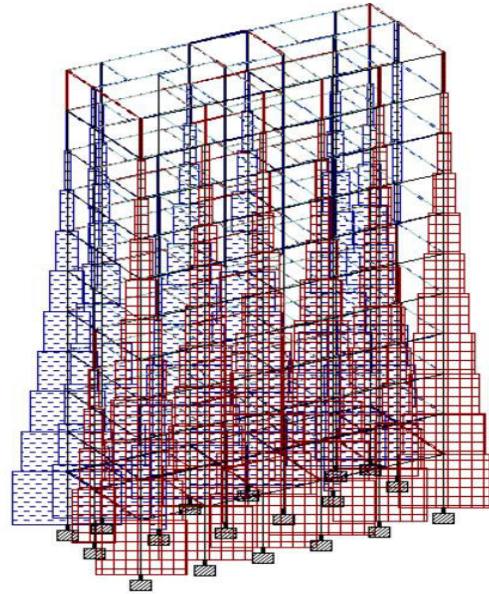
Top View Model

VI. ANALYSIS & INTERPRET THE RESULT

Interpreting the Shear Force

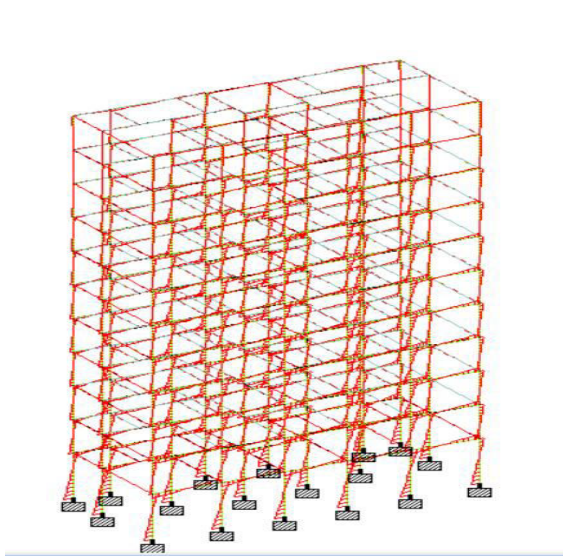


Due to EQ in X-direction

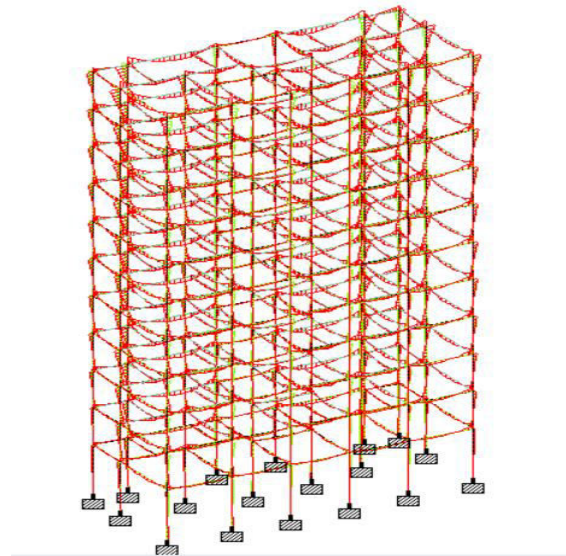


Due to EQ in Z-direction

Interpreting the Bending Moment



Due to EQ in X-direction



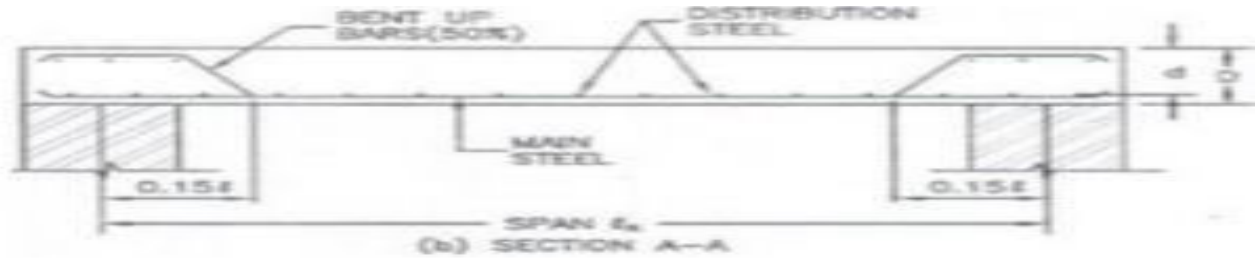
Due to EQ in Z-direction



VII. DESIGN OF STRUCTURE

Design of Slab: Slabs are the most often used structural components that make up a building's floor and roof. Using bending movements in both directions, slab supports primarily transmit transverse loads to supports. It comes in two different varieties depending on the spanning direction.

- One Way Slab
- Two Way Slab



Slab Reinforcement

Grade of concrete	M35
Grade of Steel	Fe500
Clear Cover of Slab, Beam	25 mm
Clear Cover	40 mm

Design of Beam

The screenshot shows a software window titled 'PROJECT - Beam'. It includes tabs for Geometry, Property, Loading, Shear Bending, Deflection, and Concrete Design. The main area displays 'Beam no. = 236 Design code : IS-456' and reinforcement details: '3#20 @ 565.00 0.00 To 1766.76', '3#20 @ 565.00 1766.76 To 2650.13', and '5 # 10 @ c/c 230.00'. It also shows cross-sections at 0.000, 1325.066, and 2650.133. A 'Design Load' table and 'Design Parameter' table are visible.

Mz Kn Met	Dist. Met	Load
98.91	2.7	19
-145.38	0	19
-110.14	2.7	17

Fy(Mpa)	500
Fc(Mpa)	35
Depth(m)	0.600000023
Width(m)	0.400000005
Length(m)	2.649902343

Beam Design

```

=====
      BEAM NO.    236  DESIGN RESULTS
=====
      M35          Fe500 (Main)          Fe500 (Sec.)
      LENGTH: 2650.1 mm    SIZE: 400.0 mm X 600.0 mm    COVER: 25.0 mm

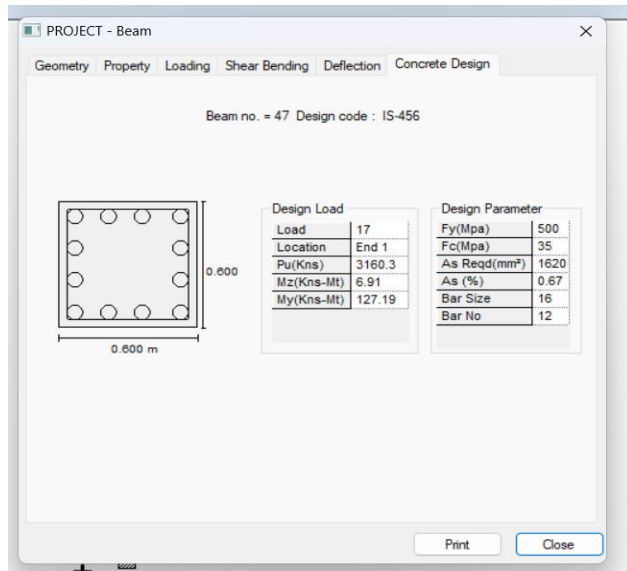
      SUMMARY OF REINF. AREA (Sq.mm)
      -----
SECTION    0.0 mm    662.5 mm    1325.1 mm    1987.6 mm    2650.1 mm
TOP        618.93     385.56     385.56     385.56     468.95
REINF.    (Sq. mm)  (Sq. mm)  (Sq. mm)  (Sq. mm)  (Sq. mm)
BOTTOM    404.49     385.56     385.56     385.56     414.87
REINF.    (Sq. mm)  (Sq. mm)  (Sq. mm)  (Sq. mm)  (Sq. mm)
      -----

      SUMMARY OF PROVIDED REINF. AREA
      -----
SECTION    0.0 mm    662.5 mm    1325.1 mm    1987.6 mm    2650.1 mm
TOP        3-20i     3-20i     3-20i     3-20i     3-20i
REINF.    1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)
BOTTOM    4-16i     4-16i     4-16i     4-16i     4-16i
REINF.    1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

SHEAR    2 legged 10i 2 legged 10i 2 legged 10i 2 legged 10i 2 legged 10i
REINF.    @ 230 mm c/c @ 230 mm c/c @ 230 mm c/c @ 230 mm c/c @ 230 mm c/c
      -----
    
```

Reinforcement details

Design of Column: A column is an element having a height that is at least three times its lateral dimension and is mostly used to support axial compressive loads. The material strength, shape, cross-sectional size, length, and intensity of proportional and dedicational restrictions at the ends of the column all affect how strong it is.



```

COLUMN NO. 110 DESIGN RESULTS

M35                Fe500 (Main)          Fe500 (Sec.)

LENGTH: 3000.0 mm  CROSS SECTION: 600.0 mm X 600.0 mm  COVER: 40.0 mm

** GUIDING LOAD CASE: 1 END JOINT: 81 TENSION COLUMN

REQD. STEEL AREA : 2880.00 Sq.mm.
REQD. CONCRETE AREA: 357120.00 Sq.mm.
MAIN REINFORCEMENT : Provide 16 - 16 dia. (0.89%, 3216.99 Sq.mm.)
(Equally distributed)
TIE REINFORCEMENT : Provide 10 mm dia. rectangular ties @ 255 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
-----
Puz : 6704.64  Muz1 : 310.90  Muy1 : 310.90

INTERACTION RATIO: 0.05 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
-----
WORST LOAD CASE: 11
END JOINT: 99 Puz : 6825.70  Muz : 590.78  Muy : 590.78  IR: 0.15
    
```

Column Design

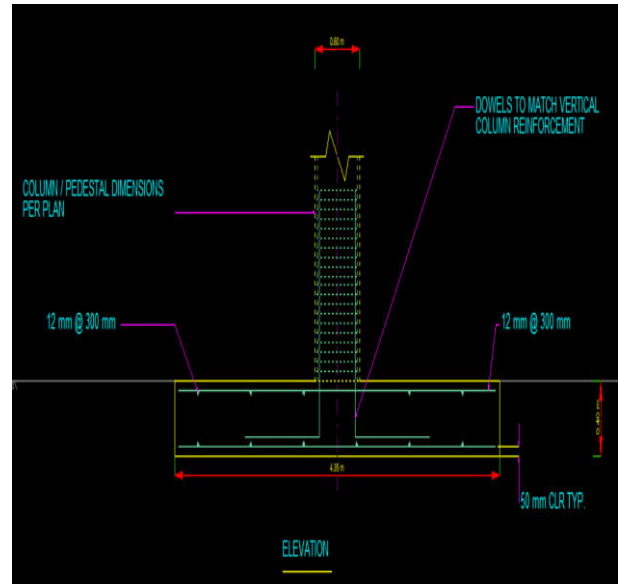
Reinforcement details

Design of Foundation: The loads from the building or each column are transferred to the earth via foundations, which are structural components. To minimize differential settlement, avoid excessive settlement or rotation, and offer enough safety against sliding and overturning, foundations must be built.

Unit weight of concrete	25 KN/m ³
Strength of Concrete	25 N/mm ²
Yield Strength of Steel	415 N/mm ²
Minimum Bar Size	10 mm
Maximum Bar Size	32 mm
Minimum Bar Spacing	50 mm
Maximum Bar Spacing	500 mm
Soil Type	Drained
Unit Weight	22 KN/m ³
Soil Bearing Capacity	100 KN/m ²

Result of Footing:

Footing No.	Group ID	Foundation Geometry		
		Length	Width	Thickness
-	-			
1	1	4.350 m	4.350 m	0.405 m
2	2	4.600 m	4.600 m	0.455 m
3	3	4.600 m	4.600 m	0.455 m
7	4	5.050 m	5.050 m	0.505 m
8	5	4.900 m	4.900 m	0.505 m
9	6	5.050 m	5.050 m	0.505 m
10	7	4.900 m	4.900 m	0.505 m
13	8	4.600 m	4.600 m	0.455 m
15	9	4.350 m	4.350 m	0.405 m
16	10	4.600 m	4.600 m	0.455 m
17	11	4.700 m	4.700 m	0.455 m
20	12	4.700 m	4.700 m	0.455 m
21	13	5.150 m	5.150 m	0.505 m
22	14	4.900 m	4.900 m	0.505 m
23	15	5.150 m	5.150 m	0.505 m
24	16	4.900 m	4.900 m	0.505 m
25	17	5.150 m	5.150 m	0.505 m
26	18	5.150 m	5.150 m	0.505 m



Geometry of footing

Elevation Plan of Footing

Footing No.	Footing Reinforcement				Pedestal Reinforcement	
	Bottom Reinforcement(M _x)	Bottom Reinforcement(M _y)	Top Reinforcement(M _x)	Top Reinforcement(M _y)	Main Steel	Trans Steel
1	Ø12 @ 80 mm c/c	Ø12 @ 80 mm c/c	Ø12 @ 300 mm c/c	Ø12 @ 300 mm c/c	N/A	N/A
2	Ø12 @ 80 mm c/c	Ø12 @ 80 mm c/c	Ø12 @ 320 mm c/c	Ø12 @ 320 mm c/c	N/A	N/A
3	Ø12 @ 80 mm c/c	Ø12 @ 80 mm c/c	Ø12 @ 320 mm c/c	Ø12 @ 320 mm c/c	N/A	N/A
7	Ø12 @ 75 mm c/c	Ø12 @ 75 mm c/c	Ø12 @ 305 mm c/c	Ø12 @ 305 mm c/c	N/A	N/A
8	Ø12 @ 80 mm c/c	Ø12 @ 80 mm c/c	Ø12 @ 315 mm c/c	Ø12 @ 315 mm c/c	N/A	N/A
9	Ø12 @ 75 mm c/c	Ø12 @ 75 mm c/c	Ø12 @ 305 mm c/c	Ø12 @ 305 mm c/c	N/A	N/A
10	Ø12 @ 80 mm c/c	Ø12 @ 80 mm c/c	Ø12 @ 315 mm c/c	Ø12 @ 315 mm c/c	N/A	N/A
13	Ø12 @ 80 mm c/c	Ø12 @ 80 mm c/c	Ø12 @ 320 mm c/c	Ø12 @ 320 mm c/c	N/A	N/A
15	Ø12 @ 80 mm c/c	Ø12 @ 80 mm c/c	Ø12 @ 300 mm c/c	Ø12 @ 300 mm c/c	N/A	N/A
16	Ø12 @ 80 mm c/c	Ø12 @ 80 mm c/c	Ø12 @ 320 mm c/c	Ø12 @ 320 mm c/c	N/A	N/A
17	Ø12 @ 75 mm c/c	Ø12 @ 75 mm c/c	Ø12 @ 305 mm c/c	Ø12 @ 305 mm c/c	N/A	N/A
20	Ø12 @ 75 mm c/c	Ø12 @ 75 mm c/c	Ø12 @ 305 mm c/c	Ø12 @ 305 mm c/c	N/A	N/A
21	Ø12 @ 70 mm c/c	Ø12 @ 70 mm c/c	Ø12 @ 310 mm c/c	Ø12 @ 310 mm c/c	N/A	N/A
22	Ø12 @ 80 mm c/c	Ø12 @ 80 mm c/c	Ø12 @ 315 mm c/c	Ø12 @ 315 mm c/c	N/A	N/A
23	Ø12 @ 70 mm c/c	Ø12 @ 70 mm c/c	Ø12 @ 310 mm c/c	Ø12 @ 310 mm c/c	N/A	N/A
24	Ø12 @ 80 mm c/c	Ø12 @ 80 mm c/c	Ø12 @ 315 mm c/c	Ø12 @ 315 mm c/c	N/A	N/A
25	Ø12 @ 70 mm c/c	Ø12 @ 70 mm c/c	Ø12 @ 310 mm c/c	Ø12 @ 310 mm c/c	N/A	N/A
26	Ø12 @ 70 mm c/c	Ø12 @ 70 mm c/c	Ø12 @ 310 mm c/c	Ø12 @ 310 mm c/c	N/A	N/A

Detailing of Footing

VIII. CONCLUSION

In the following work, we conclude that:-

1. Analysis and Design were done by Staad Pro Software and successfully verified manually as per IS code 456-2000.
2. Calculation by both software as well as manually gives the almost same result.
3. The percentage of steel required in the column is 0.08 to 3.
4. The quantity of concrete required is 486 CUM
5. The quantity of steel required is
 - 10mm = 82630 kg
 - 12mm = 264781 kg
 - 16mm = 6650 kg

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