

# Wind Analysis and Design of G+5 Residential Building Using STAAD.Pro

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**ABSTRACT:** This study presents a comparative study of wind loads to decide the design loads of a G+5 building. The significance of this examination is to estimate the design loads for a structure which is subjected to wind loads in a particular region. It is well known fact that the wind loads may be estimated in particular zone with a specified zone factor. Then the wind load of that zone can also be estimated based on the basic wind speed and other factors of that particular region. However, the wind velocity is stochastic and time dependent. In the present study a multi-storied building is analyzed and designed for wind loads using IS: 875 (Part-3) codes. In this analysis, G+5 storied building is considered and applied various loads like dead, live and wind loads and results are taken, so that clear idea can be suggested for wind analysis of the high rise buildings.

**KEYWORDS:** Residential building, STAAD.Pro, Auto CAD, Wind load etc.

## I. INTRODUCTION

Importance of wind engineering is emerging in India ever since the need for taller and slender buildings is coming forth. Considering the ever increasing population as well as limited space, horizontal expansion is no more a viable solution especially in metropolitan cities. There is enough technology to build super-tall buildings today, but in India we are yet to catch up with the technology which is already established in other parts of the world. Nowadays, construction of high rise building is a basic need because of scarcity of land. Conventional method of manual design of high rise building is time consuming as well as possibility of humans errors. So it is necessary to use some computer based software which gives more accurate results and reduce the time. STAAD. Pro is the structural software is nowadays accepted by structural engineers which can solve typical problem like static analysis, wind analysis, using various load combination to confirm various code.

Generally wind load governing for the structure more than the 10 m height. For the wind analysis of the tall building guideline is given in the IS-875 (Part 3)-1987. Which majorly includes the effect of the roughness, terrain category, surrounding building, basic wind speed, soil type and importance factor in only along the wind direction. From the previous cyclone and wind data it is observed that when wind occurs, structure not only effected in along the wind direction. Because of this reason, damage observed in so many structures although structure is well design for the wind effect according the IS-875 (Part 3) - 1987. This study describes wind analysis of high rise building in ZONE 3. For analysis purpose a five storey building in Hyderabad is selected and wind loads are estimated.

## II. OBJECTIVES

To analyze and design G+5 storied residential building as per IS code using STAAD-Pro.

- Analysis of G+5 storied RCC framed structure with wind load.
- Design of G+5 storied residential building with wind load.
- To compare the benefits of analysis and design of building by considering wind effect.

### III. METHODOLOGY

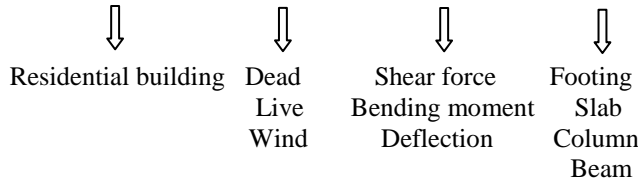
Salient features of building:

Utility of building: Residential complex  
 Building plan size: 30.49m \* 9.14m  
 Height of ground storey: 3m  
 Slab: 0.15m

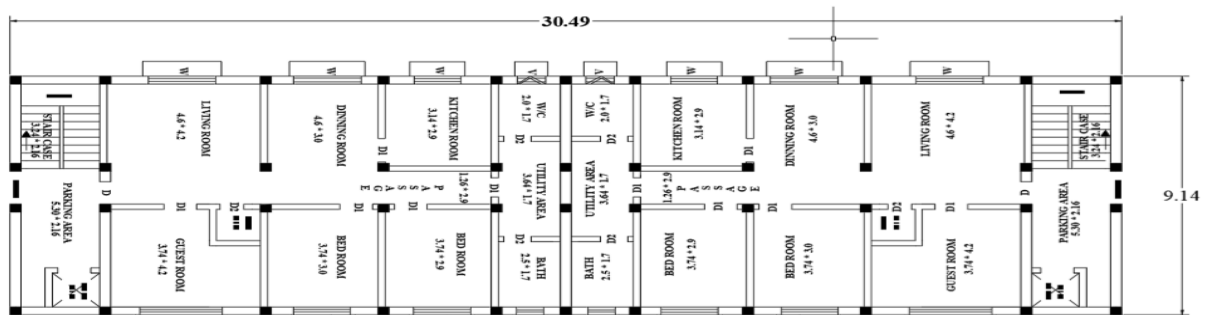
NO. Of stories: G+5  
 Parapet wall height: 1.15m  
 Total height: 18m  
 Floor to floor height: 3m

The steps involved are as follows:

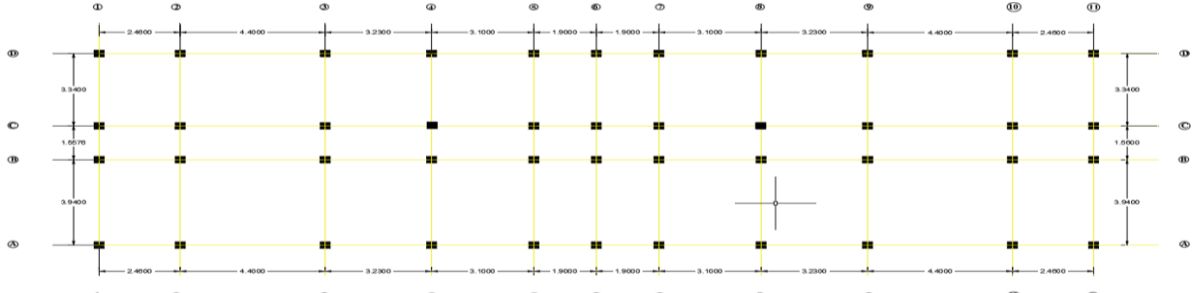
PLANNING → MODELLING → LOADS → ANALYSIS → DESIGN → RESULT → CONCLUSION



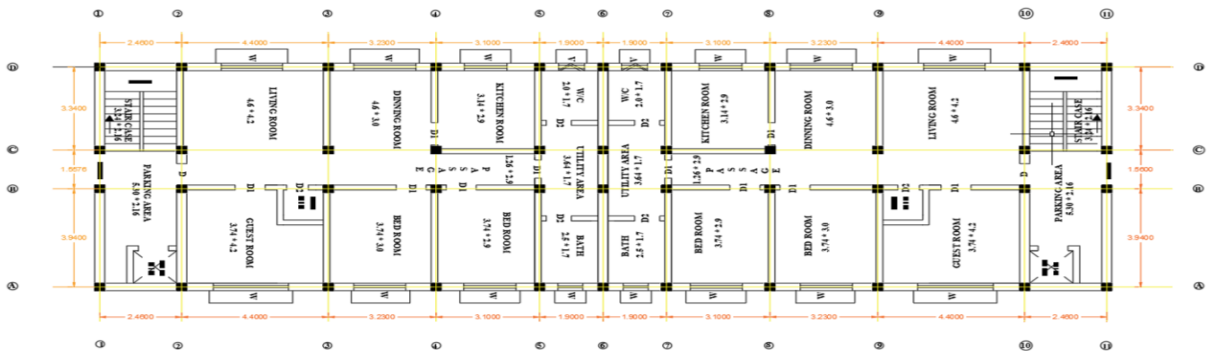
#### STEP 1: PLAN



PLAN



CENTRE LINE GRID MARKING



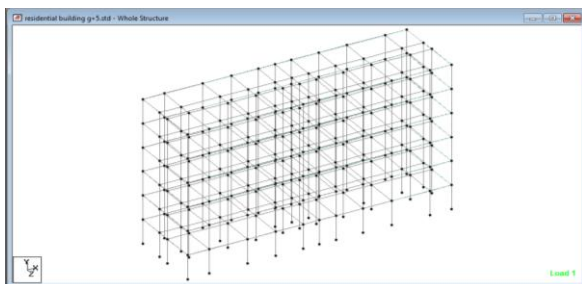
ARCHITECTURE PLAN

## STEP 2: MODELING AND STRUCTURAL ANALYSIS

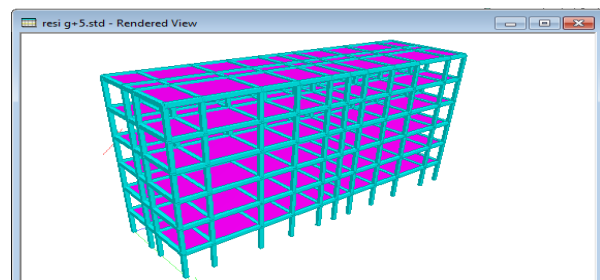
Structural analysis, which is an integral part of any engineering project, is the process of predicting the performance of a given structure under a prescribed loading condition. The performance characteristics usually of interest in structural design are:

- Stress
- Deflections
- Support reactions
- Bending moment
- Shear force

### Generating Model Geometry



Whole structure geometrical view



3 dimensional rendered view

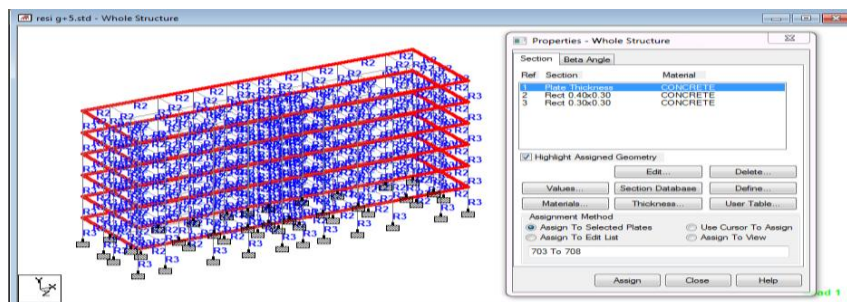
### Specifying Member Property

The next task is to assign cross section properties for the beams and columns. The member properties are assumed as given:

Thickness of slab = 150 mm

Beam = 230 × 500 mm

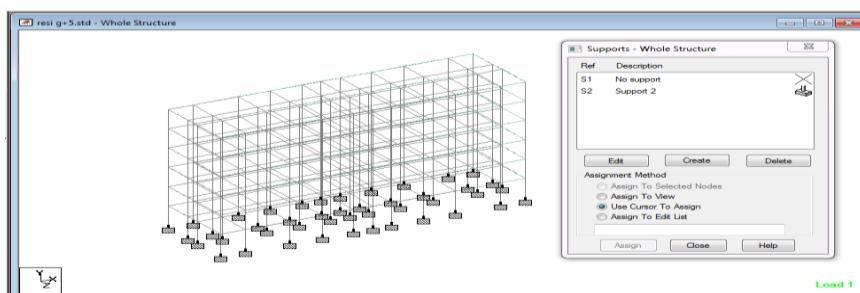
Column = 300 × 600 mm



Assigned member property

### Specifying Supports

The base nodes of all columns are restrained against translation and rotation about all the three global axes. In other words, fixed supports are specified at these nodes.

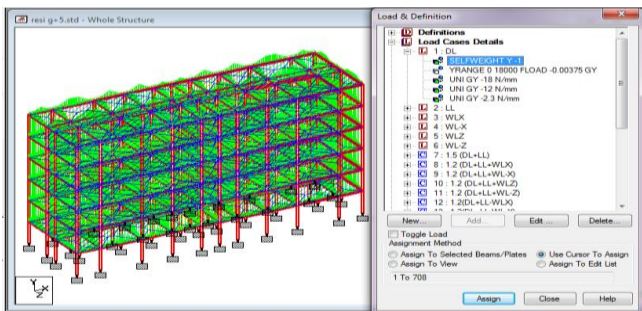


Assigned support

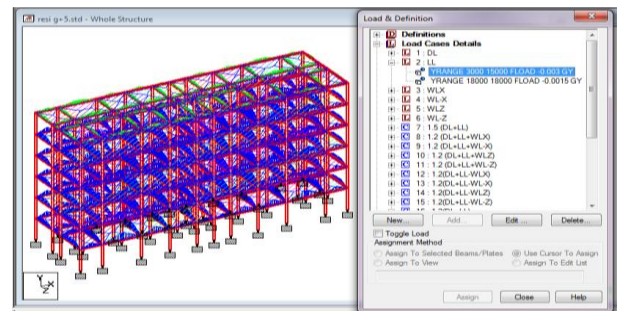
**STEP 3: LOADS**

- Dead load
  - As per IS 875:1987 (Part I)
  - Self weight = -1 kN/m<sup>2</sup>
  - Slab load = 0.15\*25 = 3.75 kN/m<sup>2</sup>
  - Wall Load
  - Outer wall = 0.3\*20\*3 = 18 kN/m
  - Inner wall = 0.2\*20\*3 = 12 kN/m
  - Parapet wall= 1.15\*20\*1 = 2.3 kN/m

- Live load
  - As per IS 875: 1987(PART-II)
  - From 1<sup>st</sup> floor to 5<sup>th</sup> floor = 3 kN/m<sup>2</sup>
  - Load at roof = 1.5 kN/m<sup>2</sup>



Dead load acting on structure



Live load acting on structure

- Wind load
  - As per IS 875:1987(Part-III)
    - Basic wind speed in Hyderabad, V<sub>b</sub>= 44 m/sec
    - Design wind speed (V<sub>z</sub>) = V<sub>b</sub> \* k<sub>1</sub> \* k<sub>2</sub> \* k<sub>3</sub> [Clause 5.3 of IS 875:1987 (Part-III)]

Where:

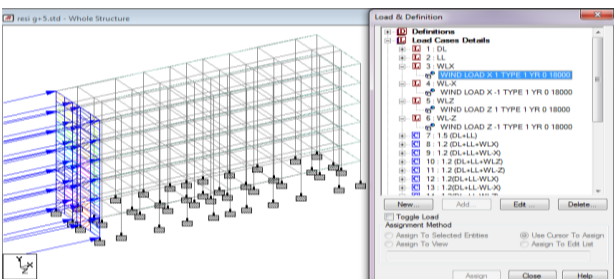
k<sub>1</sub>= Probability factor = 1(Clause 5.3.1)

k<sub>2</sub>= Terrain, height and structure size factor = 0.894(As per clause 5.3.2 the building is in category 3 and in class C, corresponding to this category and class from table 2, we find out the values of k<sub>2</sub>)

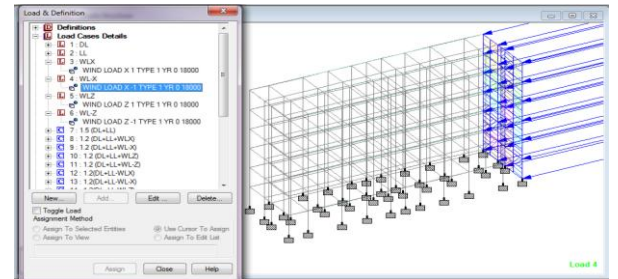
k<sub>3</sub> = Topography factor = 1 (As per Clause 5.3.3)

V<sub>z</sub> = 44 \* 1 \* 0.894 \* 1 = 39.36 m/s

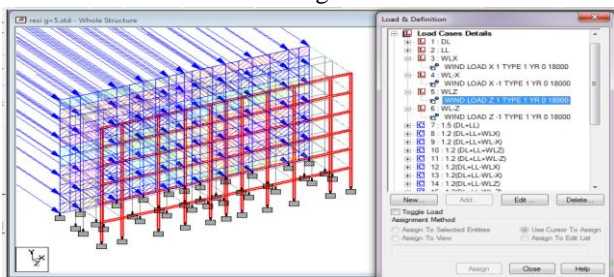
- Basic wind pressure, P<sub>z</sub> = 0.6 V<sub>z</sub> [Clause 5.4 of IS 875: 1987 (Part-III)]
  - = 0.6 \* (39.36)<sup>2</sup>
  - = 0.92 kN/m<sup>2</sup>



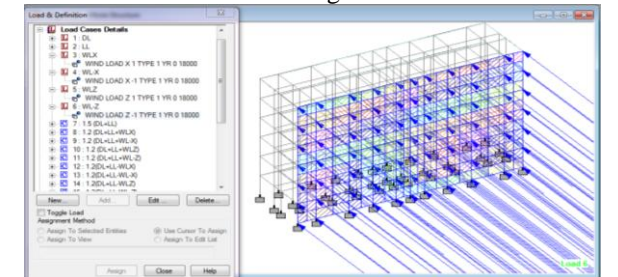
Wind load acting in X direction



Wind load acting in -X direction



Wind load acting in Z direction

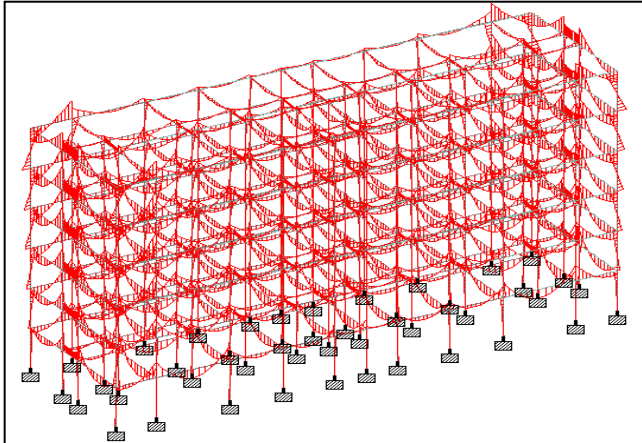


Wind load acting in -Z direction

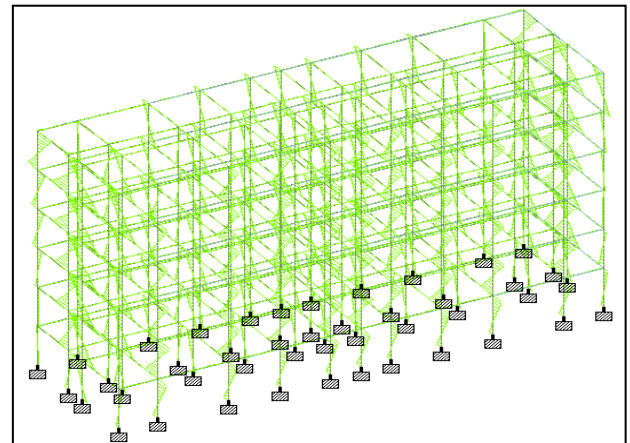


**STEP 4: ANALYSIS**

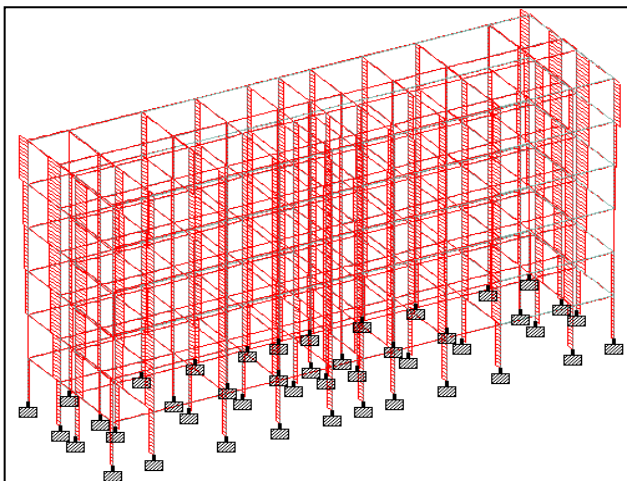
The bending moment and the Shear force can be studied from the graphs generated by post processing after the analysis in STAAD.Pro. The whole structure is shown in the screen and we can select any member and at the right side we will get the BMD and SFD for that member. The below figure shows the diagrams for whole structure.



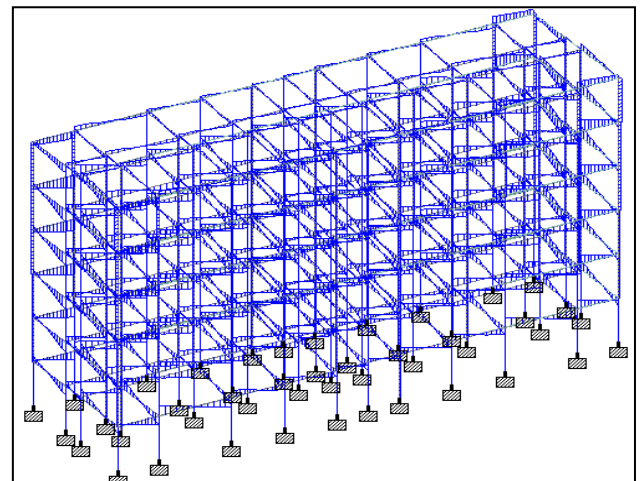
Bending moment in Z direction



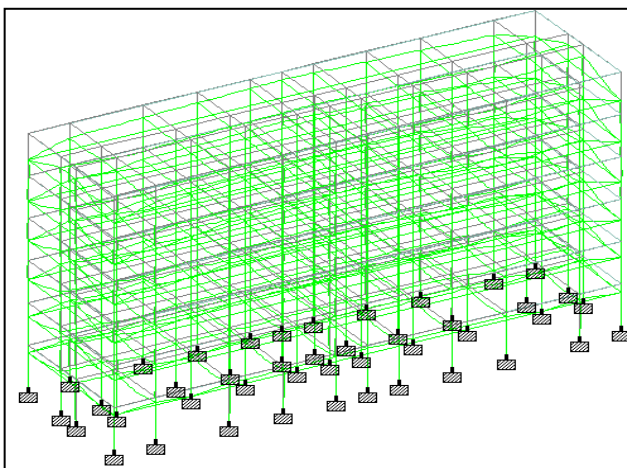
Bending moment in Y direction



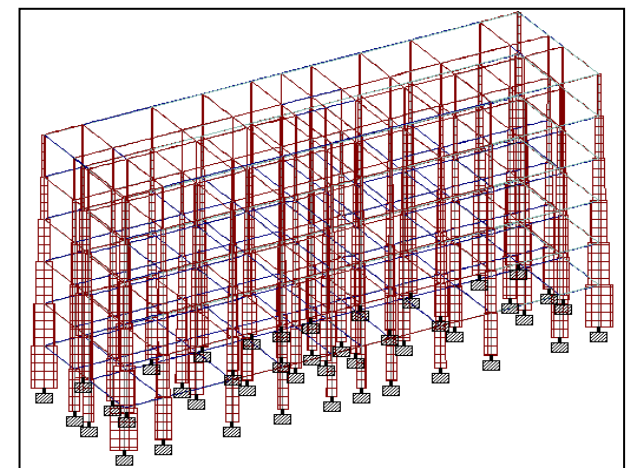
Shear force in Z direction



Shear force in Y direction



Deflection



Axial force

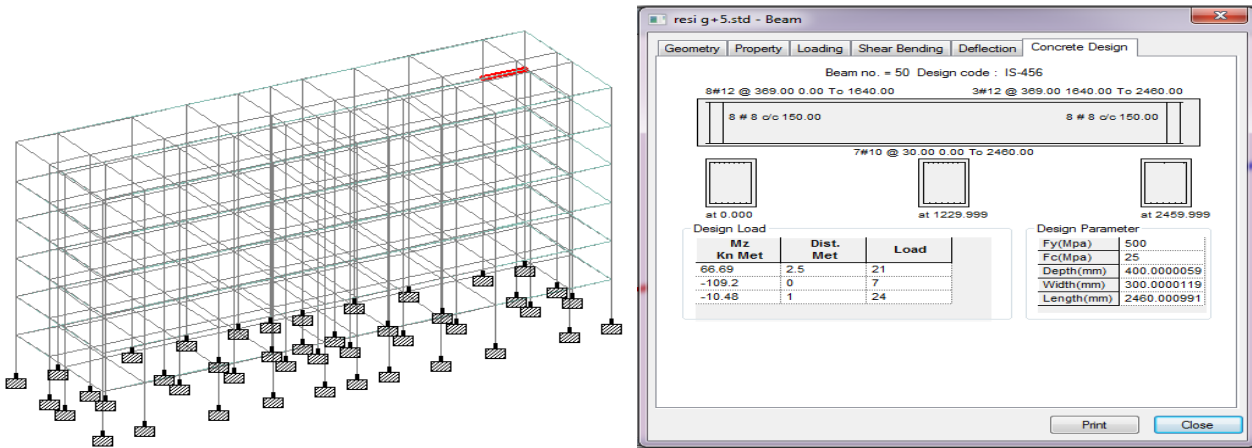


**STEP 5: DESIGN OF RCC STRUCTURE**

**Beam Design**

Beams transfer load from slabs to columns, beams are designed for bending.

Figure shows selected beam 50 and the bottom and top reinforcement details at three different sections.



Due to huge output data, output of a sample beam 50 is shown below

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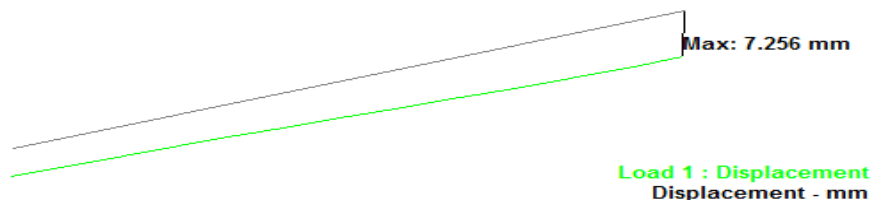
=====
BEAM NO. 50 DESIGN RESULTS
=====
M25 Fe500 (Main) Fe415 (Sec.)
LENGTH: 2460.0 mm SIZE: 300.0 mm X 400.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)
-----
SECTION 0.0 mm 615.0 mm 1230.0 mm 1845.0 mm 2460.0 mm
TOP REINF. 866.76 345.84 188.70 188.70 188.70
(Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)
BOTTOM REINF. 188.70 188.70 188.70 321.39 496.13
(Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA
-----
SECTION 0.0 mm 615.0 mm 1230.0 mm 1845.0 mm 2460.0 mm
TOP REINF. 8-12i 4-12i 3-12i 3-12i 3-12i
2 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)
BOTTOM REINF. 3-10i 3-10i 3-10i 5-10i 7-10i
1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)
SHEAR 2 legged 8i 2 legged 8i 2 legged 8i 2 legged 8i 2 legged 8i
REINF. @ 150 mm c/c @ 150 mm c/c @ 150 mm c/c @ 150 mm c/c @ 150 mm c/c

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT
-----
SHEAR DESIGN RESULTS AT 515.6 mm AWAY FROM START SUPPORT
VY = 97.80 MK = 4.88 LD= 7
Provide 2 Legged 8i @ 150 mm c/c
SHEAR DESIGN RESULTS AT 520.0 mm AWAY FROM END SUPPORT
VY = 45.17 MK = 4.54 LD= 24
Provide 2 Legged 8i @ 150 mm c/c
=====
    
```

Deflection at beam 50:



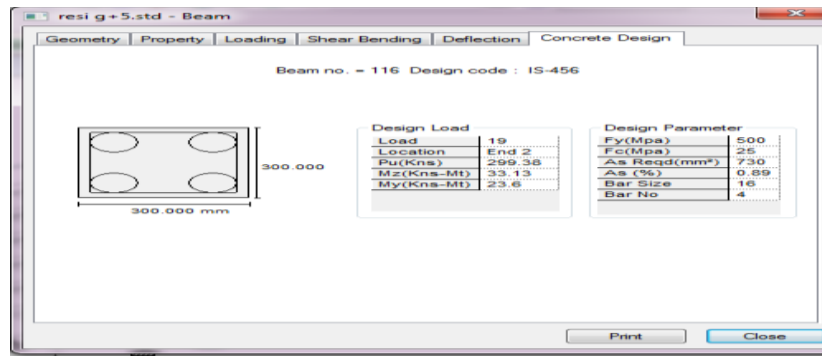
| Dist mm     | Displ mm |
|-------------|----------|
| 0           | -0.006   |
| 205.0000826 | -0.006   |
| 410.0001653 | -0.006   |
| 615.0002479 | -0.005   |
| 820.0003306 | -0.005   |
| 1025.000413 | -0.005   |
| 1230.000495 | -0.005   |
| 1435.000578 | -0.004   |
| 1640.000661 | -0.004   |
| 1845.000743 | -0.004   |
| 2050.000826 | -0.004   |
| 2255.000909 | -0.003   |
| 2460.000991 | -0.003   |



Column Design

A column may be defined as an element used primarily to support axial compressive loads and with a height of a least three times its lateral dimension. The strength of column depends upon the strength of materials, shape and size of cross section, length and degree of proportional and dedicational restrains at its ends.

Fig shows the reinforcement details of column:



Due to huge output data, output of a sample column is shown below

```

COLUMN NO. 116 DESIGN RESULTS
M25 Fe500 (Main) Fe415 (Sec.)
LENGTH: 3000.0 mm CROSS SECTION: 300.0 mm X 300.0 mm COVER: 40.0 mm
** GUIDING LOAD CASE: 19 END JOINT: 67 SHORT COLUMN
-----< PAGE 950 Ends Here >-----
STAAD SPACE -- PAGE NO. 951

REQD. STEEL AREA : 730.31 Sq.mm.
REQD. CONCRETE AREA: 89269.69 Sq.mm.
MAIN REINFORCEMENT : Provide 4 - 16 dia. (0.89%, 804.25 Sq.mm.)
(Equally distributed)
TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 255 mm c/c

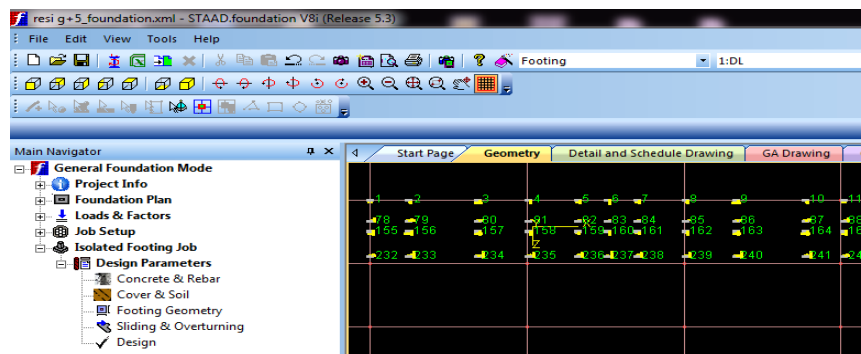
SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
-----
Puz : 1278.15 Muz1 : 55.25 Muy1 : 55.25

INTERACTION RATIO: 0.99 (as per cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
-----
WORST LOAD CASE: 24
END JOINT: 67 Puz : 1305.05 Muz : 65.14 Muy : 65.14 IR: 0.84
    
```

Foundation Design

Foundations are structural elements that transfer loads from the building or individual column to the earth. After the analysis of structure at first we have to import the reactions of the columns from STAAD.Pro using import button. After we import the loads the placement of columns is indicated in the figure.

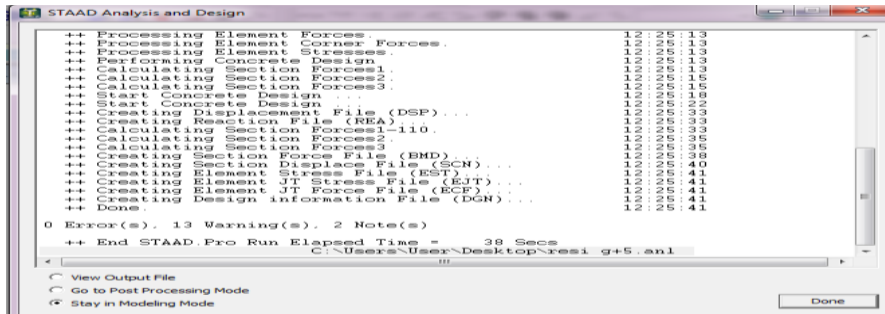


After importing the reactions in the STAAD foundation the input data is assumed regarding materials, Soil type, Type of foundation and safety factors. After the design is complete the calculations is obtained for each and every footing.



IV. ANALYSIS AND DESIGN RESULT

The structural analysis and design result after completing the work is obtained as shown below:



SUMMARY

The summary of maximum bending moment is as shown below:

|        | Beam | L/C           | Node | Fx<br>N    | Fy<br>N     | Fz<br>N    | Mx<br>kNm | My<br>kNm | Mz<br>kNm |
|--------|------|---------------|------|------------|-------------|------------|-----------|-----------|-----------|
| Max Fx | 439  | 7 1.5 (DL+LL) | 232  | 2.41446E6  | 2497.596    | -3730.433  | -0.002    | 3.629     | 2.488     |
| Min Fx | 62   | 5 WLZ         | 2    | -43015.831 | -183.040    | -9187.052  | 0.101     | 15.852    | -0.174    |
| Max Fy | 50   | 7 1.5 (DL+LL) | 65   | -2124.674  | 115.28056E  | 33.467     | 4.878     | 0.028     | 109.198   |
| Min Fy | 41   | 7 1.5 (DL+LL) | 57   | -2121.228  | -115.27603E | -34.512    | -4.879    | 0.028     | 109.192   |
| Max Fz | 334  | 20 1.5(DL+W)  | 176  | 780.80786E | 4593.983    | 26413.885  | 0.046     | -39.100   | 6.583     |
| Min Fz | 198  | 19 1.5(DL+W)  | 89   | 777.96387E | -3981.733   | -24558.922 | 0.035     | 36.267    | -5.752    |
| Max Mx | 560  | 7 1.5 (DL+LL) | 67   | -1584.946  | -14102.966  | 544.719    | 8.478     | -0.915    | -48.311   |
| Min Mx | 570  | 7 1.5 (DL+LL) | 77   | -1581.414  | -14101.344  | -542.519   | -8.478    | 0.911     | -48.309   |
| Max My | 334  | 20 1.5(DL+W)  | 187  | 771.26538E | 4593.983    | 26413.885  | 0.046     | 40.141    | -7.199    |
| Min My | 334  | 20 1.5(DL+W)  | 176  | 780.80786E | 4593.983    | 26413.885  | 0.046     | -39.100   | 6.583     |
| Max Mz | 50   | 21 1.5(DL-W)  | 65   | 450.458    | 114.43593E  | 60.957     | 4.333     | -0.010    | 109.824   |
| Min Mz | 50   | 20 1.5(DL+W)  | 66   | -1456.707  | 28888.741   | -1440.453  | 4.069     | -2.332    | -66.994   |

V. CONCLUSION

- STAAD.Pro is versatile software has the capability to calculate the reinforcement needed for any concrete section
- Reinforcement Details of each and every member can be obtained using STAAD.Pro.
- All the List of failed frame sections can be obtained in the report given by STAAD.Pro so that we can change the property data for a better section.
- Accuracy is improved by using software

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