

# Planning and Designing of Earthquake Resistance Residential Building

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**Abstract**— Earthquakes is caused because of the movement of tectonic plate that cause strain and unforeseen unleash of this strain energy cause earthquake. seismic activity is common in most elements of the globe. The past earthquake occurred experiences have incontestable vast loss of life and building stock, moving the social and economic. we all know that it's impractical to forestall associate degree earthquake, at least we will scale back the harm by making the buildings earthquake resistant. With the advancement in our understanding of the earthquakes, most of the countries have mandated the incorporation of seismic provisions in building style. within the event of associate degree earthquake, the seismic waves originating from the main focus is transmitted all told the doable directions. These shock waves propagate within the variety of body waves and surface waves through the earth's interior and, area unit extremely random in nature. These ground motions cause structures to vibrate and induce inertia forces within the structural parts. within the absence of seismic style, the building will fall and cause destruction. The seismic style aims to primarily guarantee life safety and secures the practicality of the building. In style it's essential to adopt earthquake-safe construction practices for the economical seismic performance of a building. No region within the whole of India may be thought of as earthquake free. The paper aims to form associate degree awareness regarding the earthquake-safe buildings in varied seismic zones. the foremost common building encountered within the recent years area unit the instant resisting frame (RC frame), moment resisting frames. This study investigates the development practices adopted for these common building. Any construction project to begin with starts with planning of the building or structure followed by layout then Design and Analysis of the structure. This project involves the planning, layout, design and analysis of a residential building located in Greater Noida, Uttar Pradesh. The layout of the proposed residential building is based on a plot of size 10m x 20m. Residential house is of 2BHK configuration. All the drafting was done using AutoCAD. Also, these drawings made on AutoCAD also served as a base for transfer of the structure for analysis and design into STAAD Pro. The analysis and design of the entire structure has been completed using STAAD pro. The results include the various forces acting on various members as well various schedules for various members. Also using the software, we got the concrete take-off as well as the weight of the various reinforcement bars.

**Keywords:** Earthquake Resistance, AutoCAD, STAAD pro.

## I. INTRODUCTION

### A. General

Any construction project to begin with starts with planning of the building or structure followed by layout then Design and Analysis of the structure. This project involves the planning,

layout, design and analysis of a residential building located in Greater Noida, Uttar Pradesh.

For completing the project very popular Civil Engineering software's such as AutoCAD, STAAD Pro V8i have been used.

### B. OBJECTIVE

- Planning of residential building with the help of byelaws provided by the local authority.
- To study and implement earthquake resistance measure in plan.
- To design an earthquake resistance residential building using STAAD.Pro.v8i
- Analysis of earthquake resistance residential building using STAAD.Pro.v8i

### C. Role of Bye-laws

Building bye-laws are a set of rules that developers have to abide by, while developing project. As is true of any sort of development, a specific set of rules must be followed, while carrying out building construction activities. In real estate, this specific set of rules that builders have to comply with, is commonly known as building bye-laws, which are aimed at providing orderly development in cities.

In the absence of building bye-laws, cities will be confronted with excessive coverage, encroachment and haphazard development resulting in chaotic conditions, inconvenience for the users and disregard for building aesthetics.

Typically, building bye-laws are created by the town planning authorities and address various building and safety requirements, apart from height, coverage, limitations and amenities in a building.

Formulated primarily by a central authority, building bye-laws ensure that constructions are not only safe but also adhere to aesthetic standards. In that sense, these regulate the construction and the architectural aspects of construction activities. For example, the rules prescribed under the building bye-laws can make it mandatory for builders to keep fire safety and earthquake-resistance provisions at their projects. Building bye-laws also govern the provisions for open spaces in a project, with the aim to ensure that developments do not turn the city into a concrete jungle. Building bye-laws also contain rules to ensure that there is minimum harm to the environment, as a result of developments.

### D. Role of AutoCAD

AutoCAD is a commercial software application for 2D and 3D computer aided design and drafting for various fields in engineering like civil, mechanical, electrical, automation, architecture etc. It was first launched in 1982 by Autodesk, Inc. AutoCAD Architecture allows designers to draw 3D objects such as walls, doors and windows, with more

intelligent data associated with them rather than simple objects. The data can be programmed to represent products sold in the building industry, or it can be extracted into a file for pricing material estimation etc. In this project AutoCAD has been used extensively for drafting and modelling for the structure. Also the various detailing for the foundation has also been completed using AutoCAD. Use of AutoCAD has drastically reduced the drafting time when done manually thus saving time which can be used in other productive work

#### E. Role of STAAD Pro

STAAD Pro V8i has a very user-friendly interface and very useful for designing complex structures and analyzing them. STAAD Pro V8i is a design and structural analysis program developed by Research Engineers International, CA. It was acquired by Bentley Systems in 2005. It is one of the most widely used design and structural analysis software's for concrete, steel and timber design codes. STAAD pro allows designers and structural engineers to design and analyze virtually any type of structure through its very flexible modelling environment, fluent data collection and advanced features. STAAD pro supports over 70 international codes including IS456:2000 IS800:2007 and over 20 U.S codes in more than 7 languages. STAAD pro is able to integrate with other Bentley Products such as STAAD. Foundation and ProSteel and OpenSTAAD. It is also able to integrate with other third-party applications thus giving a good flexibility to designers working on various software's. Using STAAD Pro one can check all the structural parameters in a design such as bending moment analysis, shear force analysis, buckling in a column, loads, deflection thereby helping the structural engineer in designing the structure better. STAAD pro V8i also has the DESIGN feature which enables engineers to calculate the various design data including the reinforcement in case of concrete design.

## II. LITERATURE REVIEW

### A. AutoCAD

AutoCAD is a commercial software application for 2D and 3D computer aided design and drafting for various fields in engineering like civil, mechanical, electrical, automation, architecture etc. It was first launched in 1982 by Autodesk, Inc. AutoCAD Architecture allows designers to draw 3D objects such as walls, doors and windows, with more intelligent data associated with them rather than simple objects. The data can be programmed to represent products sold in the building industry, or it can be extracted into a file for pricing material estimation etc. AutoCAD or Computer Aided Design is a very helpful tool in drafting and designing any structure. AutoCAD uses a Graphical User Interface for the purpose of drafting and designing any structure. The software has various inbuilt tools for complex drafting. Also, AutoCAD can be used for 2D and 3D design and also for perspective design. Below is a screenshot of the GUI of AutoCAD. With the help of AutoCAD all the drafting for the project has been done. It has made the life of a drafter quite easy than the conventional drafter using paper and pencil. It has made possible to make easy changes in the drawing as and when required. Also, various commands such as COPY, OFFSET, ROTATE, MOVE have made the tedious process

of redundant work quite easy and faster. Also, one of the important features of AutoCAD is the import and export feature which allows users to move their plans drawn using AutoCAD to other design softwares such as STAAD Pro and ETABS with the help of DXF file format which has in turn reduced load on the designer. Also, structural designs made on STAAD and ETABS are also exportable to AutoCAD for minute detailing required.

### B. STAAD Pro

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- A SPACE structure, is a 3D-frame structure in which loads may be applied in any plane, it is the most general type.
- A PLANE structure is bound by any two axes with loads acting on the same plane.
- A TRUSS structure is a structure having various truss members with axial loading but no bending.
- A FLOOR structure is a 2D or 3D structure with no horizontal movement of the structure. Columns are also to be modelled with the floor in a FLOOR structure as long as the structure has no horizontal loading. In case there is a horizontal load, it should be analyzed as a SPACE structure.

### C. Byelaws

The Building By laws should be followed strictly by any person or organization who plans to construct a building. Building by laws help in making a planned Development. Apart from individual plot or land owners, buyers of under construction property as well as constructed property should have a thorough knowledge of the building by laws applicable in that region. This will help the buyers question the Construction of structures by the developer. For Residential building or Group housing buildings the rules entail details such as width of a setback, percentage of Greens, Built up percentage, distance between two buildings, height of buildings, mandatory services requirements, distance from

high tension electrical lines and many more. As the building is to be sold to the end users eventually therefore the end users should take interest in gaining knowledge about building plans and mandatory construction practices also. This additional knowledge will prevent the Apartment owners from any non compliance action by the government Authorities later on. These building Regulations or building by laws are available at any concerned authority office of that locality and can be downloaded from their respective websites.

Under the building bye-laws in India, directions are laid down with respect to the following aspects of construction:

- Area and usage
- Building height
- Building coverage
- Floor space index
- Density
- Setbacks and projections
- Parking facilities
- Fire provisions with respect to staircase and exits
- Basement facilities
- Green spaces
- Open spaces
- Amenities in the project
- Provision for elevators
- Sewerage facilities
- Provision for water
- Provision for power supply
- Provision for waste management
- Rainwater harvesting
- Barrier-free environment
- Safety provisions

#### D. IITK-BMTPC Earthquake Tips

The Republic Day earthquake of 26 January 2001 in Gujarat clearly demonstrated the earthquake vulnerability profile of our country. It created a considerable interest amongst the professionals associated with construction activities in any form, as well as the non-professionals regarding the earthquake safety issues. While the subject of earthquake engineering has its own sophistication and a lot of new research is being conducted in this very important subject, it is also important to widely disseminate the basic concepts of earthquake resistant constructions through simple language. With this objective, the Indian

Institute of Technology Kanpur (IITK) and the Building Materials and Technology Promotion Council (BMTPC), a constituent of the Ministry of Urban Development & Poverty Alleviation, Government of India, launched the IITK-BMTPC Series on Earthquake Tips in early 2002. Professor C. V. R. Murty was requested to take up the daunting task of expressing difficult concepts in very simple language, which he has very ably done.

### III. METHODOLOGY

#### A. Study of byelaws

The Building By laws should be followed strictly by any person or organization who plans to construct a building.

Building by laws help in making a planned Development. Apart from individual plot or land owners, buyers of under construction property as well as constructed property should have a thorough knowledge of the building by laws applicable in that region.

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#### B. Study of IS 875 1987

IS 875 deals with the various load cases that act upon a structure and ways to calculate them. There are various parts of the code that deal with the various load types such as dead load, live load, wind load, snow load and various special loads and load combinations. As the building is situated in Delhi and is not a high-rise building, loads such as wind and snow were not considered in the design process. The Code gives the unit weights of various materials as well as the values of imposed loads that act in various types of structures and parts of these structures.

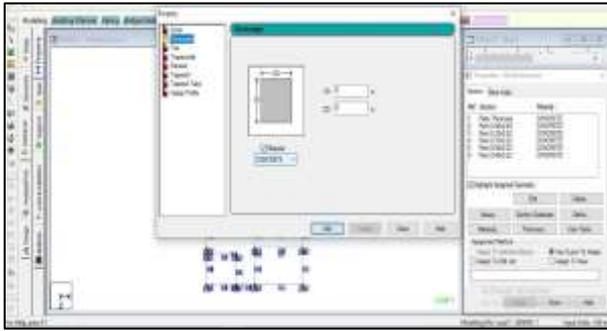
#### C. Preparation of Building Layout

The layout for the proposed building was prepared, discussed and approved by an architect. The layout was then prepared using AutoCAD. The various layouts were prepared and then later discussed with the architect for error correction.

#### D. Analysis and Design

Once the layout of the building was approved by the architect the layout was transferred from AutoCAD to STAAD Pro using a DXF file format. Once the layout was transferred, multiple stories were created using the Translational Repeat Tool in Staad Pro. After this member properties were assigned. Next the load cases were generated and applied to the structure. Once the loads were applied the structure was analyzed and corrections were made to the structure for the various errors that were generated while the structure was being analyzed. After the analysis, we started designing the structure by entering the DESIGN tab in STAAD Pro. All the design parameters were entered and load cases selected. This completes the design of the beam, columns and slabs. For designing the foundation STAAD foundation program is opened and the structure along with the load cases is transferred. Once this is done the soil conditions and the type of foundation is entered. After this the program analyses and designs the foundation.





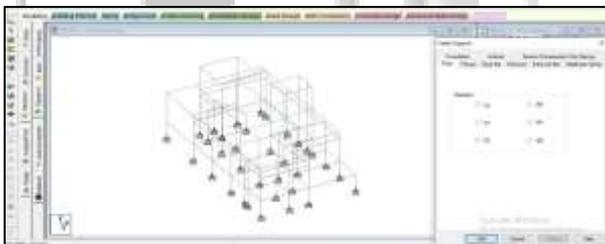
STAAD Pro can be used to create various different geometry for the members, these include:

- 1) Circle
- 2) Rectangle
- 3) TEE
- 4) Trapezoidal
- 5) General
- 6) Tapered I (Steel Section)
- 7) Tapered Tube (Steel Section)
- 8) Assign Profile

By using the Property Defining window we can generate the member property in STAAD Pro. The member section is selected and the dimensions are specified. The beams have a cross-section of 0.5 m x 0.225 m and the columns have a cross section of 0.4m x 0.4m.

#### D. Creation of Support

All the columns have been assigned fixed support using the STAAD pro Support creator and have been assigned accordingly. Fixed Supports have restricted movements in all directions as well there is restricted moment. This means FX FY FZ MX MZ MY all will have some values.



STAAD Pro can be used to create a number of different supports for various cases which include:

- 1) Fixed
- 2) Pinned
- 3) Fixed But
- 4) Enforced
- 5) Enforced But
- 6) Multilinear Spring
- 7) Foundation
- 8) Inclined
- 9) Tension/Compression Springs

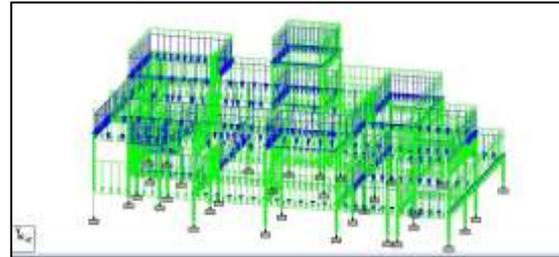
#### E. Loading

The loading that have been considered on the structure are as follows

- 1) Self-Weight
- 2) Dead Load
- 3) Live Load
- 4) Seismic Load
- 5) Load Combinations

**Self-Weight** It is the weight of the entire structure generated by STAAD Pro itself with the Self Weight Command.

**Dead Load from Slab** Dead load from the slab can be generated by STAAD Pro itself by specifying the Slab Thickness and the load on the floor per Sqm. This was found out to be 1KN/sq m



- The live load acting on each floor was considered to be 3KN/ sqm. The live load are generated in the same way as dead load.
- The seismic loads were derived from IS 1893 2002 and these loads were generated by STAAD
- Pro Seismic Load generator in accordance with IS1893
- The Seismic Load generator generates load in X and Z direction only. Y Direction only contains gravity loads
- STAAD follows the following procedure to generate the seismic loads
- User inputs the seismic zone co-efficient and desired "1893(Part 1)-2002 specs" through the load generator command
- Program calculates the structure period (T).
- Program calculates Sa/g utilizing T.
- STAAD calculates V from the above equation. W is obtained from the weight data provided by the user through the DEFINE 1893 LOAD command.
- The total lateral seismic load (base shear) is then distributed by the program among different levels of the structure per the IS: 1893(Part 1)-2002 procedures



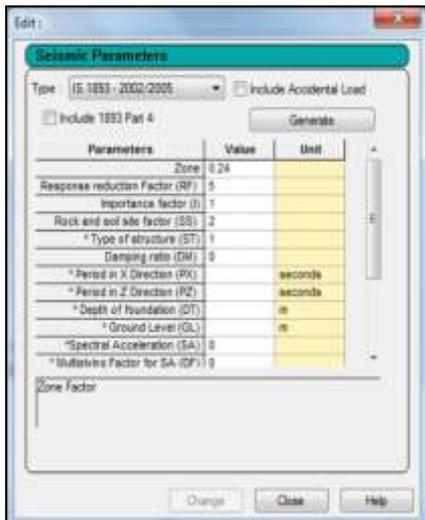
Zone Factor 0.24 for Delhi

The frame selected is Special RC Moment Resisting Frame (SMRF) and RF is taken as 5.

Importance Factor for All General Building is 1.0

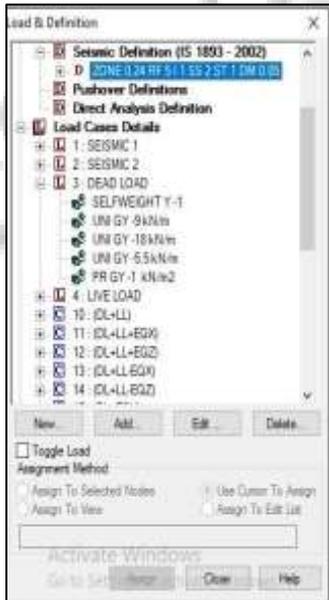
Rock Soil type is "Medium Soil"

Structure Type is "RC Frame Building"



The Figure Mentions the Seismic Code as IS 1893:2002.  
The zone factor is 0.24 for Delhi.

The response reduction factor(RF) is taken as 5.  
The importance Factor for the building is taken as 1.  
Rock and soil site factor(SS) is taken as 2 for medium soil  
Type of structure is taken as 1  
Damping Ratio is taken as 5%  
Load Combinations The structure has to be analysed for load combinations considering all the previous loads in proper ratio. These combinations are generated by the inbuilt auto-load generator for various load combinations as per IS Codes



The Various Load Combinations used are as follows:  
SEISMIC 1  
SEISMIC 2  
DEAD LOAD  
LIVE LOAD  
(DL+LL)  
(DL+LL+EQX)  
(DL+LL+EQZ)  
(DL+LL-EQX)  
(DL+LL-EQZ)  
(DL+EQX)  
(DL+EQZ)  
(DL-EQX)

(DL-EQZ)  
(1.5 DL + 1.5 LL)  
(1.2 DL + 1.2 LL + 1.2 EQX)  
(1.2 DL + 1.2 LL + 1.2 EQZ)  
22 (1.2 DL + 1.2 LL - 1.2 EQX)  
(1.2 DL + 1.2 LL - 1.2 EQZ)  
(1.5 DL+1.5 EQX)  
(1.5 DL+1.5 EQZ)  
(1.5 DL-1.5 EQX)  
(1.5 DL-1.5 EQZ)  
(0.9 DL+1.5 EQX)  
(0.9 DL+1.5 EQZ)  
(0.9 DL-1.5 EQX)  
(0.9 DL-1.5 EQZ)

## V. RESULTS:

### Support Reaction

JOINT	FORCE-X	FORCE-Y	FORCE-Z	MOM-X	MOM-Y	MOM-Z
1	0.0000E+00	9.4896E+01	0.0000E+00	-1.3090E+01	0.0000E+00	-4.1917E+01
3	0.0000E+00	-1.5247E+01	0.0000E+00	-2.2013E+01	0.0000E+00	0.0000E+00
4	0.0000E+00	9.0194E+01	0.0000E+00	-1.3090E+01	0.0000E+00	8.1917E+01
5	0.0000E+00	-4.2872E+01	0.0000E+00	8.6209E+00	0.0000E+00	0.0000E+00
6	0.0000E+00	-1.0997E+02	0.0000E+00	-1.0060E+01	0.0000E+00	-8.3481E+00
7	0.0000E+00	-9.4642E+01	0.0000E+00	8.4205E+00	0.0000E+00	-8.3481E+00
8	0.0000E+00	-1.9117E+02	0.0000E+00	-1.7104E+00	0.0000E+00	-8.3481E+00
9	0.0000E+00	-1.2492E+02	0.0000E+00	1.4540E+01	0.0000E+00	8.2551E+00
10	0.0000E+00	-9.5918E+01	0.0000E+00	-1.1752E+01	0.0000E+00	-8.3481E+00
11	0.0000E+00	-6.7342E+01	0.0000E+00	1.1752E+01	0.0000E+00	-8.4699E+00
12	0.0000E+00	-9.0672E+01	0.0000E+00	-1.0060E+01	0.0000E+00	2.7147E+01
13	0.0000E+00	-9.5437E+01	0.0000E+00	-1.0060E+01	0.0000E+00	1.9804E+00
14	0.0000E+00	-7.7948E+01	0.0000E+00	8.6205E+00	0.0000E+00	0.0000E+00
15	0.0000E+00	-1.0794E+02	0.0000E+00	-8.2876E+00	0.0000E+00	0.0000E+00
16	0.0000E+00	-8.9949E+01	0.0000E+00	2.4076E+01	0.0000E+00	1.9804E+01
17	0.0000E+00	-4.9727E+01	0.0000E+00	5.4661E+00	0.0000E+00	-3.7742E+00
18	0.0000E+00	-4.8281E+01	0.0000E+00	-5.7919E+00	0.0000E+00	1.3270E+01
19	1.5319E+00	-6.7332E+01	0.0000E+00	3.8760E+00	0.0000E+00	-3.4792E+00
20	0.0000E+00	5.3197E+01	0.0000E+00	2.8033E+01	0.0000E+00	0.0000E+00
21	0.0000E+00	-3.5941E+01	0.0000E+00	0.0000E+00	0.0000E+00	-2.3179E+01
22	0.0000E+00	-2.1440E+01	0.0000E+00	-5.7919E+00	0.0000E+00	0.0000E+00
23	0.0000E+00	-1.9487E+01	0.0000E+00	0.0000E+00	0.0000E+00	-8.3481E+00
24	0.0000E+00	-3.9440E+01	0.0000E+00	5.7919E+00	0.0000E+00	8.3481E+00
25	0.0000E+00	-1.9487E+01	0.0000E+00	0.0000E+00	0.0000E+00	8.3481E+00
26	0.0000E+00	-5.3341E+01	0.0000E+00	0.0000E+00	0.0000E+00	-8.3481E+00
27	0.0000E+00	-5.9839E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.3964E+00
28	0.0000E+00	-2.5940E+01	0.0000E+00	5.7919E+00	0.0000E+00	-1.3964E+00
30	0.0000E+00	-3.2643E+01	0.0000E+00	-5.1130E+00	0.0000E+00	-6.1130E+00
31	0.0000E+00	-2.9371E+01	0.0000E+00	-5.1130E+00	0.0000E+00	2.7149E+00
32	0.0000E+00	-2.3738E+01	0.0000E+00	1.8678E+00	0.0000E+00	0.0000E+00
33	0.0000E+00	-4.7478E+01	0.0000E+00	-8.0713E+00	0.0000E+00	-6.1130E+00
34	0.0000E+00	-5.0978E+01	0.0000E+00	3.4480E+00	0.0000E+00	-6.1130E+00
35	0.0000E+00	-4.7778E+01	0.0000E+00	7.8676E+00	0.0000E+00	-6.1130E+00
36	0.0000E+00	-1.0623E+02	3.4334E+00	-3.7286E+01	0.0000E+00	1.4832E+00
37	0.0000E+00	-5.5712E+01	0.0000E+00	3.4480E+00	0.0000E+00	6.1130E+00
38	0.0000E+00	-5.5712E+01	0.0000E+00	-8.3204E+00	0.0000E+00	3.3982E+00
39	0.0000E+00	-3.5009E+01	0.0000E+00	-8.2413E+00	0.0000E+00	1.4888E+01
40	0.0000E+00	-8.1124E+01	0.0000E+00	-2.3450E+01	0.0000E+00	6.1130E+00
41	0.0000E+00	-9.7552E+01	0.0000E+00	1.0344E+00	0.0000E+00	0.0000E+00

### BEAM NO. 187 DESIGN RESULTS

M25	Fe500 (Main)	Fe415 (Sec.)
LENGTH: 4000.0 mm	SIZE: 225.0 mm X 500.0 mm	COVER: 25.0 mm

### SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP REINF.	179.39 (Sq. mm)				
BOTTOM REINF.	179.39 (Sq. mm)				

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	1000.0 mm	2000.0 mm	3000.0 mm	4000.0 mm
TOP	3-12i	3-12i	3-12i	3-12i	3-12i
REINF.	1 layer(s)				
BOTTOM	3-12i	3-12i	3-12i	3-12i	3-12i
REINF.	1 layer(s)				
SHEAR	2 legged 8i				
REINF.	@ 160 mm c/c				

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT : 669.0 mm AWAY FROM START SUPPORT  
 $VY = 8.97$   $MX = -2.12$   $LD = 19$   
 Provide 2 Legged 8i @ 160 mm c/c

SHEAR DESIGN RESULTS AT : 669.0 mm AWAY FROM END SUPPORT  
 $VY = -13.56$   $MX = -2.12$   $LD = 19$   
 Provide 2 Legged 8i @ 160 mm c/c

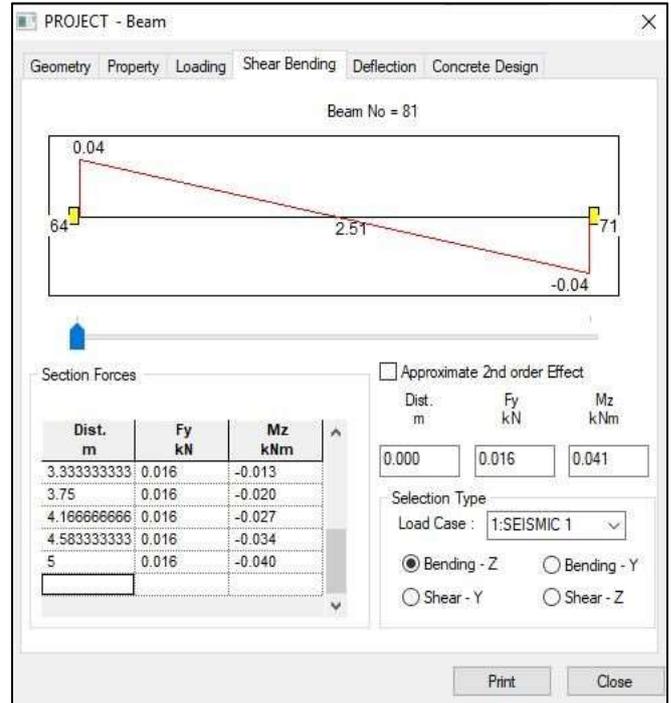
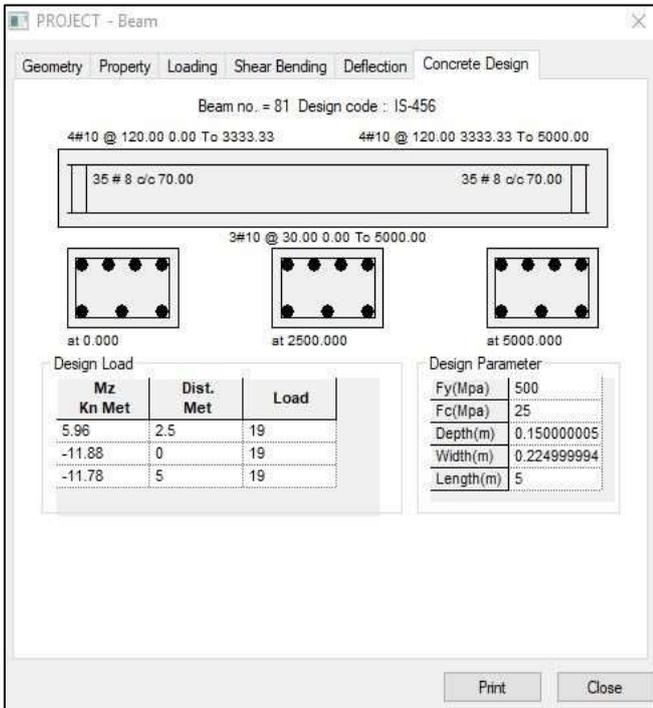


FIG 12. BEAM 187 SCHEDULE



COLUMN NO. 220 DESIGN RESULTS

M25       $F_{ck}500$  (Main)       $F_{ck}415$  (Sec.)

LENGTH: 3200.0 mm    CROSS SECTION: 400.0 mm X 400.0 mm    COVER: 40.0 mm

\*\* GUIDING LOAD CASE: 1 END JOINT: 113 TENSION COLLUM

REQD. STEEL AREA : 1260.06 Sq.mm,  
 REQD. CONCRETE AREA: 154720.00 Sq.mm,  
 MAIN REINFORCEMENT : Provide 12 - 12 dia. (0.85%, 1357.17 Sq.mm.)  
 (Equally distributed)  
 TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 150 mm c/c

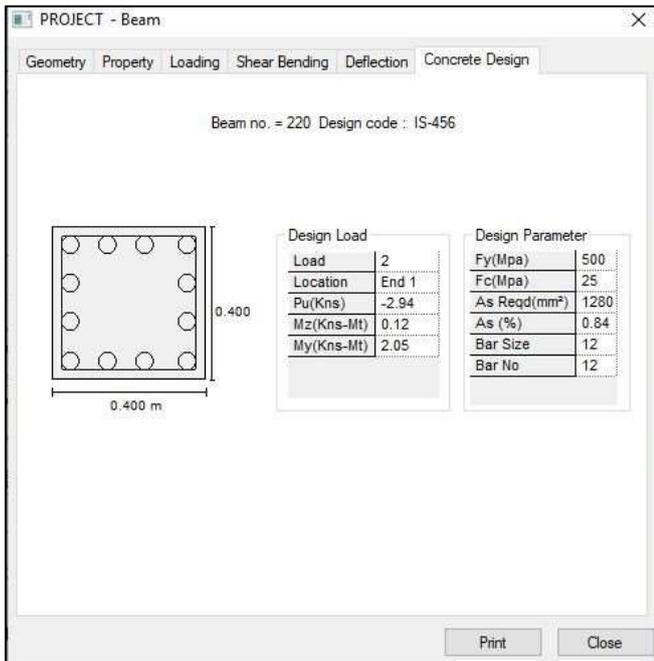
SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (RHS-MET)

-----  
 $P_{ux} : 2265.40$      $M_{ux1} : 88.48$      $M_{ux2} : 88.48$

INTERACTION RATIO: 0.53 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (RHS-MET)

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 WORST LOAD CASE: 23  
 END JOINT: 113  $P_{ux} : 2293.67$      $M_{ux} : 88.48$      $M_{ux} : 88.48$     IR: 0.10



## VI. CONCLUSION

This project includes the layout residential building using AutoCAD, Analysis and Design using STAAD Pro. The layout of the proposed residential building is based on a plot of size 20m x 10m located at Greater Noida, Uttar Pradesh. Apartment is of 2BHK configuration. All the drafting was done using AutoCAD. Also these drawings made on AutoCAD also served as a base for transfer of the structure for analysis and design into STAAD Pro. The analysis and design of the entire structure has been completed using STAAD pro. The results include the various forces acting on various members as well various schedules for various members. Also using the software we got the concrete take-off as well as the weight of the various reinforcement bars thus easing the load of cost estimation. The foundation has been designed as an isolated footing using soil condition as medium. The foundation design values were calculated using STAAD Foundation.

Maximum deflection in the structure due to different type of load combination is 4.389mm, which is within the safe limit as maximum allowable deflection according to IS 456 is  $L/350$ , so according to IS 456 maximum allowable deflection come out to be 7.142mm, Hence structure is safe in earthquake zone 4.

## REFERENCES

- [1] IS 1893: 2002/2005
- [2] IS 875: 1987
- [3] IS 456: 2000
- [4] IITK-BMTPC Earthquake Tips
- [5] STAAD Pro User Manual
- [6] AUTO CAD User Manual