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Design and Analysis of Earthquake Building C+G+7 using Staad.Pro

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Abstract: Earthquakes are caused mostly by rupture of geological faults, but also by other events such as volcanic activity, landslides, mine blasts, and nuclear tests. An earthquake (also known as a quake, tremor or temblor) is the result of a sudden release of energy in the Earth's crust that creates seismic waves. The seismicity or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers. There are many buildings that have primary structural system, which do not meet the current seismic requirements and suffer extensive damage during the earthquake. The current version of the IS: 1893 - 2002 requires that practically all multistoried buildings be analyzed as three-dimensional systems. This is due to the fact that the buildings have generally irregularities in plan or elevation or in both. Further, seismic intensities have been upgraded in weaker zones as compared to the last version IS: 1893-1984. It has now indirectly become mandatory to analyze all multistoried buildings in the country for seismic forces. The main objective of this project is design a earth quake resistant residential building (C+G+7) using STAAD PRO v 8i.

Keywords: Analysis and Design of Structure, STAAD.Pro, Seismic Loads, Seismic Zone, Indian Standard Codes.

I. INTRODUCTION

The procedure for analysis and design of a given building will depend on the type of building, its complexity, the number of stories etc. First the architectural drawings of the building are studied, structural system is finalized and sizes of structural members are decided and brought to the knowledge of the concerned architect. The procedure for structural design will involve some steps which will depend on the type of building and also its complexity and the time available for structural design. Often, the work is required to start soon, so the steps in design are to be arranged in such a way the foundation drawings can be taken up in hand within a reasonable period of time.

A. Basic Codes For Design

The design should be carried so as to conform to the following:

- IS 456: 2000 – Plain and reinforced concrete – code of practice (fourth revision)
- National Building Code 2005
- Loading Standards IS 875 (Part 1-5): 1987 – Code of practice for design loads (other than earthquake) for buildings and structures (second revision)
    - Part 1: Dead loads
    - Part 2: Imposed (live) loads
    - Part 3: Wind loads
    - Part 4: Snow loads
    - Part 5: Special loads and load combinations
- Design Handbooks
- SP16:1980–DesignAids (for Rein forced Concrete) to IS 456: 1978
- SP 24: 1983 – Explanatory handbook on IS 456: 1978
- SP 34: 1987–Handbooks on Concrete Reinforced and Detailing.

B. Features of the STAAD Pro

- **The STAAD-Pro Graphical User Interface:** It is used to generate them model, which can then be analyzed using the STAAD engineer. After analysis and design is completed, the GUI can also be used to view the results graphically.
- **The STAAD-Pro analysis and design engine:** It is a general-purpose calculation engineer for structural analysis and integrated Steel, Concrete, Timber and Aluminum design.

STAAD (structural analysis and design) is powerful design software licensed by Bentley. Any object which is stable under a given loading can be considered as structure. So first find the outline of the structure, where as analysis is the estimation of what are the type of loads that acts on the beam and calculation of shear force and bending moment comes under analysis stage. Design phase is designing the type of materials and its dimensions to resist the load. This we do after the analysis. To calculate shear force diagram (s.f.d) and Bending moment diagram (b.m.d) of a complex loading beam it takes about an hour. So when it comes into the building with several members it will take a week. STAAD pro is a very powerful tool which does this job in

just an hour's STAAD is a best alternative for high rise buildings. Now a days most of the high rise buildings are designed by STAAD which makes a compulsion for a civil engineer to know about this software. These software can be used to carry RCC steel, bridge, truss etc according to various country codes.

II. LITERATURE REVIEW

The design and analysis of multistoried C+G+7 building at Kukatpally, Hyderabad India. The study includes design and analysis of columns, beams, footings and slabs by using well known civil engineering software named as STAAD.PRO. Test on safe bearing capacity of soil was obtained. P. Jayachandran: The design and analysis of multistoried C+G+7 building at Salem, tamilnadu, India. The study includes design and analysis of footings, columns, beams and slabs by using two software's named as STAAD.PRO and RCC Design Suit. L.G.Kalurkar: The design and analysis of multistoried G+5 building using composite structure at earthquake zone.

III. CONSIDERATION OF LOADS

A. Dead Loads

The dead load comprises of the weights of walls, partitions, floor finish false, ceilings, false floors and the other permanent constructions in the buildings. The dead loads may be calculated from the dimensions of various members and their unit weights. The unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate maybe taken as 24 kN/m2 and 25 kN/m2 respectively.

B. Imposed Loads

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

C. Seismic Loads

Equivalent Static Analysis: It is one of the methods for calculating the seismic loads. The high rise structures are not considered for the design simple static method. In practical as it does not take into account all the factors that are the importance of the foundation condition. The equivalent static analysis is used to design only for the small structures. In this method only one mode is considered for each direction. The earthquake resistant designing for the low rise structures the equivalent static method is enough. Tall structures are needed more than two modes and mass weight of each story to design earthquake resistant loads. This is not suitable to design those structures and dynamic analysis method to be used for high rise structures.

Response Spectrum Analysis: The seismic forces strikes the foundation of a structure will move with the ground motion. It shows that structure movement is generally more than the ground motion. The movement of the structure as compared to the ground is refused as the dynamic amplification. It depends on the natural frequency of vibration, damping, type of foundation, method of detailing of the structure. The response "design acceleration spectrum" which refers to the max acceleration called spectral acceleration coefficient Sa/g, as a function of the structure for a specified damping ratio for earthquake excitation at the base for a single degree freedom system. The revised IS 1893-2002 uses the dynamic analysis by response spectrum. In this method takes into account all the five important engineering properties of the structures.

- The fundamental natural period of vibration of the building (T in seconds).
- The damping properties of the structure.
- Type of foundation provided for the building.
- Importance factor of the building
- The ductility of the structure represented by response reduction factor.

These loads are horizontal loads caused by the earthquake and shall be computed in accordance with IS 1893. For monolithic reinforced concrete structures located in the seismic zone 2, and 3 without more than 5 storey high and importance factor less than 1, the seismic forces are not critical.

D. Zone Factors For Different Zones In India

TABLE I. Seismic zone factors

Analysis of C+G+7 residential building using STAAD.pro Plan View

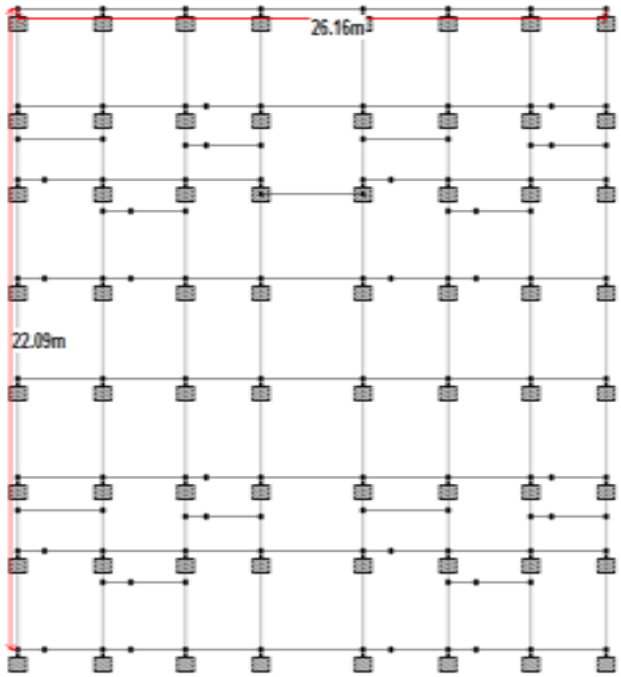

Fig.1.

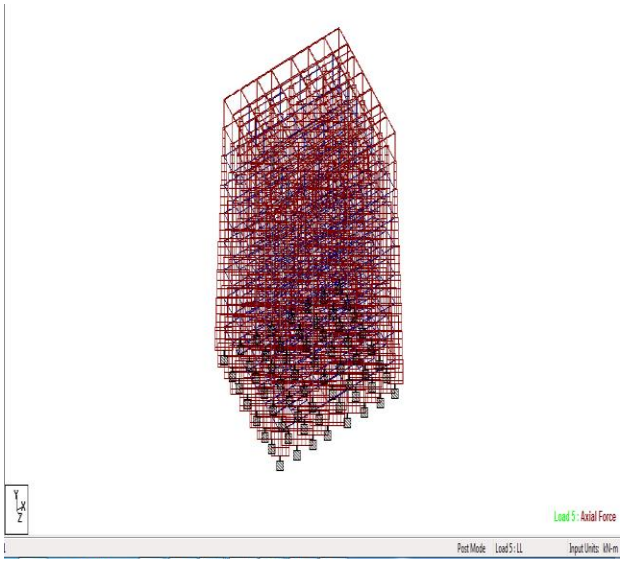

Fig.2.

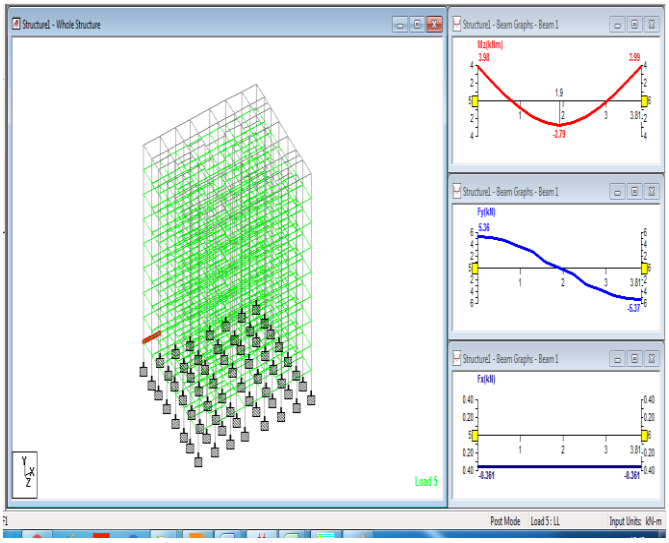

Fig.3.

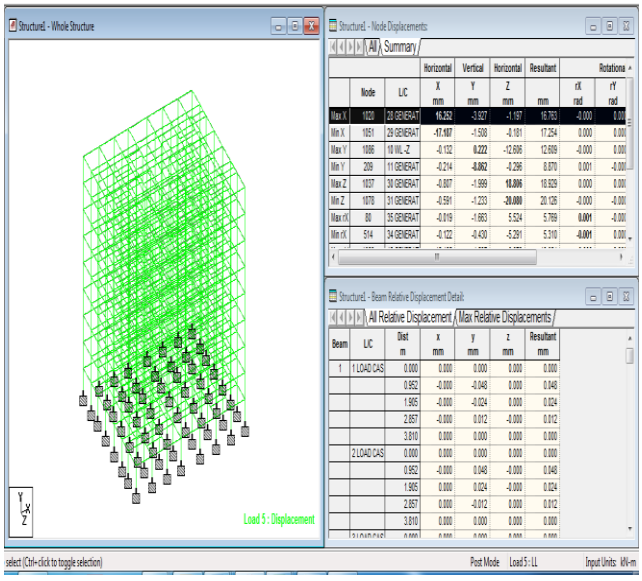

Fig.4.

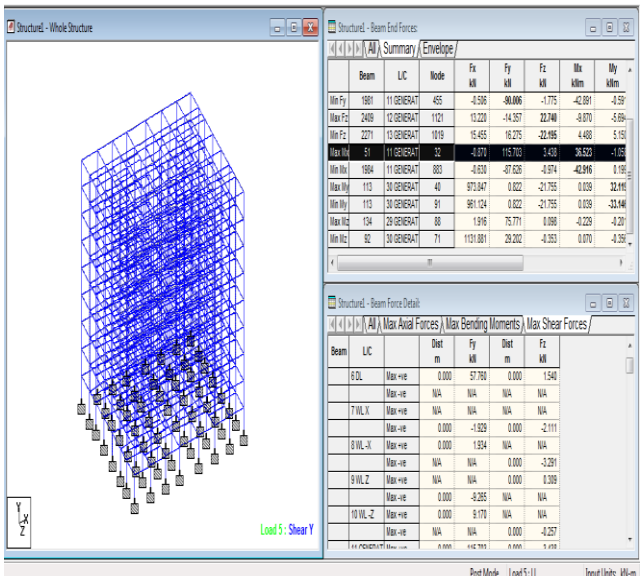

Fig.5.

- Physical parameters of a building are All columns = 0.4 × 0.3 m ,All beams = 0.35 × 0.3 m
- Slabs = 0.15 m thick
- Length = 21m
- Width = 18m
- Height = 3m + 4 storey's @ 3m= 15m (1.0 m parapet being non- structural for seismic purposes, is not considered of building frame height)
- Grade of concrete and steel used M30 concrete and Fe415 steel

Generation of member property can be done in STAAD-Pro by using the window as shown above. The member section is selected and the dimensions have been specified. The beams are having a dimension of 0.35×0.35m and the columns are having a dimension of 0.4×0.3m. The base supports of the structure were assigned as fixed. The supports were generated using the STAAD-Pro support generator. The materials for the structure were specified as concrete with their various constants as per standard IS code of practice. The loadings were calculated partially manually and rest was generated using STAAD-Pro load generator. The loading cases were categorized as:

- **Self-weight:** The self weight of the structure can be generated by STAAD-Pro itself with the self weight command in the load case column.
- **Dead load from slab:** Dead load from slab can also be generated by STAAD-Pro by specifying the floor thickness and the load on the floor per sqm.
- Calculation of the load per sq.m was done considering the weight of beam, weight of column, weight of RCC slab, weight of terracing, external walls, internal walls and parapet over roof.
- **Live load:** The live load considered in each floor and for the terrace level it was considered to be 0.75KN/sq. m. The live loads were generated in a similar manner as done in the earlier case for dead load in each floor. This

may be done from the member load button from the load case column.

- **Load combination:** The structure has been analyzed for load combinations considering all the previous loads in proper ratio. In the first case a combination of self-weight, dead load, live load and wind load was taken into consideration. In the second combination case instead of wind load, seismic load was taken into consideration.

E. Design of C+G+7 Earthquake resistant building using STAAD-Pro

Design Parameters: The structure was designed for concrete in accordance with IS code. The parameters such as clear cover, F_y, F_c, etc were specified. The window shown below is the input window for the design purpose. Then it has to be specified which members are to be designed as beams and which member are to be designed as columns.

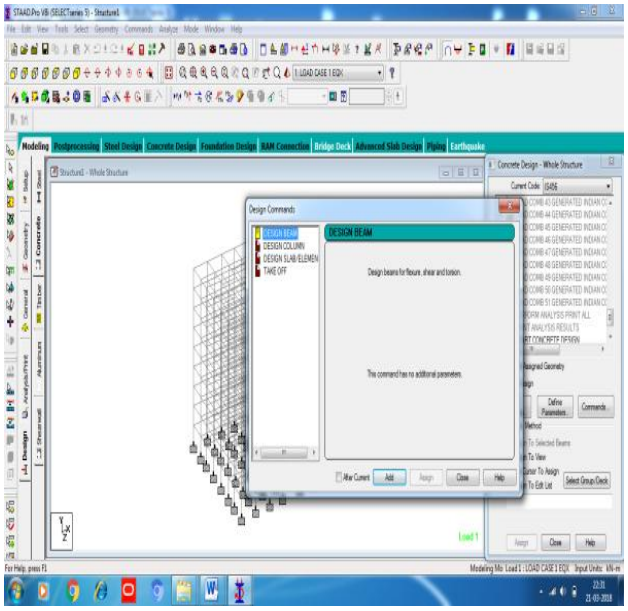

Fig.6.

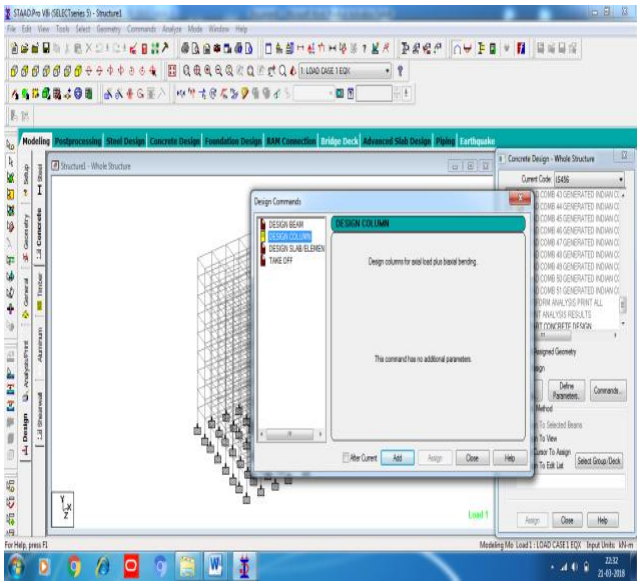

Fig.7.

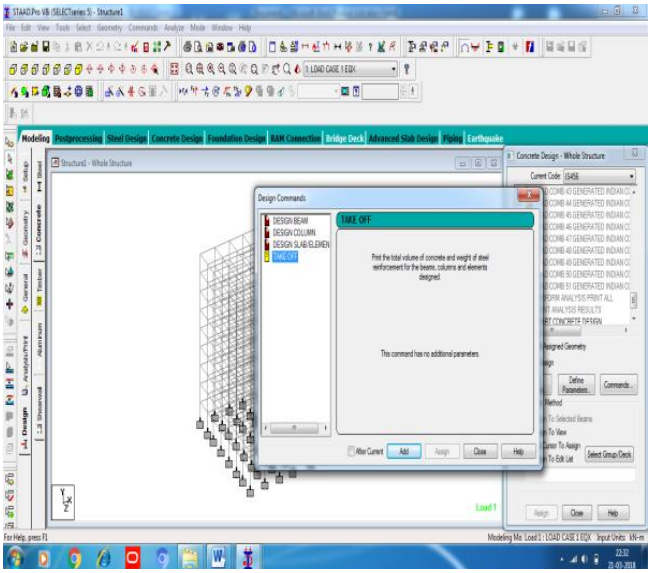

Fig.8.

TABLE I:

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm
Max X	1020	28 GENERATED INDIAN CODE GENRAL_STRUCTURES 18	16.252	-3.927	-1.197	16.763
Min X	1051	29 GENERATED INDIAN CODE GENRAL_STRUCTURES 19	-17.187	-1.508	-0.181	17.254
Max Y	1086	10 WL -Z	-0.132	0.222	-12.606	12.609
Min Y	209	11 GENERATED INDIAN CODE GENRAL_STRUCTURES 1	-0.214	-8.862	-0.296	8.87
Max Z	1037	30 GENERATED INDIAN CODE GENRAL_STRUCTURES 20	-0.807	-1.999	18.806	18.929
Min Z	1078	31 GENERATED INDIAN CODE GENRAL_STRUCTURES 21	-0.591	-1.233	-20.08	20.126
Max rX	80	35 GENERATED INDIAN CODE GENRAL_STRUCTURES 25	-0.019	-1.663	5.524	5.769
Min rX	514	34 GENERATED INDIAN CODE GENRAL_STRUCTURES 24	-0.122	-0.43	-5.291	5.31
Max rY	1063	12 GENERATED INDIAN CODE GENRAL_STRUCTURES 2	12.185	-4.597	-0.079	13.024
Min rY	1019	13 GENERATED INDIAN CODE GENRAL_STRUCTURES 3	-13.136	-6.291	-0.479	14.573
Max rZ	1007	11 GENERATED INDIAN CODE GENRAL_STRUCTURES 1	-0.453	-6.192	-0.137	6.211
Min rZ	1008	11 GENERATED INDIAN CODE GENRAL_STRUCTURES 1	-0.442	-8.289	-0.47	8.314
Max Rst	1122	34 GENERATED INDIAN CODE GENRAL_STRUCTURES 24	-0.472	-5.913	-19.922	20.786

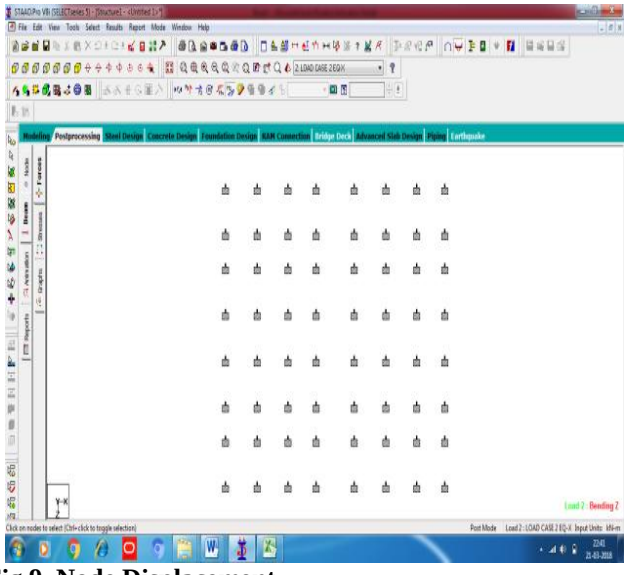

Fig.9. Node Displacement.

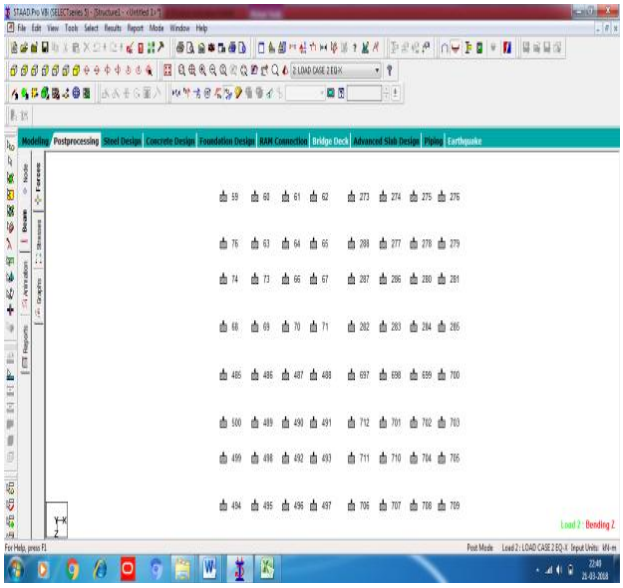

Fig.10. Support Reaction.

TABLE II:

			Horizontal	Vertical	Horizontal
	Node	L/C	Fx kN	Fy kN	Fz kN
Max Fx	68	32 GENERATED INDIAN CODE GENRAL_STRUCTURES 22	36.261	988.346	-3.065
Min Fx	281	33 GENERATED INDIAN CODE GENRAL_STRUCTURES 23	-28.118	341.49	0.167
Max Fy	67	11 GENERATED INDIAN CODE GENRAL_STRUCTURES 1	1.884	1717.313	4.025
Min Fy	496	10 WL -Z	0.091	-60.649	17.255
Max Fz	62	34 GENERATED INDIAN CODE GENRAL_STRUCTURES 24	-1.519	1015.878	36.539
Min Fz	497	35 GENERATED INDIAN CODE GENRAL_STRUCTURES 25	2.2	469.592	-31.417
Max Mx	287	34 GENERATED INDIAN CODE GENRAL_STRUCTURES 24	-2.173	713.023	29.274
Min Mx	71	30 GENERATED INDIAN CODE GENRAL_STRUCTURES 20	-0.353	1131.881	-29.202
ax My	494	35 GENERATED INDIAN CODE GENRAL_STRUCTURES 25	2.451	250.234	-16.959
Min My	494	31 GENERATED INDIAN CODE GENRAL_STRUCTURES 21	2.582	96.774	13.802
Max Mz	282	33 GENERATED INDIAN CODE GENRAL_STRUCTURES 23	-25.563	668.377	-0.466
Min Mz	68	32 GENERATED INDIAN CODE GENRAL_STRUCTURES 22	36.261	988.346	-3.065

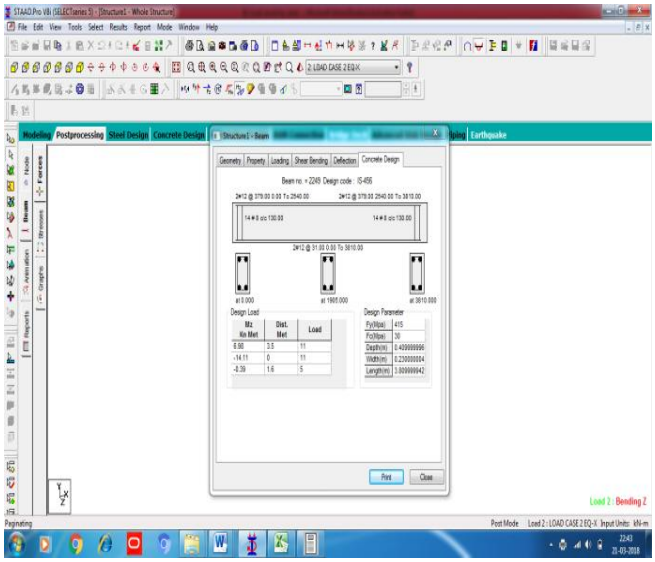

Fig.11. Beam Design.

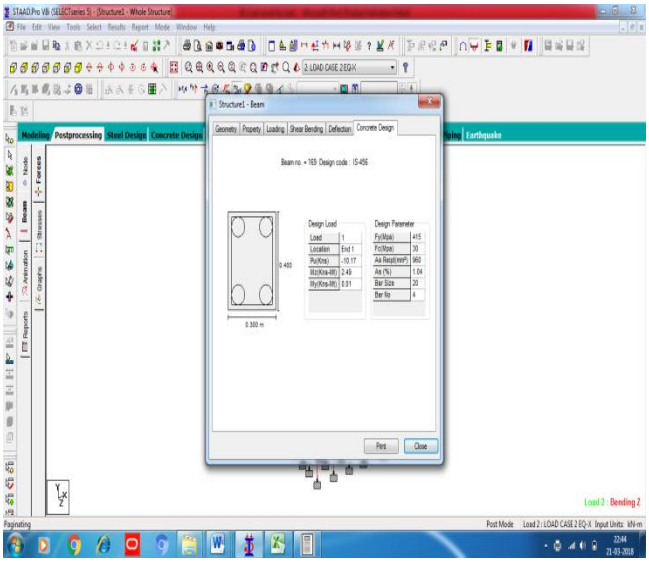

Fig.12. Column Design.

IV. CONCLUSION

STAAD-PRO has the capability to calculate the re inforcement needed for any concrete section. The program contains a number of parameters which are designed as per IS: 456(2000). Beams are designed for flexure, shear and torsion.

A. Design for Flexure

Maximum sagging (creating tensile stress at the bottom face of the beam)and hogging (creating tensile stress at the top face) moments are calculated for all active load cases at each of the above mentioned sections. Each of these sections are designed to resist both of these critical sagging and hogging moments. Where ever the rectangular section is in adequate as singly reinforced section, doubly reinforced section is tried.

B. Design for Shear

Shear reinforcement is calculated to resist both shear forces and torsion moments. Shear capacity calculation at different sections without the shear reinforcement is based on the actual tensile reinforcement provided by STAAD program. Two-legged stirrups are provided to take care of the balance shear forces acting on these sections.

C. Beam Design Output

The default design output of the beam contains flexural and shear reinforcement provided along the length of the beam.

D. Column Design

Columns are designed for axial forces and biaxial moments at the ends. All active load cases are tested to calculate reinforcement. The loading which yield maximum reinforcement is called the critical load. Column design is done for square section. Square columns are designed with reinforcement distributed on each side equally for the sections under biaxial moments and with reinforcement distributed equally in two faces for sections under uni-axial

moment. All major criteria for selecting longitudinal and transverse reinforcement as stipulated by IS: 456 have been taken care of in the column design of STAAD-pro.

V. REFERENCES

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