DESIGN AND ANALYSIS OF RESIDENTIAL BUILDING C+G+7 USING STAAD.PRO

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Abstract : The project comprises the development of plans, elevations, and sectional view of a Residential Reinforced Concrete building of ground floor, using Auto-cad 2008. Structural loads (Gravitational loads only), Dead and Live loads are only considered for the design of structure, and the loads considered are as per IS: 875 – Part-I & II. The analysis and design of the building skeletal fame is performed by using STAAD Pro V8i package for factored (Limit state of strength) combination(s). The structural displacements in vertical and horizontal directions of the building are permitted to the limitations as per IS: 456 – 2000, for un-factored (Limit state of serviceability) combination(s). Structural elements like Slab(s) and Footing(s) are designed manually using MS Excel. The reinforcement details are furnished according to the Codal provisions and presented in this report.

1.0 INTRODUCTION
ABOUT STAAD PRO

STAAD Pro is a Structural Analysis and design computer program originally developed by Research Engineers International in Yorba Linda, CA. In late 2005, Research Engineer International was bought by Bentley Systems.
STAAD Pro allows structural engineers to analyze and design virtually any type of structure through its flexible modelling environment, advanced features and fluent data collaboration.
STAAD Pro is one of the leading structural analysis and design software which supports more than 100 steel, concrete and timber design codes and has the largest worldwide user base.
It can make use of various forms of analysis from the traditional 1st order static analysis, 2nd order p-delta analysis, geometric nonlinear analysis or a buckling analysis. It can also make use of various forms of dynamic analysis from modal extraction to time history and response spectrum analysis.
In recent years it has become part of integrated structural analysis and design solutions mainly using an exposed API called Open STAAD to access and drive the program using an VB macro system included in the application or other by including Open STAAD functionality in applications that themselves include suitable programmable macro systems. Additionally, STAAD Pro is added direct links to applications such as RAM Connection and STAAD Foundation to provide engineers working with those applications which handle design post processing not handled by STAAD Pro itself. Another form of integration supported by STAAD Pro is the analysis schema of the CIM steel Integration Standard, version 2 commonly known as CIS/2 and used by a number modelling and analysis applications.

Behavior of the Structure:

The building and other structure are composed of horizontal and vertical structural elements that resist lateral forces. The horizontal elements, diaphragms and horizontal bracings are used to distribute the lateral forces to vertical elements. The vertical elements that are used to transfer lateral forces to the ground are shear wall, braced frames and moment resisting frames. The structure must include complete lateral and vertical force resisting systems, capable of providing adequate energy dissipation capacity to withstand the design ground motions within the prescribed limits, deformations and strength demand.

Motivation:

Day to day variations in the designing of the structures we were motivated to deal with this project. As civil engineering is much concerned with different designs to meet the necessity of human life, we took this project.

Problem definition:

As the land is con sized to meet the demands of all the growing population the adoption of multi storied had grown up to meet their demands. As it is cost effective. Many of Rc building constructed recent times have special feature of the ground is left open for the purpose of parking, i.e. columns in the ground story do not have any partition walls of either masonry or RC between them.

Objectives of project:

Carrying out a complete design of the main structural elements of a multi – storied building including slabs, beams, columns and footing. Getting real life experience with the engineering practices.

Structure should be so arranged that it can transmit dead, wind and imposed loads in a direct manner to the foundations. The general arrangement should ensure a robust and stable structure that will not collapse progressively under the effects of misuse or accidental damage to any one element.

Limitations of project:

- Depending on the site area the number of floors is limited.
- Designing is completely based on IRC codes.
- Once the structure is designed completely minor changes are accepted in site with cost consideration.
- If once the structure is designed for one purpose it cannot be used for other purpose if the load acting on it is increased than the designed.

STEEL REINFORCEMENT

Steel bars are essentially used in the tension zone of flexural members of concrete to resist the tensile stresses as concrete is weak in tension and in compression members to increase the load carrying capacity.

Steel is used as reinforcement to take up the tensile stresses in RCC construction the following reasons,

- Its tensile strength is high
- It can develop good bond with concrete
- Its coefficient of expansion is nearly same as for concrete
- It is easily available

FUNCTIONS OF REINFORCEMENT IN RCC

The reinforcement in RCC serves the following different types of functions,

- To resist the bending tension in flexural members like slabs, beams and walls of water tanks etc.
- To increase the load carrying capacity of compression members like columns
- To resist diagonal tension due to shear.
- To resist the effects of secondary stresses like temperature etc.
- To reduce the shrinkage of concrete.
- To resist spiral cracking due to torsion
- To prevent the development of wide cracks in concrete due to tensile strain.

TYPES OF REINFORCEMENT

Reinforcing steel consists of bars usually circular in cross section. The following four types of steel reinforcement are generally used in reinforced concrete construction.

- Mild steel and medium tensile steel bars conforming to IS 432 (part I)
- High yield strength deformed steel bars (HYSD bars) conforming to IS 1566
- Steel wire fabric conforming to IS 1566
- Structural steel conforming to Grade A of IS 2062

All reinforcement shall be free from loose mill scale, loose rust, oil, mud, and any other substances which reduces bond between steel and concrete. The grades of steel normally used for reinforcement are Fe 250, Fe 415, and Fe 500. Fe refers to ferrous metal and the number following it refers to specified yield strength in N/mm2.

2.0 LITERATURE REVIEW

Chandurkar, Pajgade (2013) evaluated the response of a 10-story building with seismic shear wall using Staad Pro V8i Main focus was to compare the change in response by changing the location of shear wall in the multi-story building. Four models were studied- one being a bare frame structural system and rest three were of dual type structural system. The results were excellent for shear wall in short span at corners. Larger dimension of shear wall was found to be ineffective in 10 or below 10 stories. Shear wall is an effective and economical option for high-rise structures. It was observed that changing positions of shear wall was found to attract forces, hence proper positioning of shear wall is vital. Major number of horizontal forces were taken by shear wall when the dimension is large. It was also observed that shear walls at substantial locations reduced displacements due to earthquake.

Viswanath K.G (2010) investigated the seismic performance of reinforced concrete buildings using concentric steel bracing. Analysis of a four, eight, twelve and sixteen storied building in seismic zone IV was done using Staad Pro software, as per IS 1893: 2002 (Part-I). The bracing was provided for peripheral columns, and the effectiveness of steel bracing distribution along the height of the building, on the seismic performance of the building was studied. It was found that lateral displacements of the buildings reduced after using X-type bracings. Steel bracings were found to reduce flexure and shear demand on the beams and columns and transfer lateral load by axial load mechanism. Building frames with X- type bracing were found to have minimum bending as compared to other types of bracing. Steel bracing system was found to be a better alternative for seismic retrofitting as they do not increase the total weight of the building significantly.

Chavan, Jadhav (2014) studied seismic analysis of reinforced concrete with different bracing arrangements by equivalent static method using Staad Pro. Software. The arrangements considered were diagonal, V-type, inverted V-type and X-type. It was observed that lateral displacement reduced by 50% to 60% and maximum displacement reduced by using X-type bracing. Base shear of the building was also found to increase from the bare frame, by use of X-type bracing, indicating increase in stiffness.

Esmaili et al. (2008) studied the structural aspect of a 56 stories high tower, located in a high seismic zone in Tehran. Seismic evaluation of the building was done by non-linear dynamic analysis. The existing building had main walls and its side walls as shear walls, connected to the main wall by coupling of beams. The conclusion was to consider the time-dependency of concrete. Steel bracing system should be provided for energy absorption for ductility, but axial load can have adverse effect on their performance. It is both conceptually and economically unacceptable to use shear wall as both gravity and bracing system. Confinement of concrete in shear walls is good option for providing ductility and stability.

Akbari et al. (2015) assessed seismic vulnerability of steel X-braced and chevron-braced Reinforced Concrete by developing analytical fragility curve. Investigation of various parameters like height of the frame, the p-delta effect and the fraction of base shear for the bracing system was done. For a specific designed base shear, steel-braced RC dual systems have low damage probability and larger capacity than unbraced system. Combination of stronger bracing and weaker frame reduces the damage probability on the entire system. Irrespective of height of the frame, Chevron braces are more effective than X-type bracing. In case of X-type bracing system, it is better to distribute base shear evenly between the braces and the RC frame, whereas in case of Chevron braced system it is appropriate to allocate higher value of share of base shear to the braces. Including p-delta effect increases damage probability by 20% for shorter dual system and by 100% for taller dual systems. The p-delta effect is more dominant for smaller PGA values.

Kappos, Manafpour (2000) presented new methodology for seismic design of RC building based on feasible partial inelastic model of the structure and performance criteria for two distinct limit states. The procedure is developed in a format that can be incorporated in design codes like Euro code 8. Time-History (Non-linear dynamic) analysis and Pushover analysis (Non-linear Static analysis) were explored. The adopted method showed better seismic performance than standard code procedure; at least in case of regular RC frame building. It was found that behavior under "life-safety" was easier to control than under serviceability earthquake because of the adoption of performance criteria involving ductility requirements of members for "life-safety" earthquake.

3.0 MODEL GENERATION

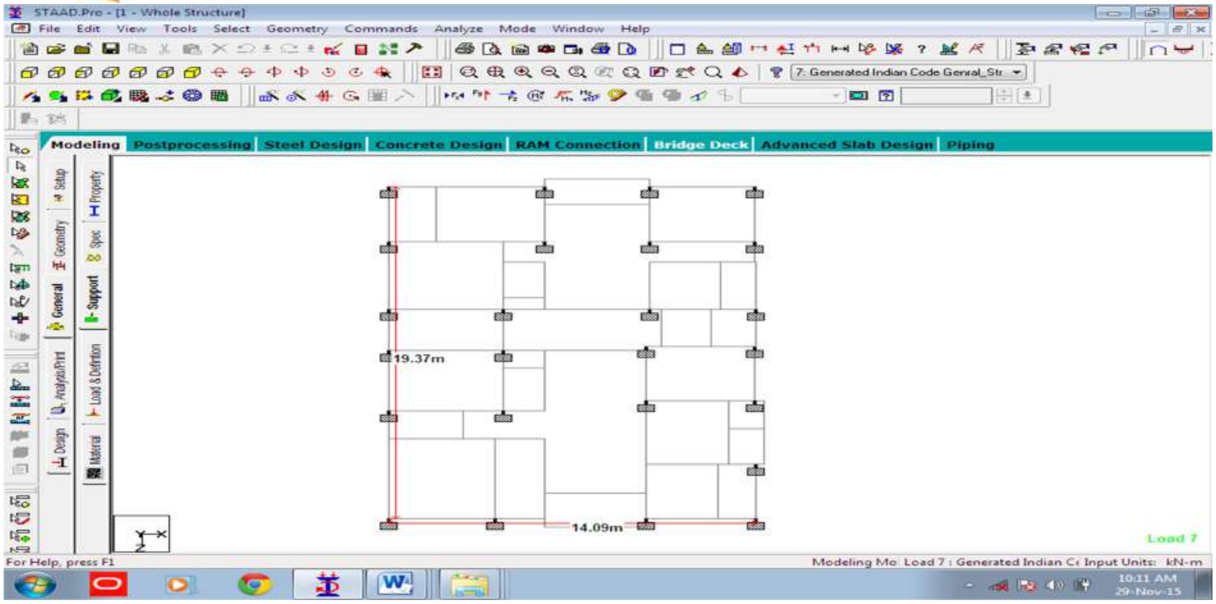
STATEMENT OF THE PROJECT:

SAILENT FEATURES:

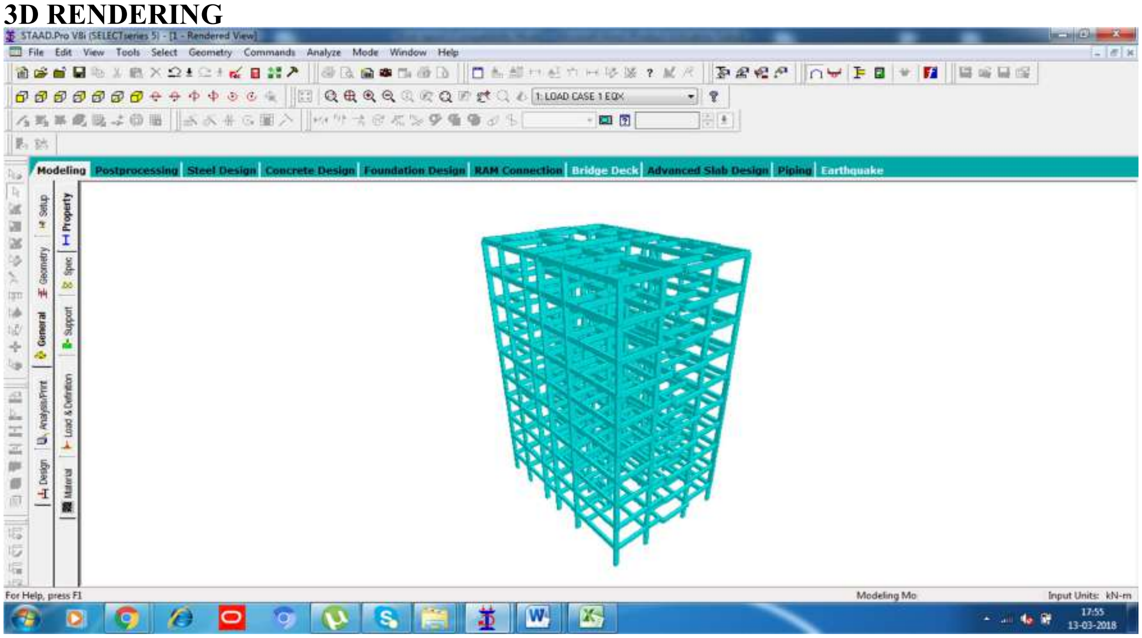
Utility of Building : Residential
No. Of Floors : C+ G+7 floors
Shape of Building : Rectangular
Type of Construction : R.C.C framed structure
Type of Walls : Brick walls 115 and 230mm
Geometric details

Length of the building: 14.09 m
Width of the building : 19.37 m
Floor height : 3.0m
Founding depth : 2.5 m (From N.G.L)
Materials:
Concrete : M25
Steel grade : Fe415

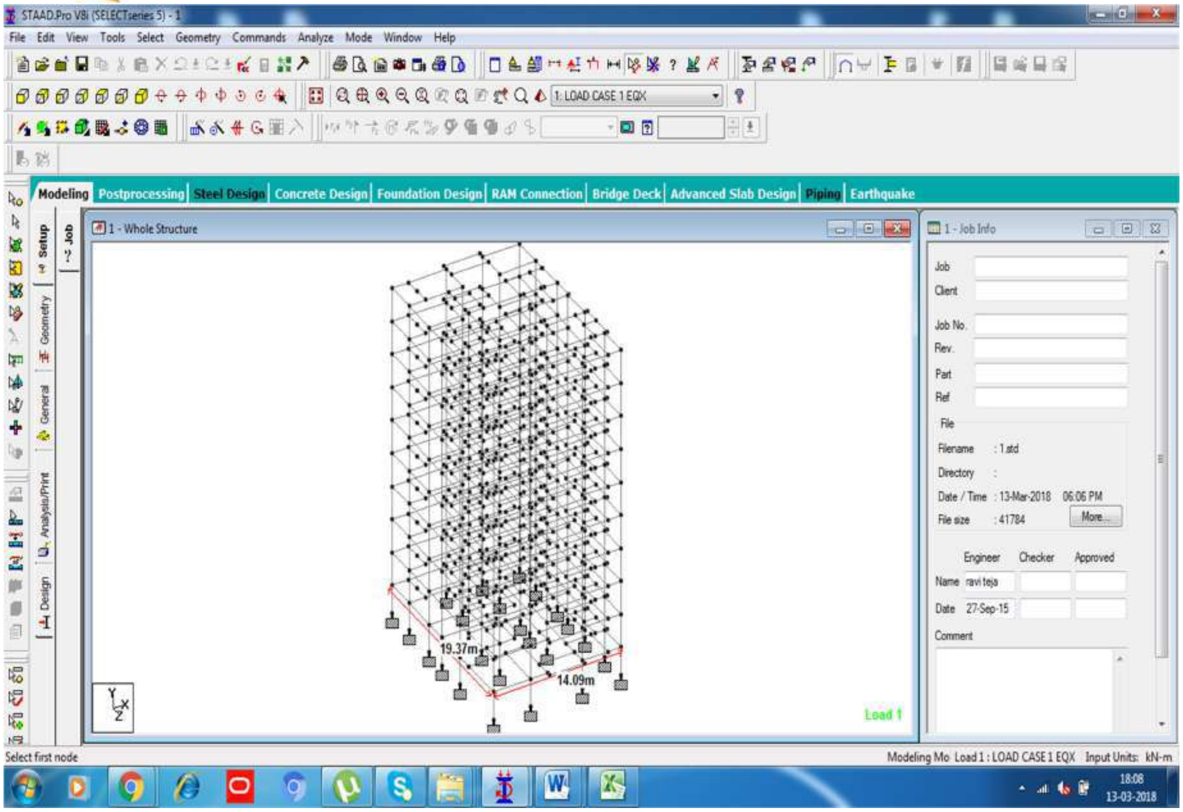
PLAN OF THE STRUCTURE



3D RENDERING



ISOMETRIC VIEW OF BUILDING



MATERIAL PROPERTIES

Material	Property	Value	Units	Remarks
Concrete, M25	Density	25	kN/ m3	IS : 875 Part - 1
	Characteristic Strength	25	N/ mm2	IS: 456 :2000
	Modulus of Elasticity	25000	N/ mm2	IS:456 :2000
Reinforcing Steel	Density	78.5	kN/ m3	IS : 875 Part - 1
	Characteristic Strength	415	N/ mm2	IS:800 - 2007
	Modulus of Elasticity	200000	N/ mm2	IS:800 - 2007

4.0 ANALYSIS OF C+ G+7 BUILDING

IS 1893:2002 CODAL PROVISIONS

LOADS

The reinforced concrete structures are designed to resist the following types of loads.

Dead load

Dead loads are permanent or stationary loads which are transferred to the structure throughout their life span. Dead loads mainly cause due to self-weight of structural members, permanent partitions, fixed equipment's and fittings. These loads shall be calculated by estimating the quantity of each material and them multiplying it with the unit weight. The unit weights of various materials used in building construction are given in the code IS 875 (part -1) -1987. The unit weight of commonly used building materials are given below:

RC PROPERY:
Column Size: 300x420 mm
Beam Size: 300x450 mm
Table : Unit weight of common building materials

s.no.	Material	Unit weight KN/m3
1	Plain concrete	24
2	Reinforced concrete	25
3	Brick masonry, cement plaster	20
4	Stone masonry	24
5	Wood	8
6	Steel	78.5
7	Floor finish	0.6-1.2

Load calculations
Self - weight of Slab load:
Floor loads for 120mm thick slab
Thickness of slab -120mm
Unit weight of reinforced concrete - 25.00kn/m3
= 0.12 x 1x 25
= 3.0 KN/m2
Dead load of slab = 3.0kn/m2
Floor finishes = 1.50kn/ m2
= 3.0 x 1. 5
= 4.5KN/m2
Roof Finishing: 1.0 KN/Sq.m
Total load of slab = 8.5kn/ m2
Self-weight of Beam Load:
Beam Size- 300x450mm
Unit weight of reinforced concrete - 25.00kn/m3
= 0.3 x 0.45 x 25
= 3.375Kn/m3
Wall loads
External Wall
230mm thick wall for 3.0 heights
Thickness of wall 'b' - 0.23m
Height of walls 'h' – 2.7mm
Unit weight of brick masonry γ - 19.2kN/m3
= 0.23 x 2.7 x 19.2
Total load h*b* γ = -11.9 kN/m3
Internal or Partition Walls
150mm thick wall for height 3.0m
Thickness of wall 'b' - 0.12m
Height of walls 'h' - 2.7m
Unit weight of brick masonry 'γ' - 19.2kN/m3
= 0.12 x2.7x 19.2
Total load h*b* γ = -5.912 kN/m3
Parapet & Balcony wall load
Thickness of wall 'b' - 0.115m

Parapet wall ‘h’ - 1.00m
Unit weight of brick masonry ‘γ’ - 19.20kn/m3
= 0.115 x 1 x 19.2
Total load h*b* γ = 2.208 kn/m3

Live loads (or) imposed loads:

These are the loads that changes with time. Live loads or imposed loads include loads due to the people occupying the floor, weight of movable partitions, weight of furniture and materials. The live loads to be taken in design of buildings have been given in IS: 875 (part-2) -1987. Some of the common live loads used in the design of buildings are given below:

Live loads are either movable or moving loads without any acceleration or impact. There are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc. The floor slabs have to be designed to carry either uniformly distributed loads or concentrated loads whichever produce greater stresses in the part under consideration.

Since it is unlikely that any one particular time all floors will not be simultaneously carrying maximum loading, the code permits some reduction in imposed loads in designing columns, load bearing walls, piers supports and foundations.

Live load as per Code IS: 875 (Part-2)
Patient rooms 4.000kn/ m2
Stair case, corridor 3.000kn/ m2
Terrace, portico 2.000kn/ m2

Live loads on floors (IS 875, part-2)

S.no.	Type of floor	Minimum live load KN/m^2
1	Floors in dwelling houses, tenants, hospital wards, hostels.	2.0
2	Office floor other than entrance halls, floors of light	2.5-4.0 (2.5 when separate storage work rooms facility is provided, other wise 4.0
3	Floors of banking halls, office entrance halls and reading rooms	3.0
4	Shops, educational buildings, assembly buildings, restaurants	4.0
5	Office floors for storage, assembly floor space without fixed seating, public rooms in hotels, dance halls and waiting halls	5.0
6	Ware houses, shops and factories • Light weight loads • Medium weight loads • Heavy weight loads	 5.0 7.5 10.0
7	Garages (light –handling vehicles of weight<25 KN) Garages (heavy-vehicles of weight >25 KN)	4.0 7.5
8	Stairs, landings, balconies and corridors for floors mentioned in 1, but not liable to	3.0

	overcrowding stairs, landings and corridors for floors mentioned in 1, but liable to overcrowding and for all other floors	5.0
9	Flat slabs, sloped roofs • Access provided • Access not provided	 1.5 0.75

Wind loads:

The horizontal load caused by the wind is called as wind loads. It depends up on the velocity of wind and shape and size of the building. Complete details of calculating wind loads on structures are given in IS 875(part -3)-1987.

Wind load is primarily horizontal load caused by the movement of air relative to earth. Wind load is required to be considered in design especially when the heath of the building exceeds two times the dimensions transverse to the exposed wind surface. For low rise building say up to four to five storeys, the wind load is not critical because the moment of resistance provided by the continuity of floor system to column connection and walls provided between columns are sufficient to accommodate the effect of these forces. Further in limit state method the factor for design load is reduced to 1.2 (DL+LL+WL) when wind is considered as against the factor of 1.5(DL+LL) when wind is not considered. IS 1893 (part 3) code book is to be used for design purpose.

Design Wind Speed Vz = Vb x K1 x K2 x K3

Where

Vb- Design Wind speed

K1- Probability factor

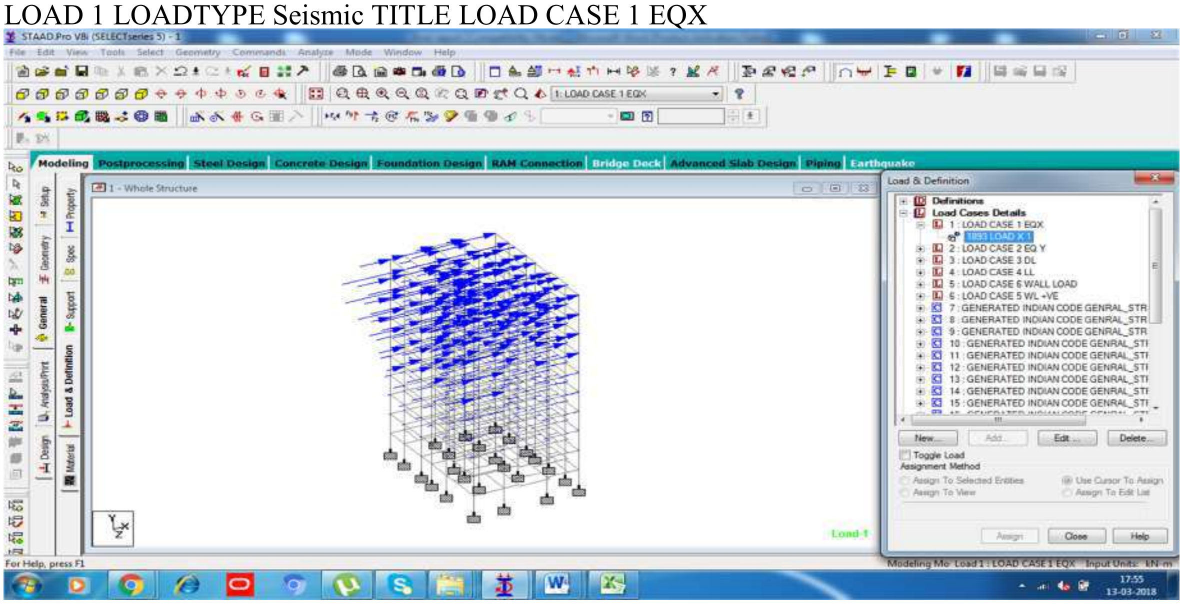
K2 – Terrain factor

K3- Topography Factor

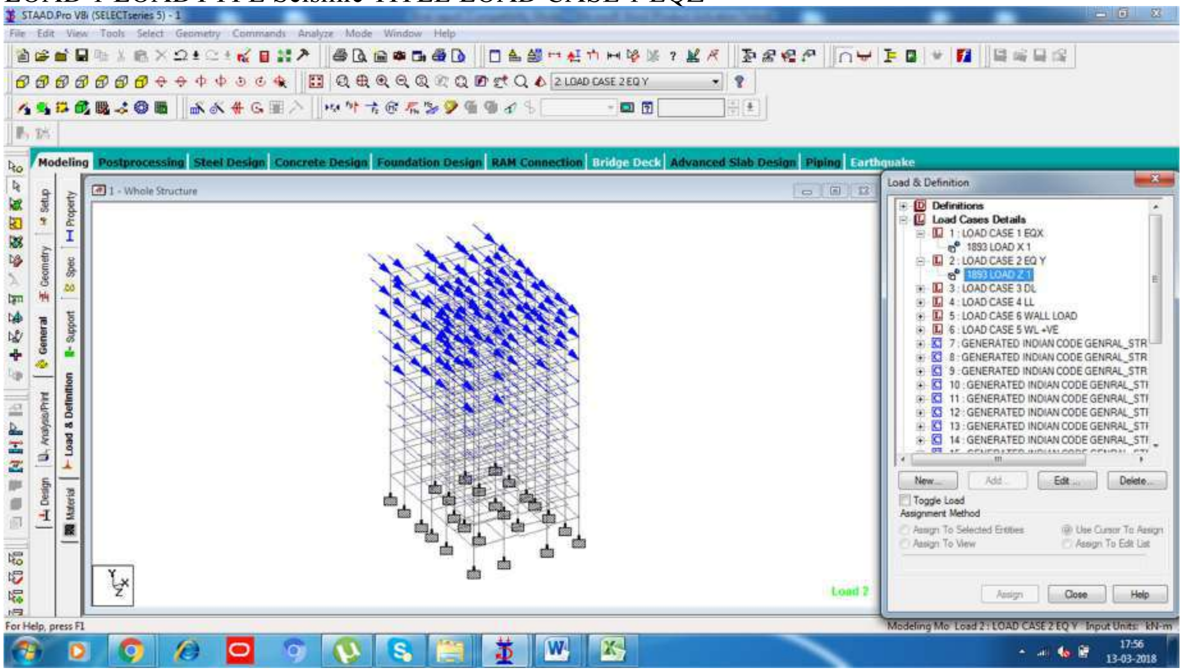
Exposure factor is -1.0 (As per code)

ANALYSIS OF STRUCTURAL FRAME

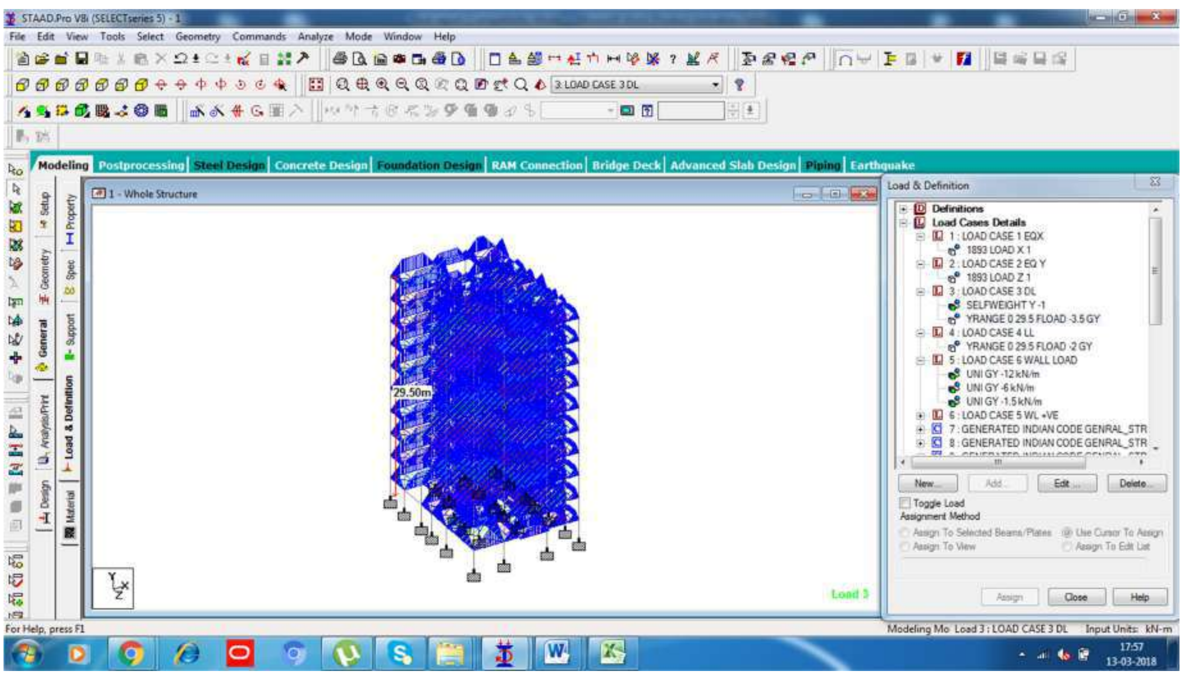
LOAD 1 LOADTYPE Seismic TITLE LOAD CASE 1 EQX



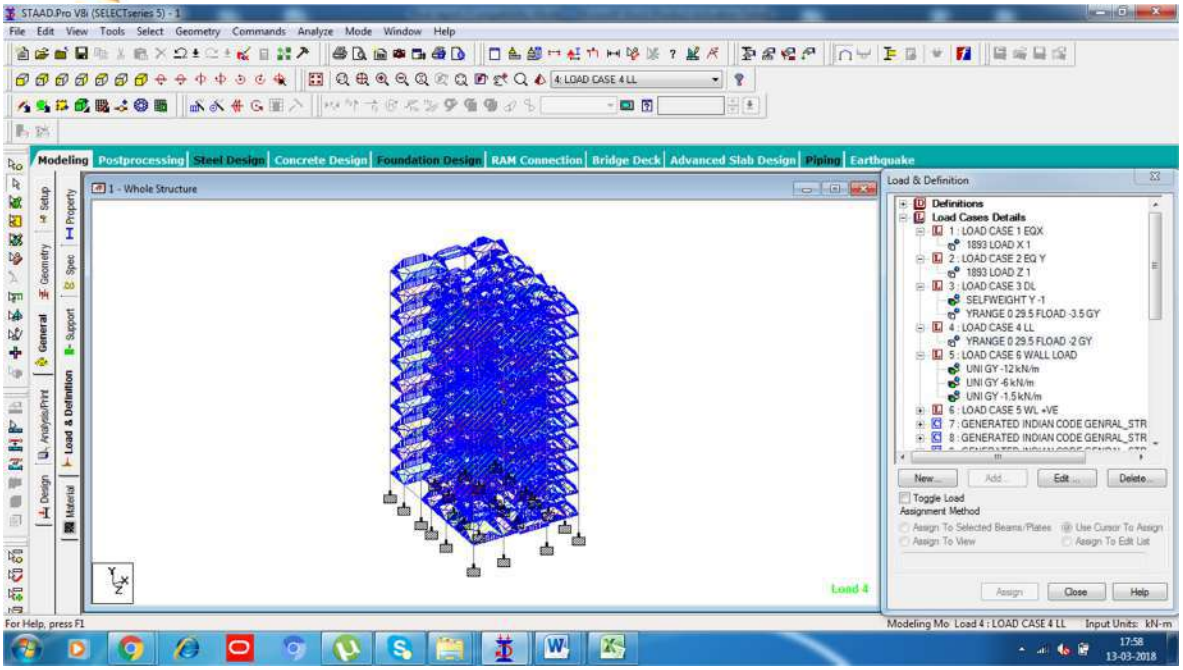
LOAD 1 LOADTYPE Seismic TITLE LOAD CASE 1 EQZ



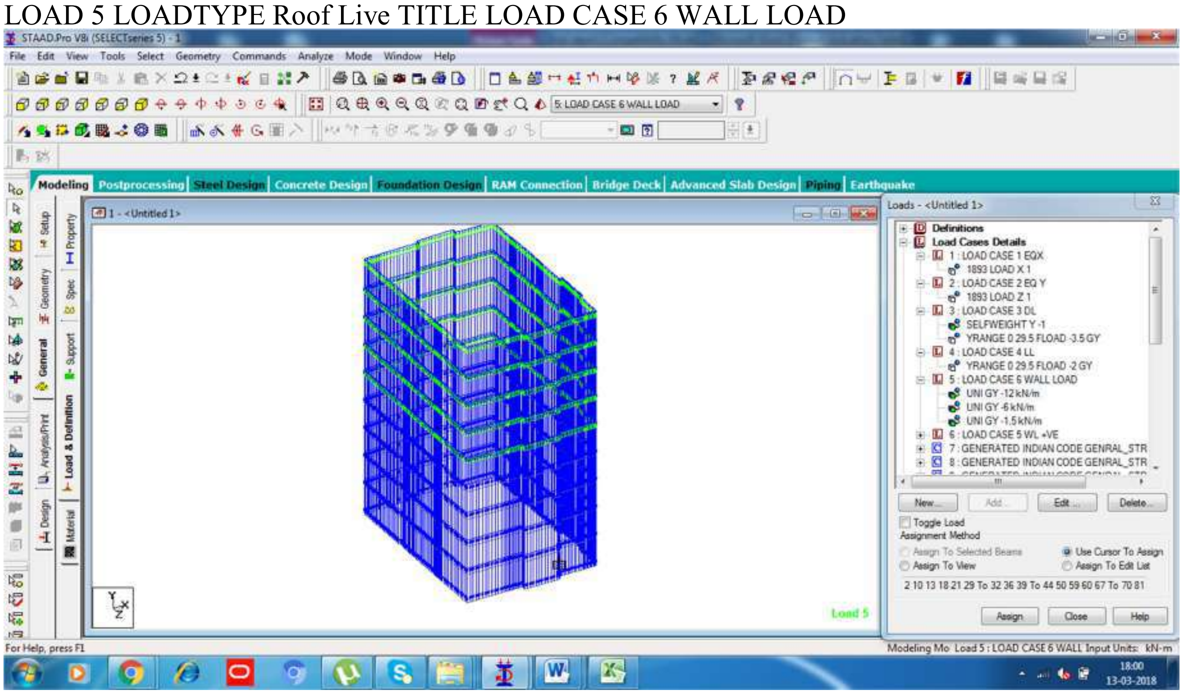
LOAD 3 LOADTYPE Dead TITLE LOAD CASE 3 DL



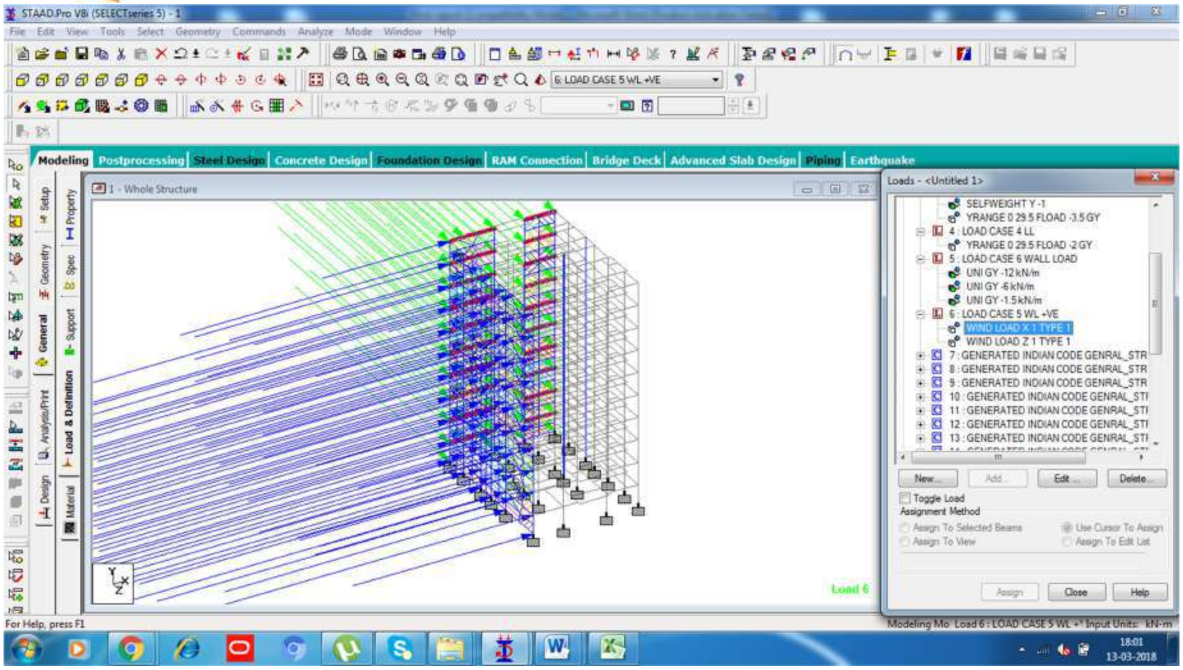
LOAD 4 LOADTYPE Live TITLE LOAD CASE 4 LL



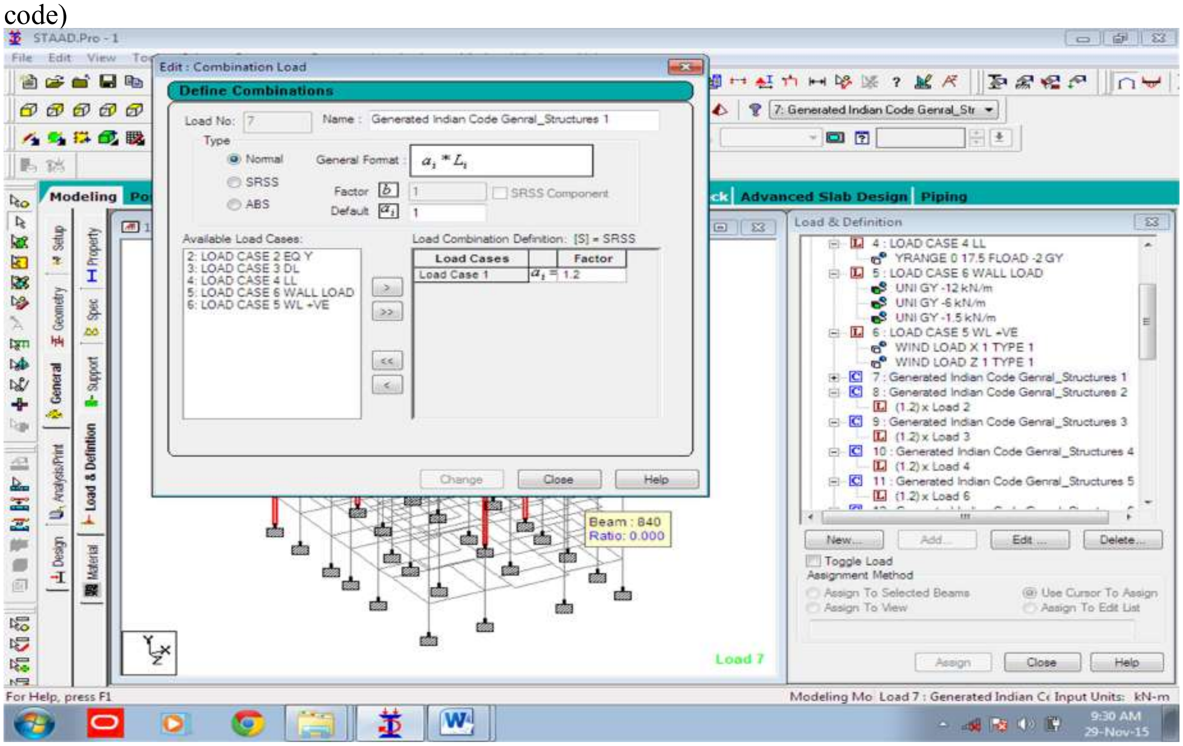
LOAD 5 LOADTYPE Roof Live TITLE LOAD CASE 6 WALL LOAD



LOAD 6 LOADTYPE Wind TITLE LOAD CASE 5 WL +VE



LOAD COMB 7 Generated Indian Code Genral_Structures 1 1 1.2 (Autoload combination Indian code)



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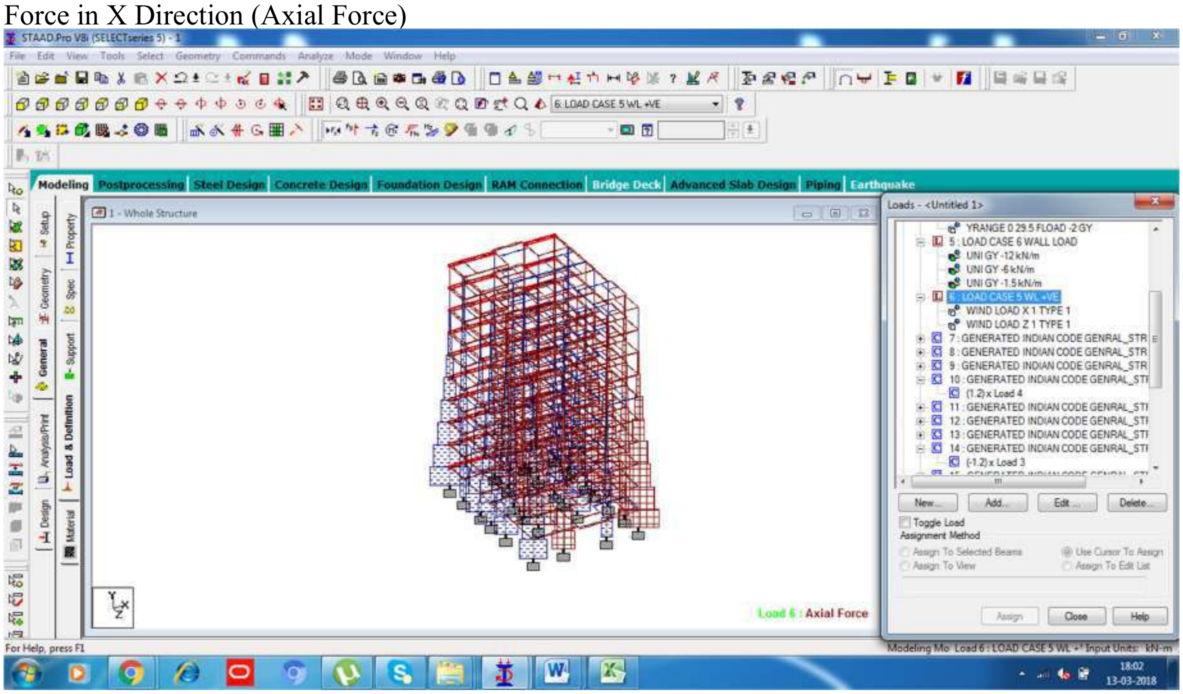
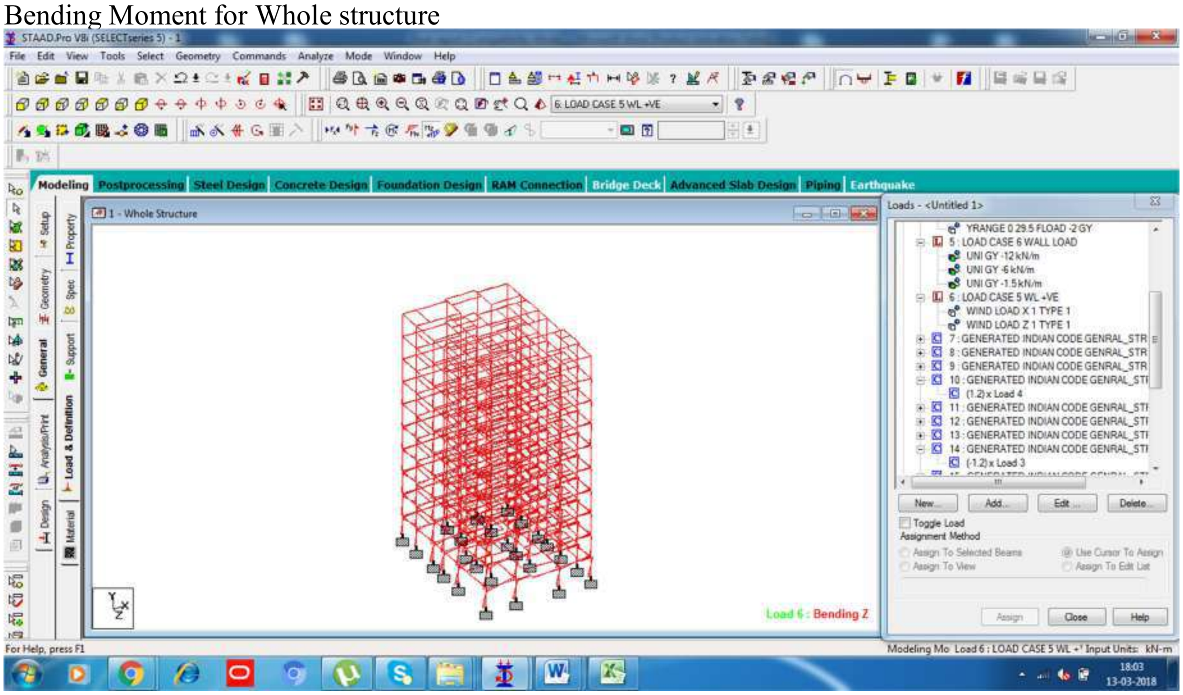
RESULTS

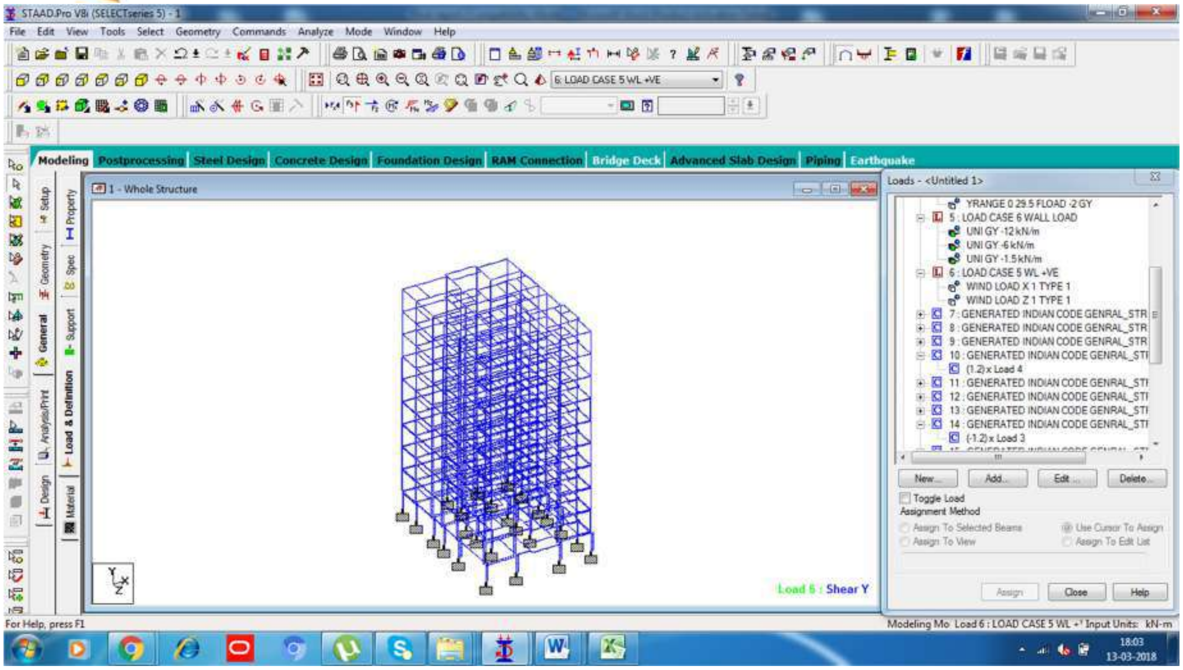
Force in X Direction (Axial Force)



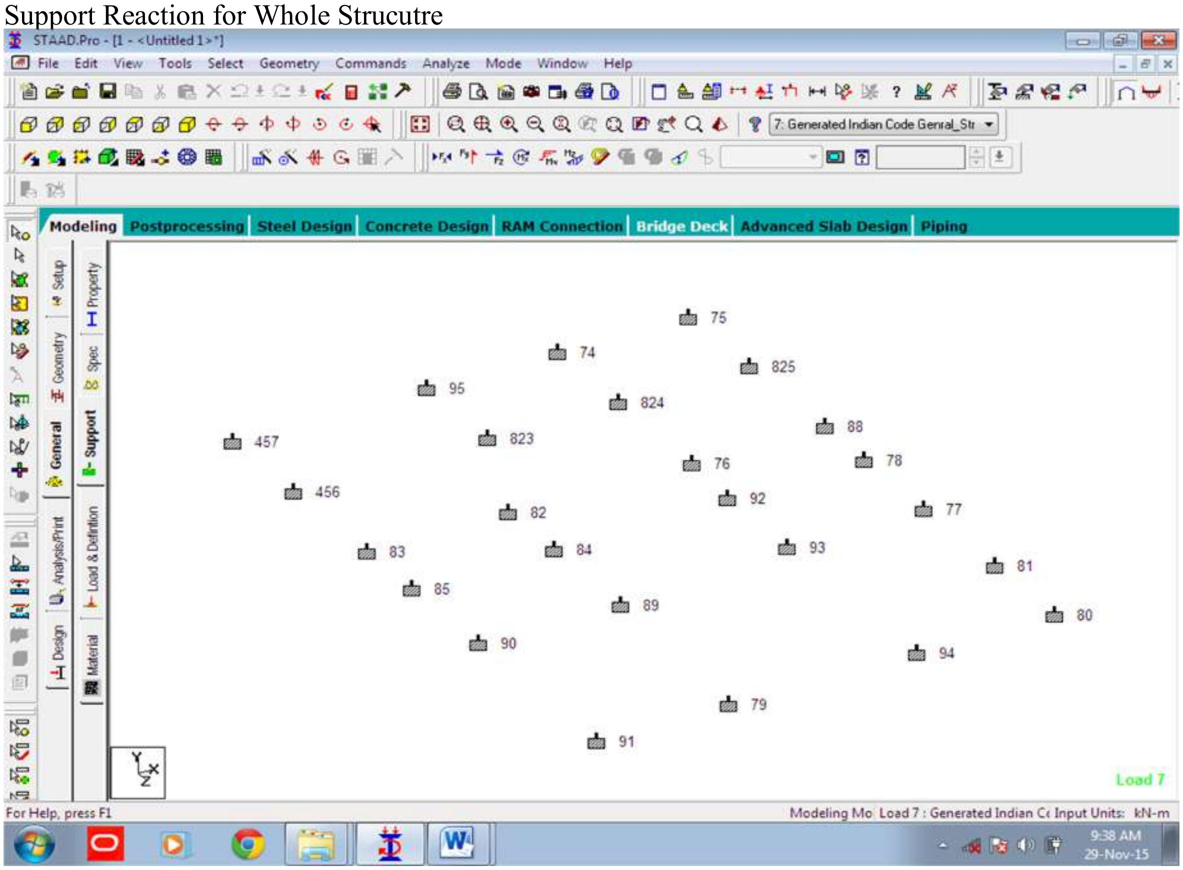
Bending Moment for Whole structure



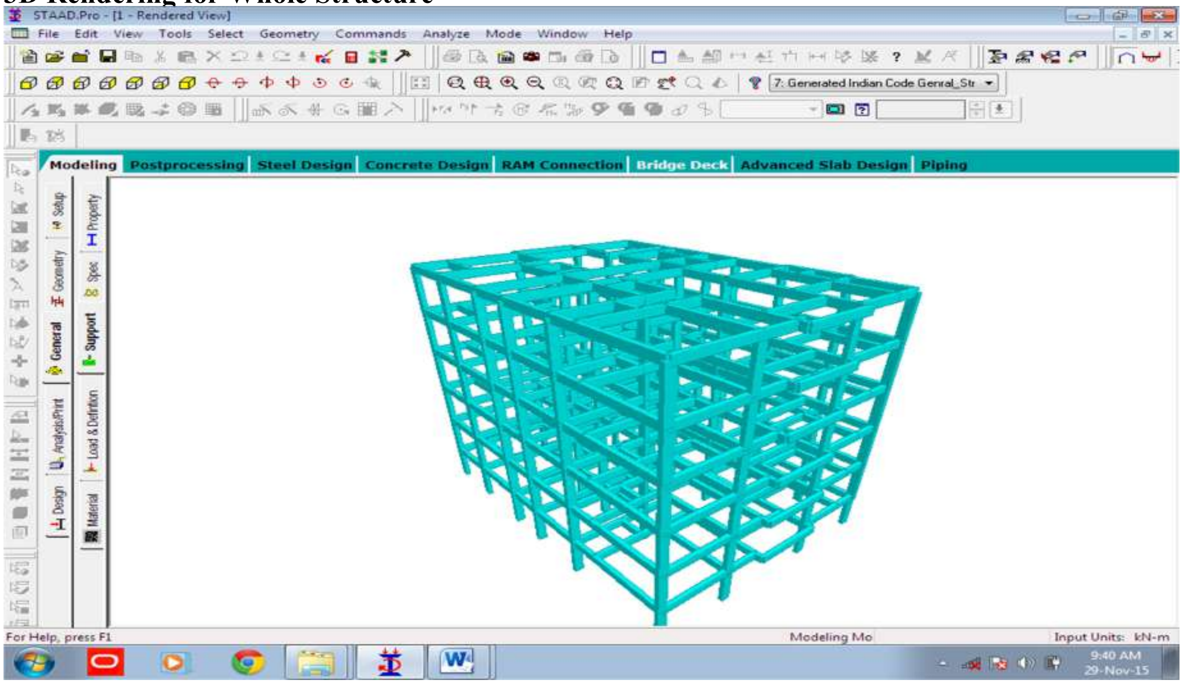
Shear force Moment for Whole structur



Support Reaction for Whole Strucutre

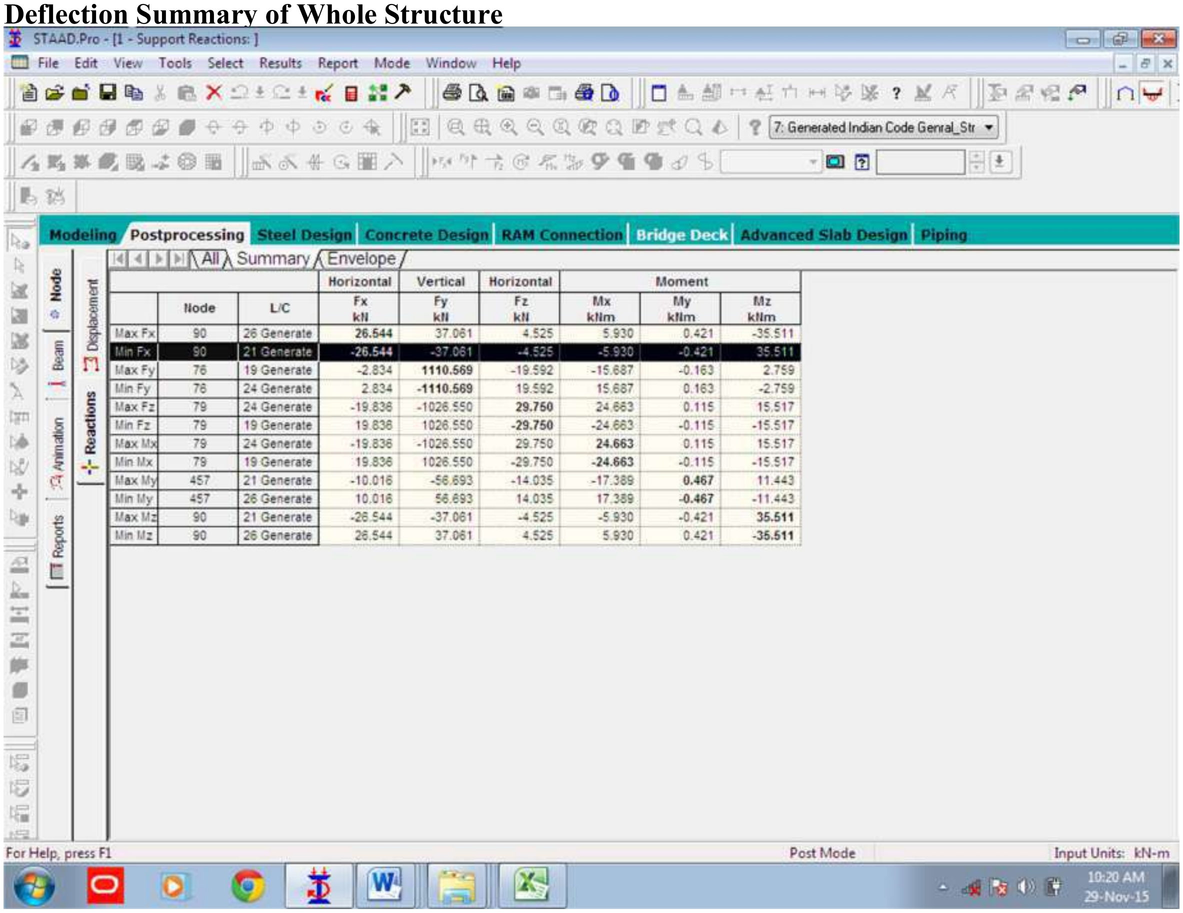


3D Rendering for Whole Structure



DEFLECTION CHECK

Deflection Summary of Whole Structure



			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	90	26 Generate	26.544	37.061	4.525	5.930	0.421	-35.511
Min Fx	90	21 Generate	-26.544	-37.061	-4.525	-5.930	-0.421	35.511
Max Fy	76	19 Generate	-2.834	1110.569	-19.592	-15.687	-0.163	2.759
Min Fy	76	24 Generate	2.834	-1110.569	19.592	15.687	0.163	-2.759
Max Fz	79	24 Generate	-19.836	-1026.550	29.750	24.663	0.115	15.517
Min Fz	79	19 Generate	19.836	1026.550	-29.750	-24.663	-0.115	-15.517
Max Mx	79	24 Generate	-19.836	-1026.550	29.750	24.663	0.115	15.517
Min Mx	79	19 Generate	19.836	1026.550	-29.750	-24.663	-0.115	-15.517
Max My	457	21 Generate	-10.016	-56.693	-14.035	-17.389	0.467	11.443
Min My	457	26 Generate	10.016	56.693	14.035	17.389	-0.467	-11.443
Max Mz	90	21 Generate	-26.544	-37.061	-4.525	-5.930	-0.421	35.511
Min Mz	90	26 Generate	26.544	37.061	4.525	5.930	0.421	-35.511

Lateral deflection developed in the structure = 10.081 mm

Permissible limit = H/500

= 17500/500 = 35 mm

= 26.544 < 35 mm (SAFE)

Vertical deflection developed in the structure = 6.825

Permissible limit (minimum of) = L/350 or 20 mm

= 3830/350 = 10.95 mm

= 6.825 < 10.95 (SAFE)

Conclusions

STAAD PRO has the capability to calculate the reinforcement 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.

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 inadequate as singly reinforced section, doubly reinforced section is tried.

Design for Shear:

Shear reinforcement is calculated to resist both shear forces and torsional 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.

Beam Design Output:

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

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.

REFERENCES :-

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2. *Reinforced concrete* – **Ashok.K. Jain.**
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