IJMTARC – VOLUME – IX – ISSUE – 38, APR - JUN, 2022 ISSN: 2320-1363

STRUCTURAL DESIGNING OF A MULTISTOREY BUILDING (C+G+8+R) BY PUSHOVER ANALYSIS BY USING STAADPRO

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Abstract: *STAADPro is the leading design software in today's market. Not only it is being used in many design and consultant companies for designing purposes but also it is also being taught at different study levels. For these reasons, a good knowledge of software is necessary. This report mainly deals with the design of a Multi-storey residential structure (C+G+8+R) using STAADPro. This would include the designing of complete R.C.C structure and the results will be compared in the end.*

A structure is an assembly of members, each of which is subjected to bending or direct force (either tensile or compressive) or to a combination of bending and direct forces.These primary influences may be accompanied by shearing forces and sometimes by torsion. Effects due to changes in temperature, shrinkage and creep of the concrete, the possibility of damage resulting from overloading, abrasion, local damage, vibration frost, chemical attack and similar causes may also have to consider. Design includes the calculations of, or other means of accessing and providing resistance against the moments, forces and other effects on the members. An efficiently design structure is one in which the members are arranged in such a way that the weight, load and forces are transmitted to the foundation by the cheapest means consistent with the intended use of structure of the site. Efficient design means more than providing suitable sizes for the concrete members and the provisions of the calculated amount of reinforcement in the economical manners.

I- INTRODUCTION

Pushover analysis involves certain approximations and simplifications that some amount of variation is always expected to exist in seismic demand prediction of pushover analysis. In literature, some improved pushover procedures have been proposed to overcome the certain limitations of traditional pushover procedures. The effects and the accuracy of invariant lateral load patterns utilised in pushover analysis to predict the behavior imposed on the structure due to randomly selected individual ground motions causing elastic and various levels of nonlinear response were evaluated in this study. For this purpose, pushover analyses using various invariant lateral load patterns and Modal Pushover Analysis were performed on reinforced concrete and steel moment resisting frames covering a broad range of fundamental periods. Certain response parameters predicted by each pushover procedure were compared with the 'exact' results obtained from nonlinear dynamic analysis. The primary observations from the study showed that the accuracy of the pushover results depends strongly on the load path, properties of the structure and the characteristics of the ground motion (seismic performance evaluation).

In this project, an effort made on planning, analysis and design of commercial building. For analysis and design of building, the plan draft by AUTO-CAD software which plan import in STAAD Pro.

1.1 PUSHOVER ANALYSIS

Pushover analysis has been developed over the past twenty years and has become the preferred analysis procedure for design and seismic performance evaluation purposes as the procedure is relatively simple and considers post elastic behavior. However, the procedure involves certain approximations and simplifications that

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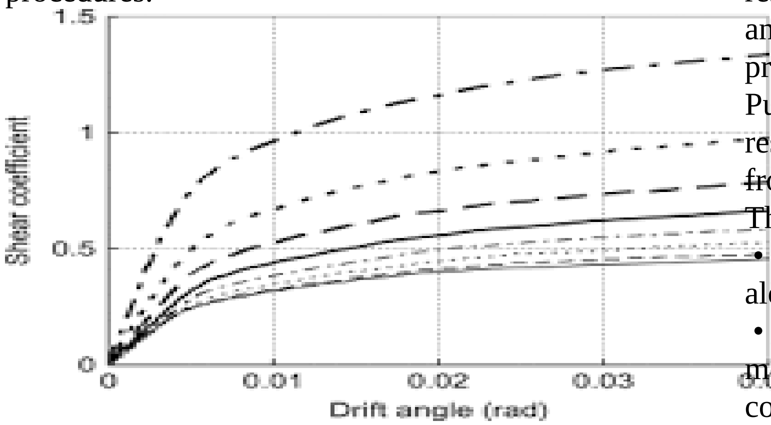
some amount of variation is always expected to exist in seismic demand prediction of pushover analysis. Although, in literature, pushover analysis has been shown to capture essential structural response characteristics under seismic action, the accuracy and the reliability of pushover analysis in predicting global and local seismic demands for all structures have been a subject of discussion and improved pushover procedures have been proposed to overcome the certain limitations of traditional pushover procedures.



However, the improved procedures are mostly computationally demanding and conceptually complex that use of such procedures are impractical in engineering profession and codes. As traditional pushover analysis is widely used for design and seismic performance evaluation purposes, its limitations, weaknesses and the accuracy of its predictions in routine application should be identified by studying the factors affecting the pushover predictions. In other words, the applicability of pushover analysis in predicting seismic demands should be investigated for low, mid and high-rise structures by identifying certain issues such as modeling nonlinear member behavior, computational scheme of the procedure, variations in the predictions of various lateral load patterns utilized in traditional pushover analysis, efficiency of invariant lateral load patterns in 1 representing higher mode effects and accurate estimation of target displacement at which seismic demand prediction of pushover procedure is performed.

1.2 USE OF PUSHOVER RESULTS

Pushover analysis has the preferred method for seismic performance evaluation of structures by the major rehabilitation guidelines and codes because it is 5 conceptually and computationally simple. Pushover analysis allows tracing the sequence of yielding and failure on member and structural level as well as the progress of overall capacity curve of the structure. The expectation from pushover analysis is to estimate critical response parameters imposed on structural system and its components as close as possible to those predicted by nonlinear dynamic analysis. Pushover analysis provides information on many response characteristics that cannot be obtained from an elastic static or elastic dynamic analysis. These are ;

• Estimates of interstory drifts and its distribution along the height

• Determination of force demands on brittle members, such as axial force demands on columns, moment demands on beam-column connections

• Determination of deformation demands for ductile members

• Identification of location of weak points in the structure (or potential failure modes)

• Consequences of strength deterioration of individual members on the behavior of structural system

• Identification of strength discontinuities in plan or elevation that will lead to changes in dynamic characteristics in the inelastic range

• Verification of the completeness and adequacy of load path Pushover analysis also expose design weaknesses that may remain hidden in an elastic analysis. These are story mechanisms, excessive deformation demands, strength irregularities and overloads on potentially brittle members.

1.3 LIMITATIONS OF PUSHOVER ANALYSIS

Although pushover analysis has advantages over elastic analysis procedures, underlying assumptions, the accuracy of pushover predictions and limitations of current pushover procedures must be identified. The estimate of target displacement, selection of lateral load patterns and identification of failure mechanisms due to higher modes of vibration are important issues that affect the accuracy of pushover results. Target displacement is the global displacement expected in a design earthquake. The roof displacement at mass center of the structure is used as target displacement. The accurate estimation of target displacement associated with specific performance objective affect the accuracy of seismic demand predictions of pushover analysis.

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1.4 OBJECTIVES OF THE PROJECT

The main objective of the project is to design and analyze a multi-storey building using pushover analysis with STAAD.Pro. Because of the growing population and less availability of land, construction of multi-storey buildings is coming into play to serve commercial spaces in limited area.

II - LITERATURE REVIEW

Gülkan and Sözen noted that most of the time the displacement would be significantly smaller than the maximum response under earthquake loading. Thus the equivalent damping proposed by Rosenblueth and Herrera would result in an overestimation of equivalent viscous damping that the response would be underestimated. Gülkan and Sözen developed an empirical equation for equivalent damping ratio using secant stiffness Takeda hysteretic model and the results obtained from experiments made on single story, single bay frames supported the proposed procedure.

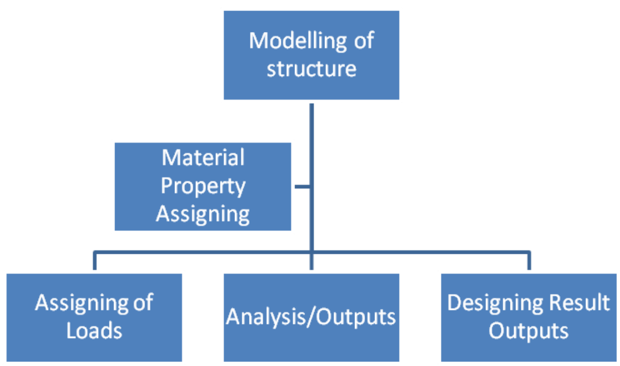
In 1981, Q-model which is a 'low-cost' analytical model for the calculation of displacement histories of multistory reinforced concrete structures subjected to ground motions was proposed by **Saiidi and Sözen**. Q-model is a SDOF system consisting of an equivalent mass, a viscous damper, a mass less rigid bar and a rotational spring. The hysteretic response of the spring was based on force-displacement curve of actual structure under monotonically increasing lateral force with a triangular height-wise distribution. The measured displacement histories of eight 10-story small scale R/C 12 structures with frame and frame-wall structural systems were used to test the Q-model. For structures without abrupt changes in stiffness and mass along their heights, the overall performance of Q-model in simulating earthquake response was satisfactory.

Mr K. Prabin Kumar, et.al (2018): A Study on Design of Multi-Storey commercial Building: They used STAAD Pro. to analysis and designing all structure member and calculate quantity of reinforcement needed for concrete section. Various structure actions is considered as members such as axial, flexure, shear and tension. Pillars are delineated for axial forces and biaxial ends at the ends. The building was planned as per IS: 456- 2000.

R. D. Deshpande, et.al (June, 2017): Analysis, Design and Estimation of Basement+G+2 commercial Building: They found that check for deflection was safe. They carried design and analysis of G+2 commercial building by using E-Tabs software with the estimation of building by method of center line. They safely designed column using SP-16 checked with interaction formula.

III - METHODOLOGY

3.0 FLOW CHART FOR THE PROPOSED PROJECT



3.1 METHODOLOGY

A multistory building frame is a three-dimensional structure or a space structure. It is idealized as a system of interconnected two-dimensional vertical frames along the two mutually perpendicular horizontal axes for analysis. These frames are analyzed independently of each other. In frames where the columns are arranged on a rectangular grid, loading patterns giving biaxial bending need not be considered except for corner columns.

The degree of sophistication to which a structural analysis is carried out depends on the importance of the structure. A wide range of approaches have been used for buildings of varying heights and importance, from simple. Approximate methods which can be carried out manually, or with the aid of a pocket calculator, to more refined techniques involving computer solutions. Till a few years ago most of the multistory buildings were analyzed by approximate methods such as substitute frame, moment distribution, portal and cantilever methods.

In this project a commercial building plan was developed in Auto CAD and them later the geometry of the site was developed in Staad pro in order to get the required design outputs. The steps are as follows:

- Developing floor plans in Auto CAD which includes grid plan, Beam and column Orientation.
- Developing plan geometry in STAADPro
- Assigning Material Properties to the structure.(For all structural Elements)
- Assigning of Loads as per IS standards.
- Analysis of structure.
- Analysis results.
- Design outputs of the structure.

IV - LAYOUT OF C+G+8+R STRUCTURE USING AUTOCAD

4.1 General

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, 3D and for perspective design.

With the help of AutoCAD all the drafting for the project has been done.

4.2 Details of the Project:

The plot size for the project was 31.5x26.5 mts accordingly the building has been laid in the centre of the plot leaving ample space on all the sides for landscaping and pathways for cars and for visitors parking.

The complete structure is of 1000.00 sqyards and the numbers of floors are C+G+8+R with column orientation, beam placements and slabs as per different floors.

4.3 Layout Using AutoCAD

The layout has been mostly completed using the Line command. The unit for the layout is metres with accuracy of “0.000”. Below is a screen shot of the line diagram showing the centre line for beam and column layout.

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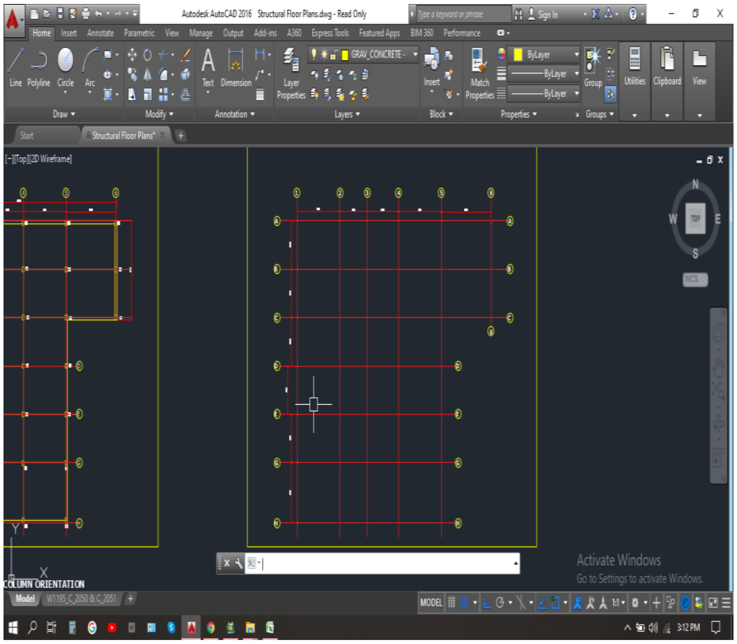

Fig 1. Shows grid lines of the building

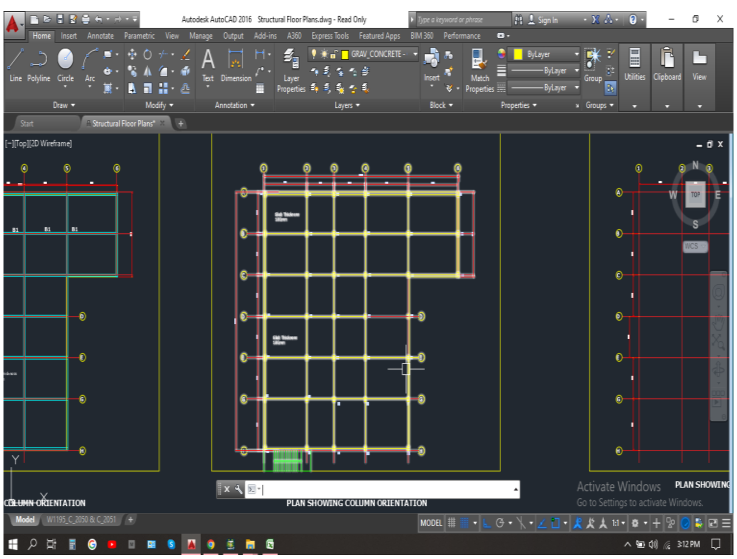

Fig 2 shows the column orientation of the building

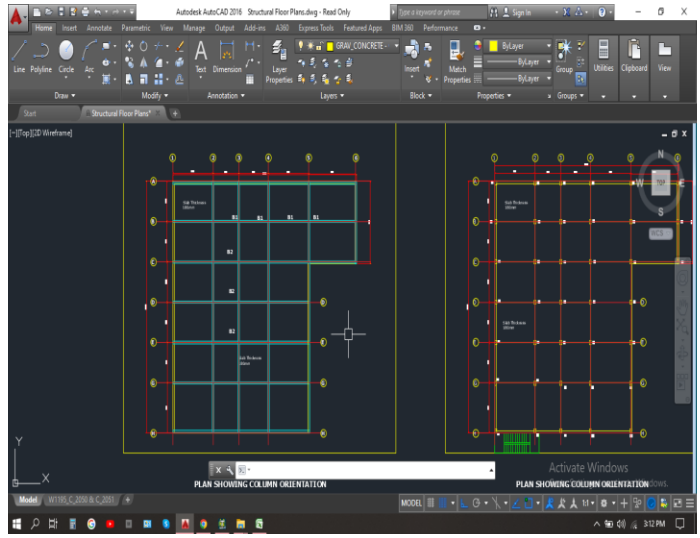

Fig 3 shows the beam orientation of the structure.

V - DESIGN PARAMETERS

5.1 Staad pro Inputs

Concrete Grade = M25

Clear Cover = 25mm

Fc = 20mpa

Fy main = 500mpa

Fy Section/ Stirrups = 500mpa

Density of Concrete = 24 Kn/m^3

Loading Considerations for elements

Consider Finishes of 75mm with 20 Kn/m^3 Density of concrete

Brick wall/Partition walls Moderate Grade = 20 Kn/m^3

Live Load = 2.0Kn/m^2 & 2.50Kn/m^2 for commercial

5.2 Properties of elements

a). Beam Sizes

300 mm × 400 mm C+G.F to 2nd Floor

250 mm × 350 mm 3rd to 6th Floor

225 mm × 300 mm 7th to Roof

b).Column Sizes

250 mm × 400 mm C+G.F to 2nd Floor

230 mm × 400 mm 3rd to 6th Floor

230 mm × 350 mm 7th to Roof

c). Slabs Thickness

Floors C+G.F to 2nd Floor = 200mm

Floors 3rd to 6th Floor = 180mm

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7th to Roof Slab = 150mm

d). Wall Thickness

Partition wall = 115mm

Outer Main wall = 230mm

Parapet wall = 75mm thick / Height= 1.2m

VI - ANALYSIS OF STRUCTURE

6.1 Modelling of structure

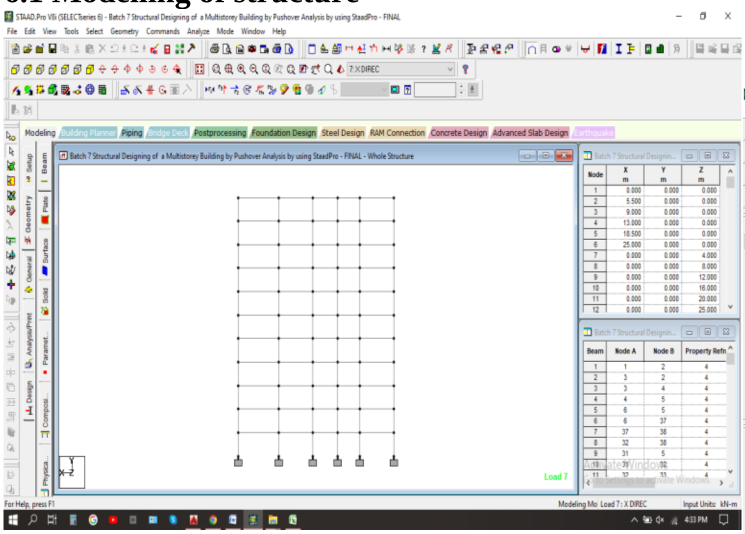


Fig 4 shows the geometry of the structure.

6.2 Member property assigning to the structural elements

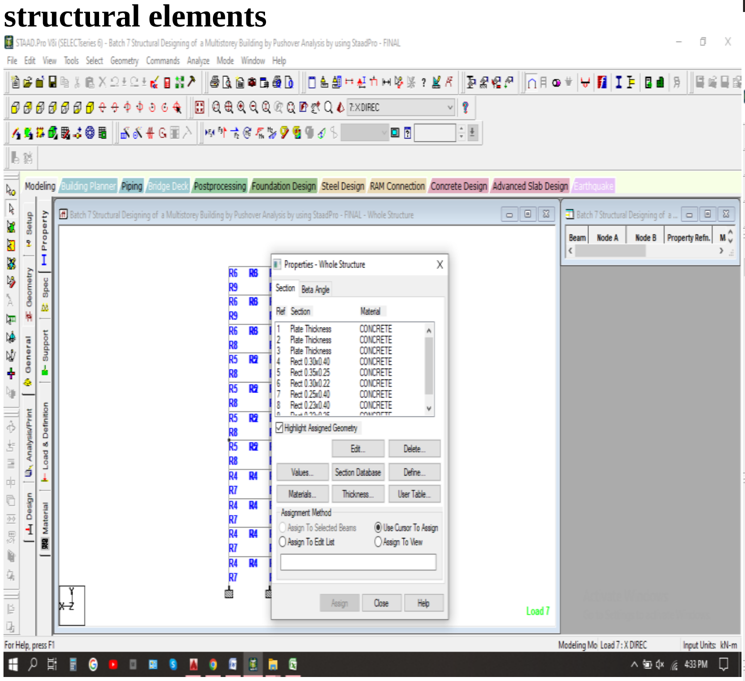
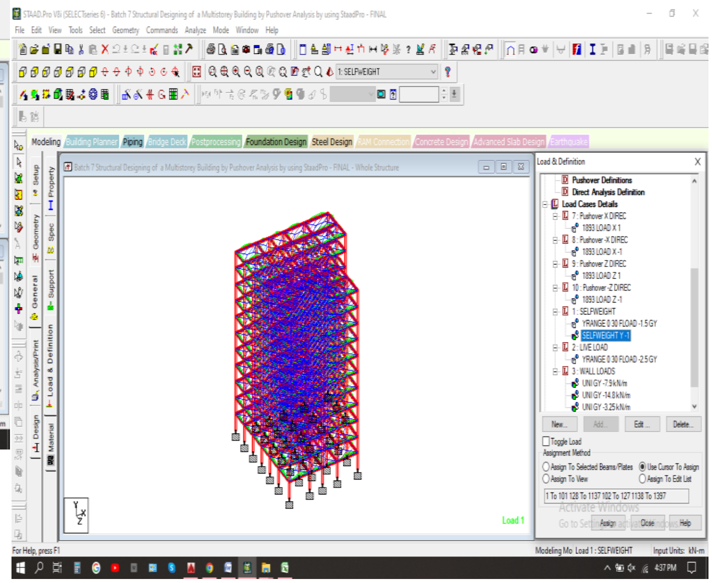
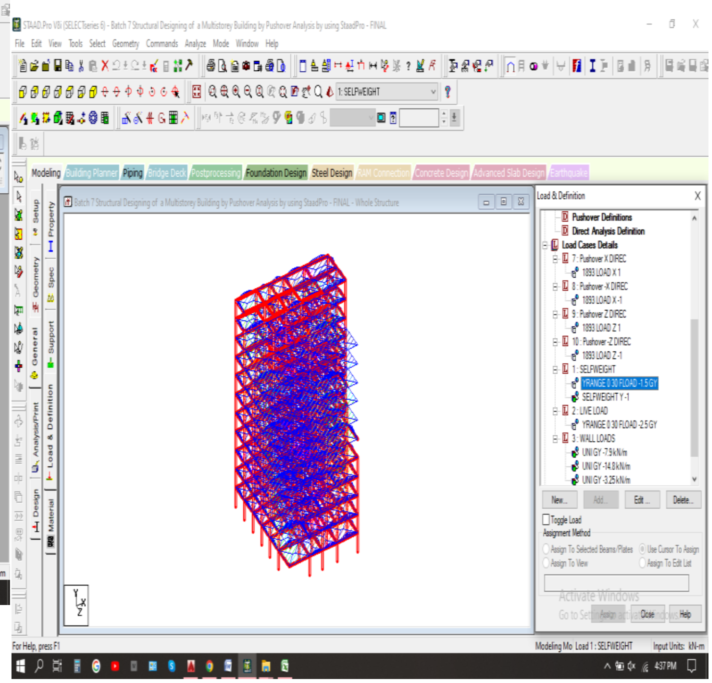


Fig 5 shows the member property of the elements.

6.3 Assigning of Loads

- Dead Load
- Live Load
- Floor Finishes
- Pushover Analysis Results
- Brick Wall Load
- Inner Partition Wall Loads
- Roof Loads





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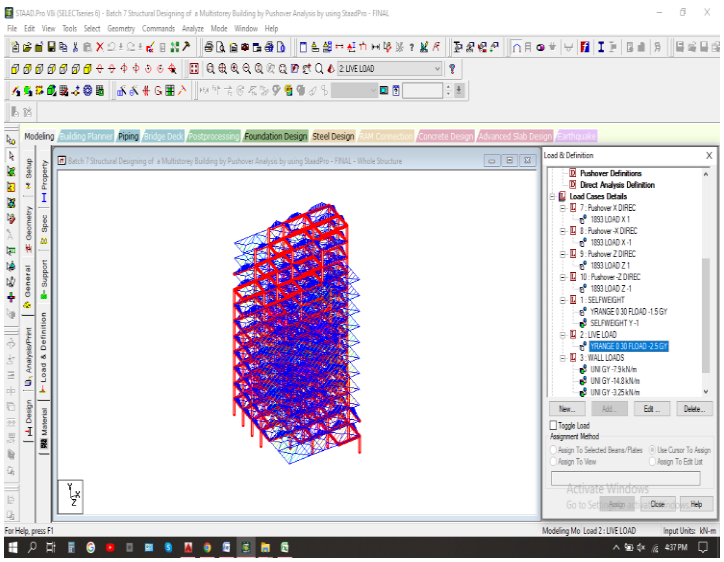

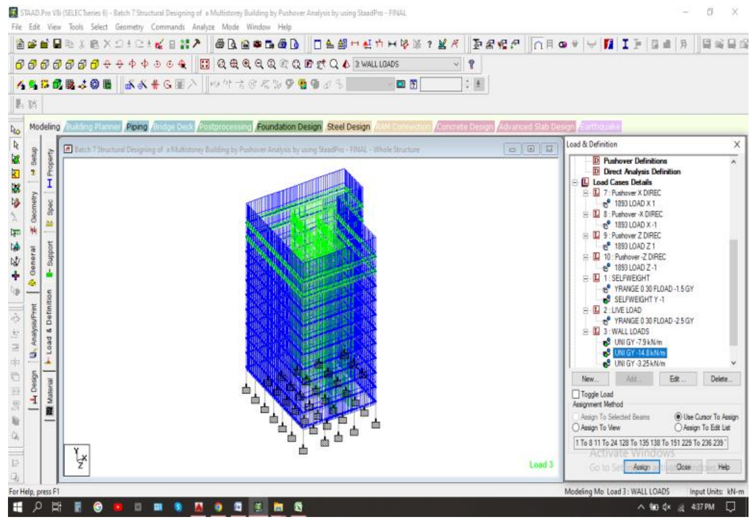

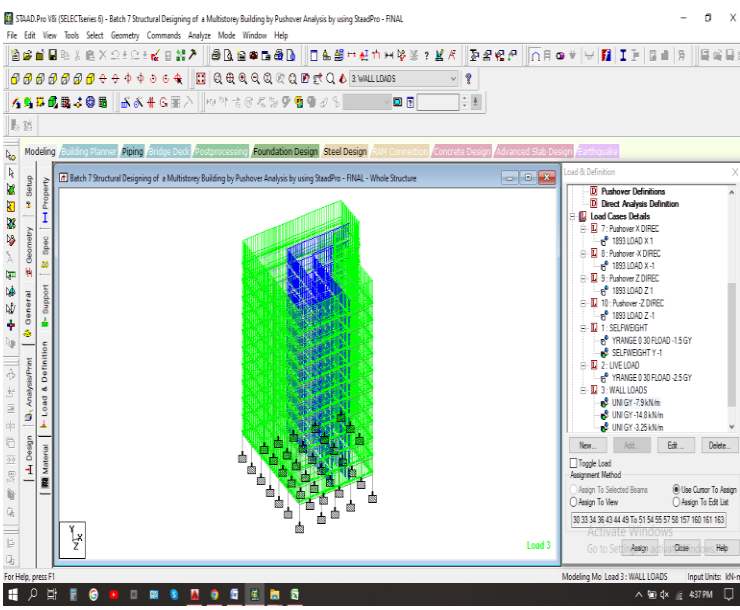

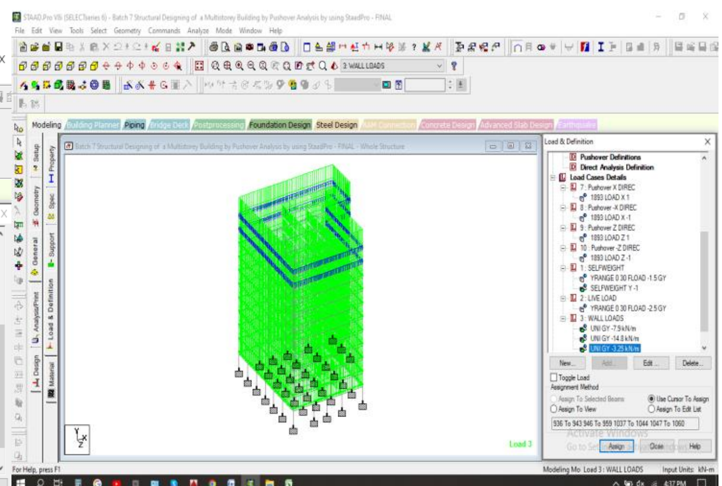

VII - STAAD PRO RESULTS

7.1 Staad result output.

The analysis done from considering all the above parameters state that the structure is safe without any errors

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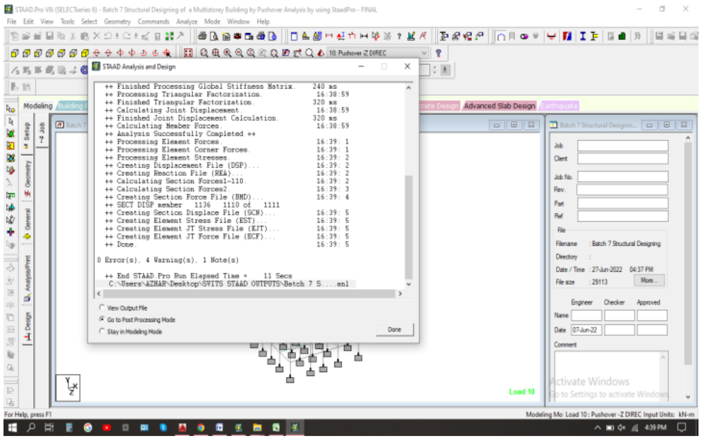


Fig 6 showing Shear Force diagram of the structure

8.4 Displacements Outputs

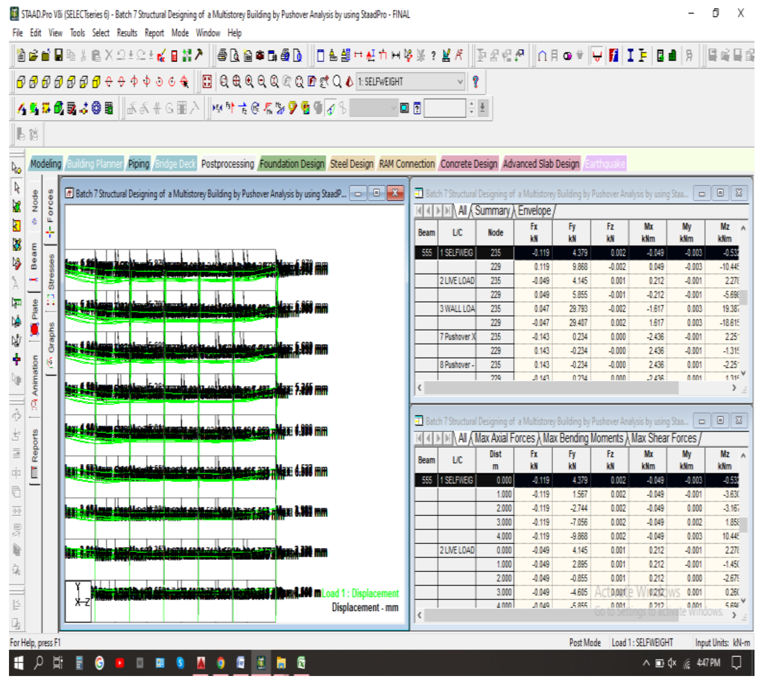


Fig 7 showing Displacements of the structure with in 6.0mm

8.2 Bending Moments Output

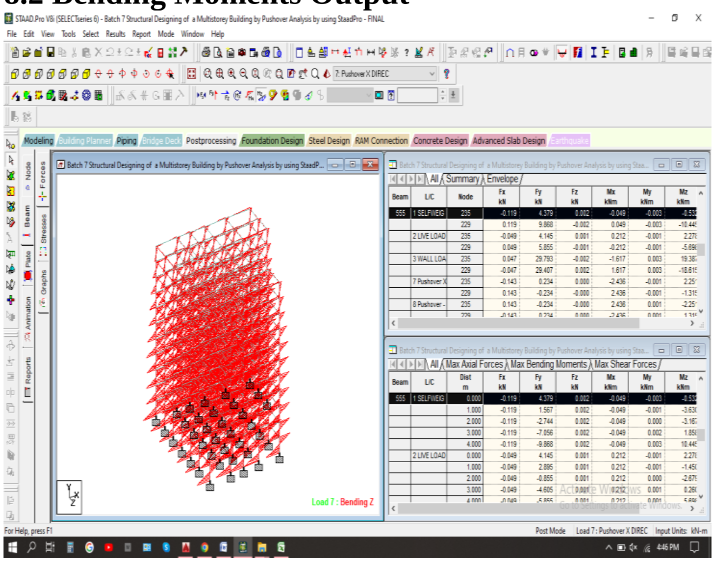
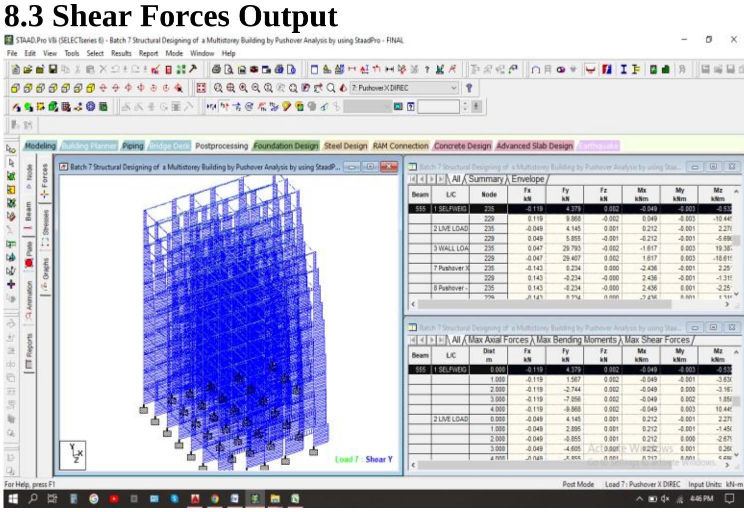


Fig 25 showing Bending moment diagram of the structure

8.3 Shear Forces Output



8.5 PUSHOVER ANALYSIS RESULTS

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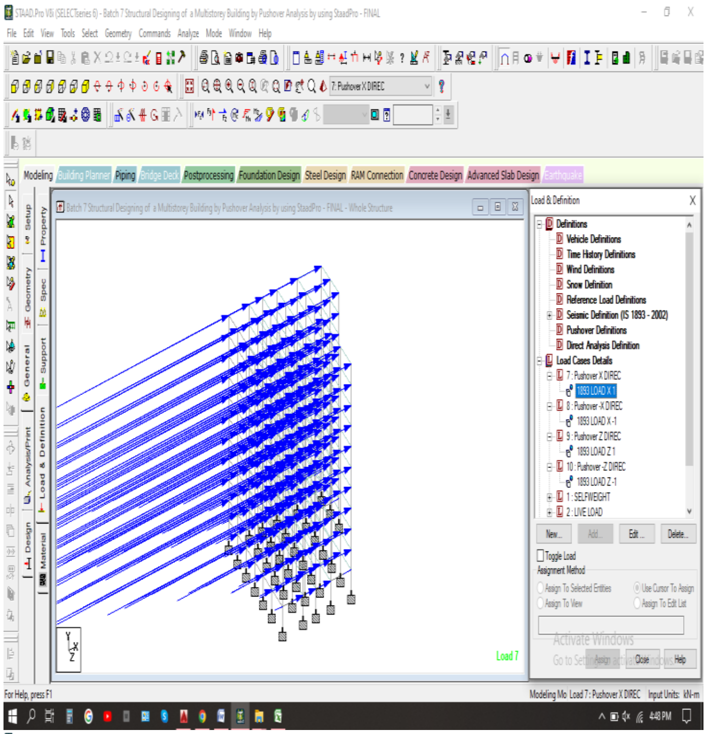

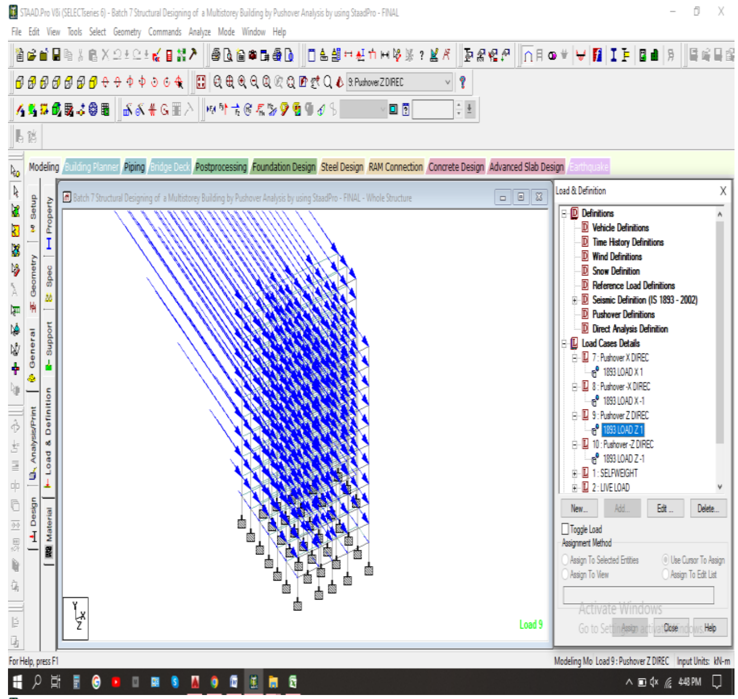

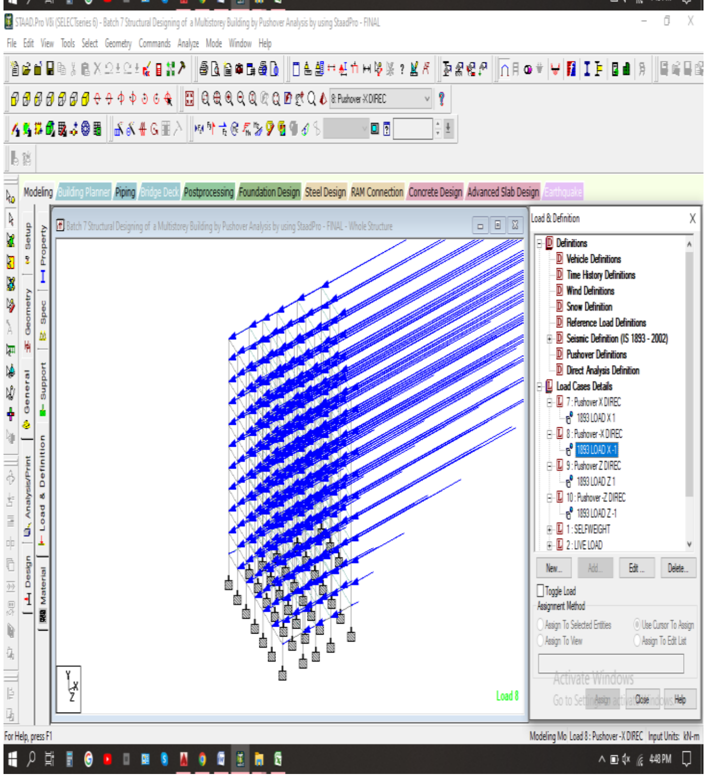

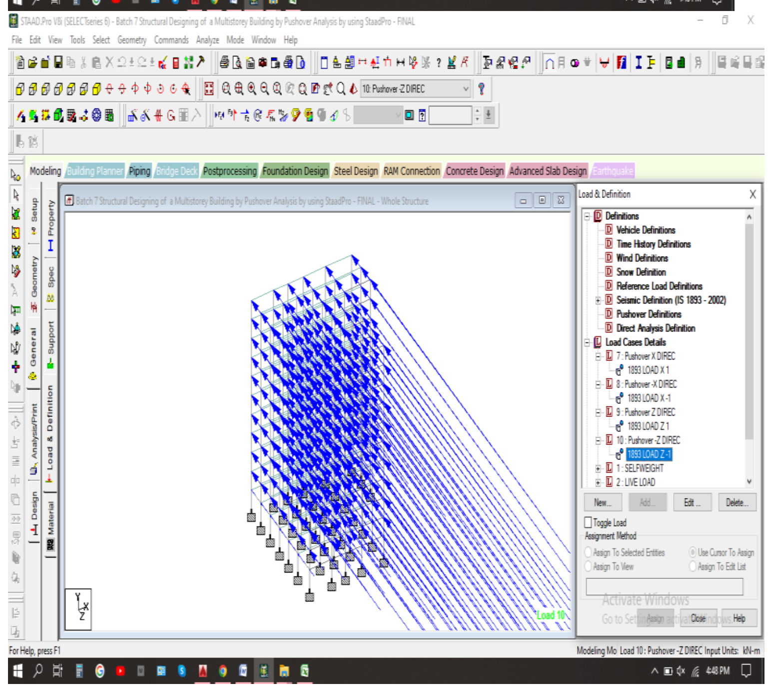

8.6 DESIGN RESULTS OF BEAMS AND COLUMNS REINFORCEMENT

B E A M N O. 5 D E S I G N R E S U L T S

M25 Fe500 (Main) Fe500 (Sec.)

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LENGTH: 6500.0 mm SIZE: 400.0 mm X 300.0 mm COVER: 25.0 mm

DESIGN LOAD SUMMARY (KN MET)

SECTION |FLEXURE (Maxm. Sagging/Hogging moments)| SHEAR (in mm) | P MZ MX Load Case | VY MX Load Case

----

0.0 | 0.00 58.00 1.24 8 | 46.98 -0.32 3
| 0.00 -58.00 -1.24 7 |
541.7 | 0.00 49.57 1.24 8 | 38.96 -0.32 3
| 0.00 -49.57 -1.24 7 |
1083.3 | 0.00 9.06 2.22 10 | 30.95 -0.32 3
| 0.00 -9.06 -2.22 9 |
1625.0 | 0.00 11.25 -0.32 3 | 22.93 -0.32 3
| 0.00 0.00 0.00 7 |
2166.7 | 0.00 24.29 1.24 8 | -15.56 1.24 8
| 0.00 -24.29 -1.24 7 |
2708.3 | 0.00 27.40 -0.32 3 | -15.56 1.24 8
| 0.00 -15.86 -1.24 7 |
3250.0 | 0.00 28.97 -0.32 3 | -15.56 1.24 8
| 0.00 0.00 0.00 7 |
3791.7 | 0.00 10.33 0.18 1 | -15.56 1.24 8
| 0.00 -0.99 1.24 8 |
4333.3 | 0.00 19.07 -0.32 3 | -15.56 1.24 8
| 0.00 -9.42 1.24 8 |
4875.0 | 0.00 17.84 -1.24 7 | -25.17 -0.32 3
| 0.00 -17.84 1.24 8 |
5416.7 | 0.00 26.27 -1.24 7 | -33.19 -0.32 3
| 0.00 -26.27 1.24 8 |
5958.3 | 0.00 34.70 -1.24 7 | -41.20 -0.32 3
| 0.00 -34.70 1.24 8 |
6500.0 | 0.00 43.12 -1.24 7 | -49.22 -0.32 3
| 0.00 -52.84 -0.32 3 |

SUMMARY OF REINF. AREA (Sq.mm)

SECTION | TOP | BOTTOM | STIRRUPS (in mm) | Reqd./Provided reinf. | Reqd./Provided reinf. | (2 legged)

0.0 | 509.74/ 549.78(7-10í)| 509.74/ 549.78(7-10í)| 8í @ 150 mm
541.7 | 436.67/ 471.24(6-10í)| 436.67/ 471.24(6-10í)| 8í @ 150 mm
1083.3 | 183.60/ 314.16(4-10í)| 183.60/ 314.16(4-10í)| 8í @ 150 mm
1625.0 | 0.00/ 235.62(3-10í)| 183.60/ 314.16(4-10í)| 8í @ 150 mm
2166.7 | 218.66/ 314.16(4-10í)| 218.66/ 314.16(4-10í)| 8í @ 150 mm
2708.3 | 183.60/ 314.16(4-10í)| 237.33/ 314.16(4-10í)| 8í @ 150 mm
3250.0 | 0.00/ 235.62(3-10í)| 250.77/ 314.16(4-10í)| 8í @ 150 mm
3791.7 | 183.60/ 314.16(4-10í)| 183.60/ 314.16(4-10í)| 8í @ 150 mm
4333.3 | 183.60/ 314.16(4-10í)| 183.60/ 314.16(4-10í)| 8í @ 150 mm
4875.0 | 183.60/ 314.16(4-10í)| 183.60/ 314.16(4-10í)| 8í @ 150 mm
5416.7 | 235.69/ 314.16(4-10í)| 235.69/ 314.16(4-10í)| 8í @ 150 mm
5958.3 | 308.21/ 314.16(4-10í)| 308.21/ 314.16(4-10í)| 8í @ 150 mm
6500.0 | 456.82/ 471.24(6-10í)| 380.92/ 392.70(5-10í)| 8í @ 150 mm

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

SHEAR DESIGN RESULTS AT 395.0 mm AWAY FROM START SUPPORT
VY = 41.21 MX = -0.32 LD= 3
Provide 2 Legged 8í @ 150 mm c/c

SHEAR DESIGN RESULTS AT 395.0 mm AWAY FROM END SUPPORT
VY = 35.44 MX = -0.32 LD= 3
Provide 2 Legged 8í @ 150 mm c/c

VII - CONCLUSION

Building plan was develop and draft in Auto-CAD with required dimension. During designing C+ G+ 8+R storeys commercial building structure is capable to sustain all loads acting on building. The design of slab, beam, column, is done with IS 456-2000 as limit state method in addition to that IS code 875 were also used for other loading parameters the structure is also designed against pushover analysis in order to make sure that the structure drift value is within the limit and also it is safe. STAAD.Pro has the ability to calculate the Reinforcement needed for any concrete section. The design output gives the reinforcement quantity of the complete structure as output and as per result; structure is safe without any errors as per output given by staad pro.

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IJMTARC – VOLUME – IX – ISSUE – 38, APR - JUN, 2022 ISSN: 2320-1363

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