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"Structural Design and Comparative Study of RCC Building on PT Slab & Flat Slab Building Under the Dynamic Analysis"

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Abstract— Precast concrete is well known technology in which some Standardized units which are manufactured in factories are used for fast Construction. Though the technology is developed many years ago but the Implementation is not up the mark in our country. In this study we have carried out detailed study of various concepts of precast, go through number of Literature & found the facts associated with it. Existing reinforced concrete Structures stock is wide and also includes buildings with precast elements, being largely used since Fifties primarily to satisfy needs of the manufacture and tertiary purposes. Their diffusion has been supported by flexibility of structural net dimensions and by the economy and efficiency of the constructional process. For this purpose, a reference project at Chennai location is taken and modelled in SAP2000 software to analyses the structure and design.

Key Words: Design, Dynamic Analysis, Prefabricated Structure, Flat slab, PT slab, SAP2000

I. INTRODUCTION

Precast concrete (PCC) methods are gaining popularity due to improved quality control, less material waste, and faster construction. Precast joints are the weakest link. Bolts, welds, anchors, reinforcing steel, grout and concrete are used to mechanically attach structural components. Structure component connections must reinforce the structure's structural integrity. They are designed to transfer forces between pieces to provide structural interaction when the system is loaded. Researchers have researched the load distribution and behavior in PCC beam–column junctions. The connection type impacts the structure's constructability, stability, strength, flexibility, and residual forces. However, PCC member connections are normally constructed for various loads. The researchers can now evaluate and generate exact connections under various loading conditions.

Fig1.1: Connection detail of post-tensioned precast specimen

Precast concrete construction is superior in quality and speed. Precast concrete methods can be used to build almost any form of building, including car parks, commercial, cultural, hotels, dormitories, apartment complexes, bridges, and industrial buildings. This is because the behavior of beam-to-column connections controls the structural performance of precast concrete systems. In previous earthquakes, precast concrete structures were destroyed mostly owing to faulty design, detailing, and manufacture of the

joints. A lack of strength and energy dissipation capability of connections is regarded by several researchers as the main cause of earthquake damages.

Precast System Type

Precast systems are classified according to the load bearing structure:

- Frame systems
- Slab column systems with wall
- System mix

In this technology, massive wall and floor concrete panels are joined vertically and horizontally, enclosing appropriate spaces for rooms within a building. These panels resemble abond. Vertical and horizontal panels resist gravity. It is also possible to use linear elements or spatial beam-column sub-assemblages to build precast frames. The connecting faces between precast beam-column sub-assemblages can be located distant from essential frame regions, however linear elements are often favored because to the difficulties associated with making, handling, and erecting spatial elements.

This method relies on shear walls to resist lateral loads, while the slab-column structure resists gravity loads. This category has two main systems:

A lift slab system with walls uses precast reinforced concrete columns and slabs as the load bearing structure. They are normally two stories high. Special joints unite all precast structural elements.

2 x pre-stressed slab-column Uses horizontal pre-stressing in two orthogonal directions to establish continuity. There are 1 to 3 story precast columns. The reinforced concrete floor slabs bridge the columns.

- Precast Slabs
- Precast Beams and Girders
- Precast Columns
- Precast Walls
- Precast Stairs

Need of the Study

Initially, pre-cast elements are designed so that all members of the same type are designed and dimensioned similarly. The design and drawing of slab members should be comparable for all floors of the building. The same goes for other members like beams, columns, stairways, and railway sleepers. The structural aspects require a large initial investment.

However, if a huge number of similar members are made in a factory, the investment is not as costly. The government should supply affordable land so that the initial expenditure in building the pre-cast plant is minimized and the owner makes a profit, thus improving the country's economic status.

The commercial and public sectors should establish various workshops or training programs to train people or labour to solve the challenges originating in the absence of trained workforce for various phases of the activity. It should be accessible. And for that, proper site selection should be done early on. It has

- Good road access
- Site space availability
- Fewer cars Site layout is an important pre-engineering task that must be completed before construction can begin.

It should be planned effectively and have enough space for stacking/storing the elements transported for erection. The site layout should be planned properly. Pre-cast members are heavy; hence light concrete is used to reduce the weight of the member.

The construction sector has grown fast with the advent of new construction methods and technologies. Many countries use pre-cast concrete technology, which is one of the most cost-effective and quality-controlled systems. The protective environment ensures quality, productivity, and safety. To improve and speed up building, human resources must be divided and specialized, and design and planning must be integrated.

II. LITERATURE REVIEW

Joaquín G. Ruiz-Pinilla a, Antoni Cladera "Joint strengthening by external bars on RC beam-column joints" Published by Elsevier Ltd. 8 October 2022

To analyze two joint strengthening designs, for which an experimental campaign of eight full-scale beam-column joints strengthened with steel caging, and subjected to cyclic and gravity loads, was carried out. As access to joint panels is very complex in existing structures, joint strengthening consists of external solutions: vertical or diagonal bars and capitals connecting columns. The results showed that these techniques significantly increased beam-column joint strength and highlighted that failure can be undesirably transferred to the joint. Vertical bars prevented the bending failure of the column-joint interface, but failure occurred at the joint in this study. Diagonal bars can also prevent joint failure.

Wissam Nadir, Ammar Yasir Ali, Majid M.A. Kadhim "Structural behavior of hybrid reinforced concrete beam-column joints under cyclic load: State of the art review", Published by Elsevier Ltd. 20 September 2021

To provide a review of the literature on the hybrid reinforced concrete beam-column joints that used steel fibers reinforced concrete (SFRC) or high-performance fibers reinforced cementitious composites (HPFRCC) in the joint region instead of conventional concrete. The results of the previous work indicated that using SFRC in the joint region of beam-column joints improves seismic performance; hence the transverse reinforcement spacing in the joint zone can be increased.

Shilpa S, Dr. GopinathNayak, Dr. Ramakrishna Hegde "Review on Precast Beam Column Joint" International Journal for Modern Trends in Science and Technology, 12-May-2021

The behavior of precast concrete structures is subjected to different loading conditions. Loading conditions depend on type, location and the connections between elements. Exiguous strength and indigent ductility of the beam column joint create the weakest link in the structure, which the reason for failure of any kind of structures

D. Vinutha, R. Vidjeapriya* and K. P. Jaya "Seismic performance of precast slab to beam connection: an overview" Current Science, Vol. 121, No. 1, 10 July 2021

Focuses on the seismic performance of the precast slab to beam connections with an experimental evaluation of the basic concepts of design and detailing of the connections; this overview will pave way to refine work on the slab to beam connections in future research.
Failures observed during induced earthquakes were: beam elongations in plastic hinges, relative rotation at the support connection, positive and negative moment failure, shear failure, incompatible displacement between frame and the floor, and torsional failure. The performance of the connections can be improved by using low friction bearing strip with a compressible backing board on the seat of HC slab to reduce concentrated end reaction and rotation of the simply supported slabs

Seismic Behavior Experimental Study on the Joint of Circular Tubed Steel-Reinforced Concrete Columns Yan Dai, Shaofeng Nie, Tianhua Zhou, and Research Article 29 September 2021

We study new joint has reasonable failure characteristics, high bearing capacity, good ductility, excellent seismic energy dissipation performance, and strong resistance to strength and stiffness degradation, which meets the seismic design principle of "strong joint and weak component" and is suitable for the results with special requirements for seismic performance. In addition, preliminary design recommendations were put forward. The research results of this paper can provide a theoretical basis for the application of this kind of new structure.

Khaleel Mohammed, M Jameel, Zainah Ibrahim and Chee Ghuan Tan Performance of a Ductile Hybrid Post-Tensioned Beam-to-Column Connection for Precast Concrete Frames under Seismic Loads: A Review Science Direct 16 August 2021

This paper study on structural engineers and researchers with a detailed review of hybrid post-tensioned connections; this review is focused mainly on precast beam-to-column connections, studies on the development of hybrid connections, performance evaluations of hybrid connections, and the performance evaluation of precast frames with hybrid connections.

Hilal Meydanli Atalay and Sevket Ozden "Cyclic Behavior of Beam-Column Connections in Precast Structures" Science Direct 11 February 2021

Precast specimens and an aseismic monolithic reference specimen have been tested under reverse cycling loads. The contribution of the mild steel in the connection region to the flexural moment capacity, and to the initial pre-stressing force on post-tensioning bolt has been the main test variables. The moment capacity, stiffness, energy dissipation capacity and the residual displacement performance of the precast connections have been compared with those of the a seismically detailed monolithic connection

Numerical simulation of beam-to-column connections in precast reinforced concrete buildings using fibre-based frame models Romain Sousaa, Nádia Batalhab, Hugo Rodriguesc, Elsevier Ltd 2020

Identified the main lateral load resisting mechanisms involved, a new numerical model is proposed accounting for friction, dowel behaviors and the contribution of the neoprene components. The proposed model was validated against different experimental tests and a parametric study was performed to understand the contribution of the different components, especially in what concerns to the maximum horizontal strength and hysteretic energy dissipation.

Beam-to-Beam Connection of Precast Concrete Structures: State of the Art Kristiyanto Hery, Triwiyono Andreas, MATEC Web of Conferences, 2020

To assemble the connection that consists of some joints. Research and application of the precast concrete beam-to-beam connection details have published. This paper reviews the state of the art of research and practical application of beam-to-beam connection system related to connection models, joint locations, and details. It concluded from the review that the developing research leads to improve the performance of earthquake resisting structures

Arthi S and Jaya KP, "Seismic performance of precast shear wall-slab connection under cyclic loading: experimental test vs. numerical analysis" Council of Scientific and Industrial Research, July2020

The shear resistance is provided by the dowel bars and the stiffness of the precast specimen is due to the diaphragm action of the precast slab. The damage parameter and the interaction between structural members play a crucial role in the modelling of precast connections.

III. RESEARCH METHODOLOGY

3.1 AIM

"As the structural elements in precast building will only form a stable structural system after the joints are connected, structural considerations for stability and safety are necessary at all stages".

3.2 OBJECTIVES

- Design and analysis of precast building structure for G+7 story Building for Symmetrical Building using SAP2000.
- We analyse the below Outcome
- Story drift
- Story acceleration
- Displacement
- Base Shear
- Time History
- To compare RCC structure and precast building structure including post tension in G+7 by using SAP2000.
- To compare RCC structure and precast building structure including flat slab in G+7 by using SAP2000.

3.3 PROBLEM STATEMENT

"We need design and analysis precast building including post tension slab, flat slab for story G+7 and we study technical parameters drift, acceleration, displacements & base shear etc."

3.4 METHODOLOGY

- Study for literature review survey
- To study the construction techniques of precast and traditional method we have gone through various research papers, books, and some field works
- Building design using Static Linear Analysis.
- Dynamic analysis using SAP2000 software
- Study of prefabricated structure and all parameters
    - Story drift
    - Story acceleration
    - Overturning Moment
    - Story displacements
    - Axial force
    - Base shear
- Analysis result
- Result and discussion
- Conclusion

3.5 DESIGN AND MODELLING

- All model design for response spectrum analysis
- Material properties
- M40 FE500
- Beam 300x600, beam 350x675mm
- Col 500x500
- Col 450x450
- Study for literature review survey to study the construction techniques of precast and traditional method we have gone through various research papers, books, and some field works
- Building design using Static Linear Analysis.
- Building plan using AutoCAD
- Dynamic analysis using SAP 2000 software
- Study of prefabricated structure and all parameters

- Story drift
- Story acceleration
- Story displacements
- Axial force
- Base shear

Structural Design Work on SAP 2000

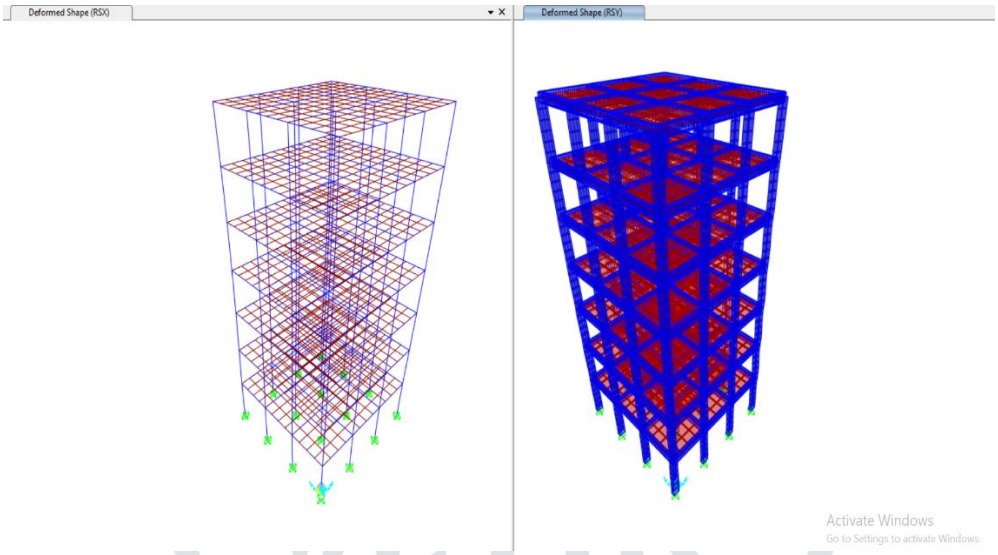


Figure 3.1: 3D Model RCC Framed Structure

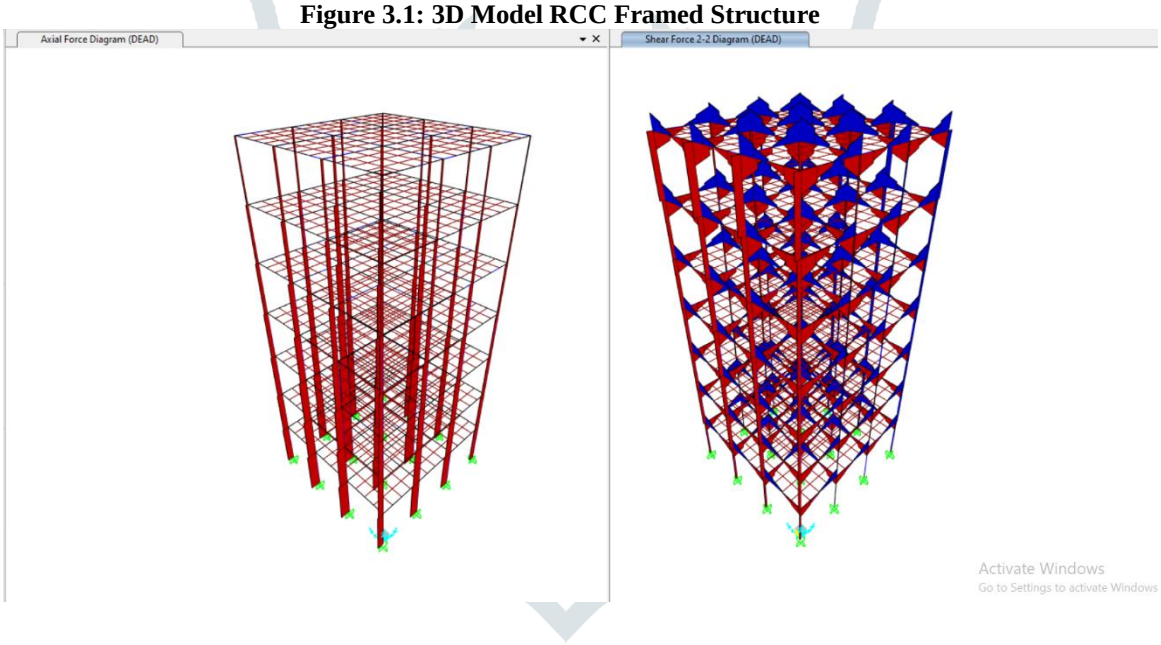


Figure 3.2: Axial force and Shear Force (G+7)

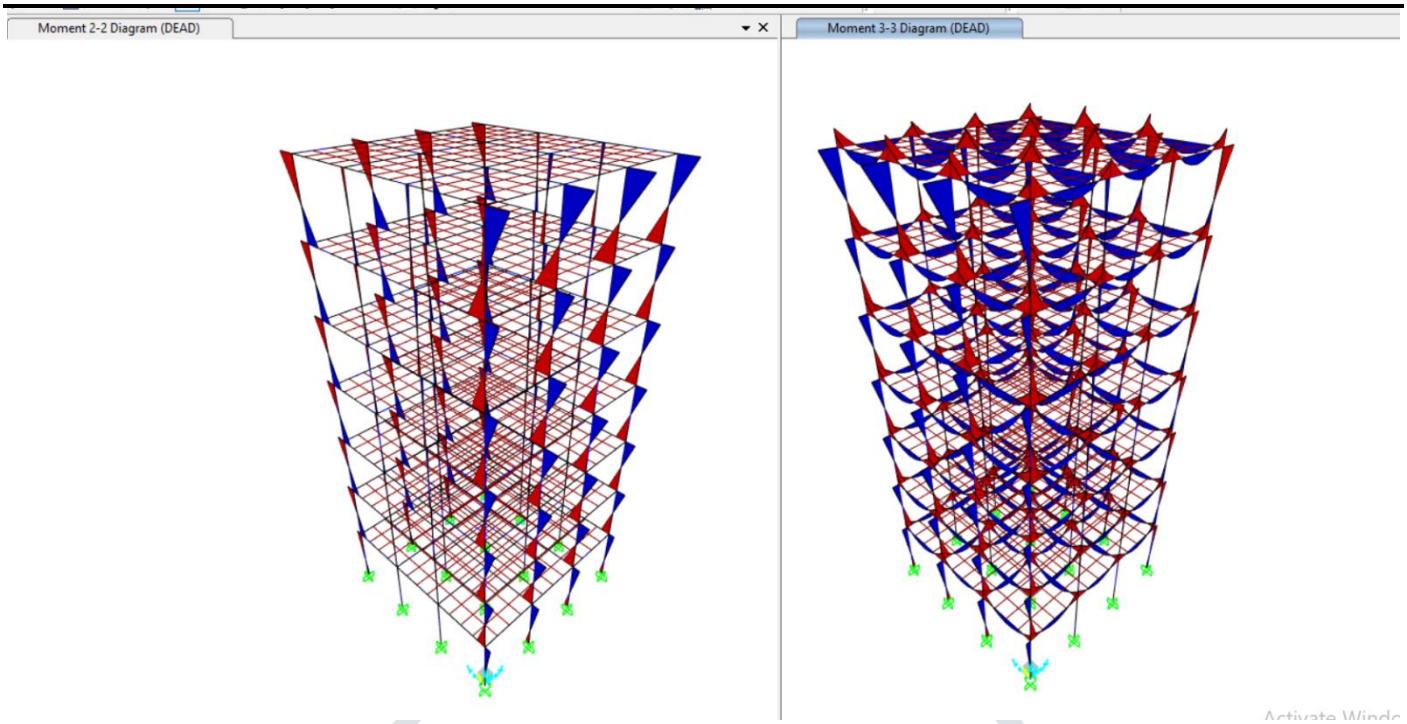


Figure 3.3: Bending Moment (G+7)

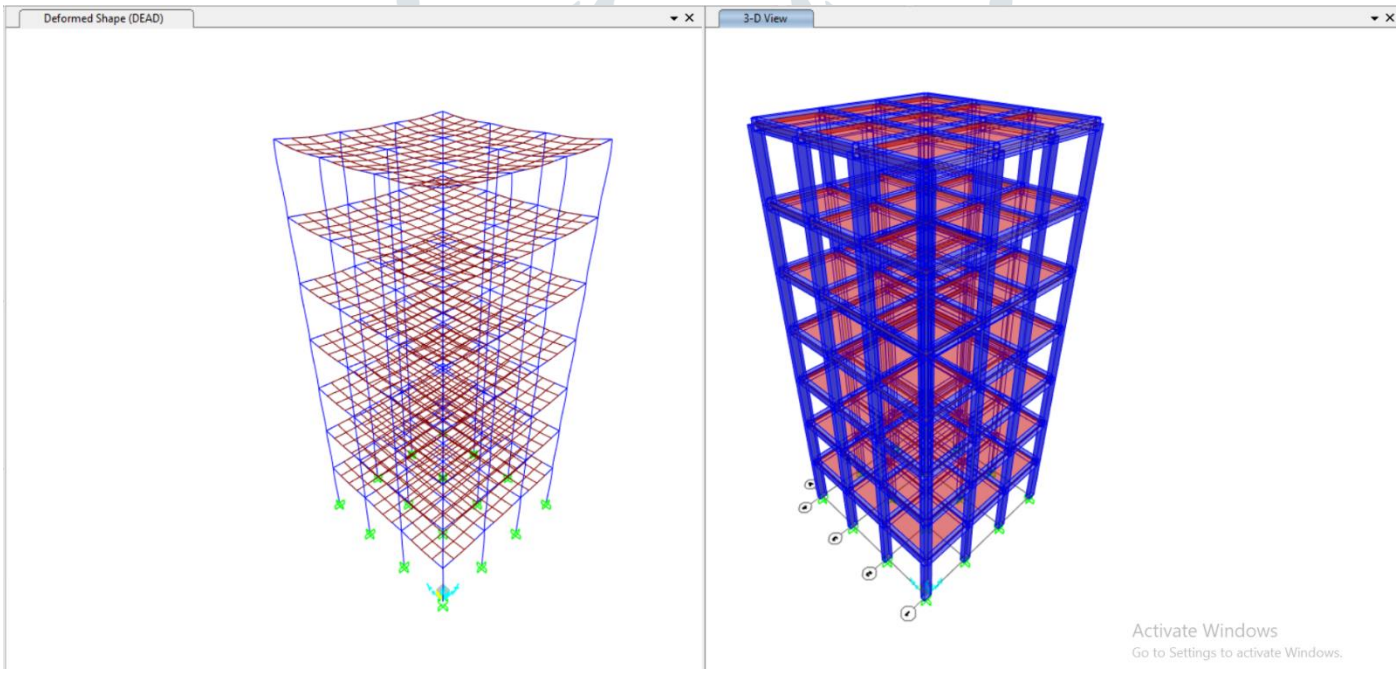


Figure 3.4: 3D model RCC framed str (G+7)

Structural Design Work
SAP 2000 ON FLAT (G+7)

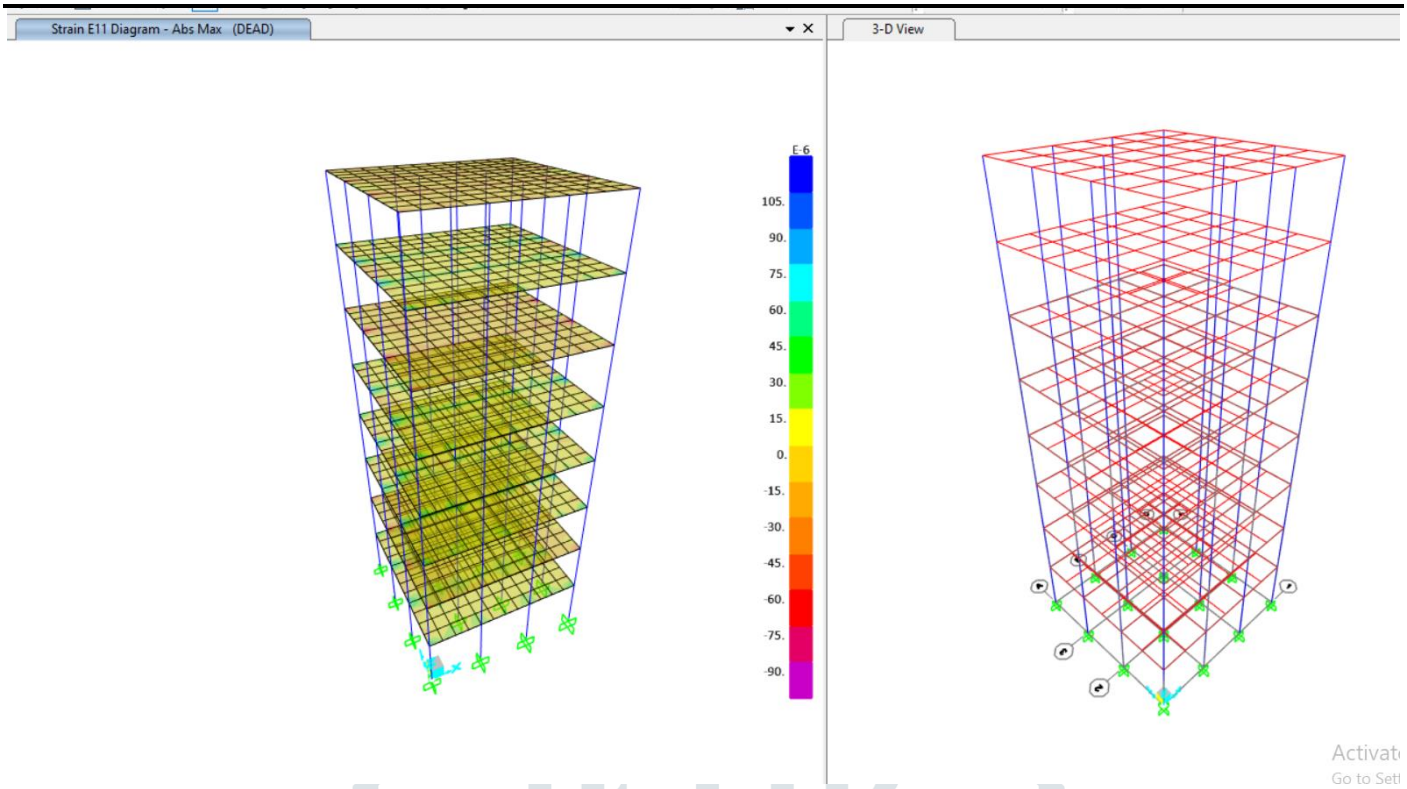


Figure 3.5: Plan of (G+7) Flat

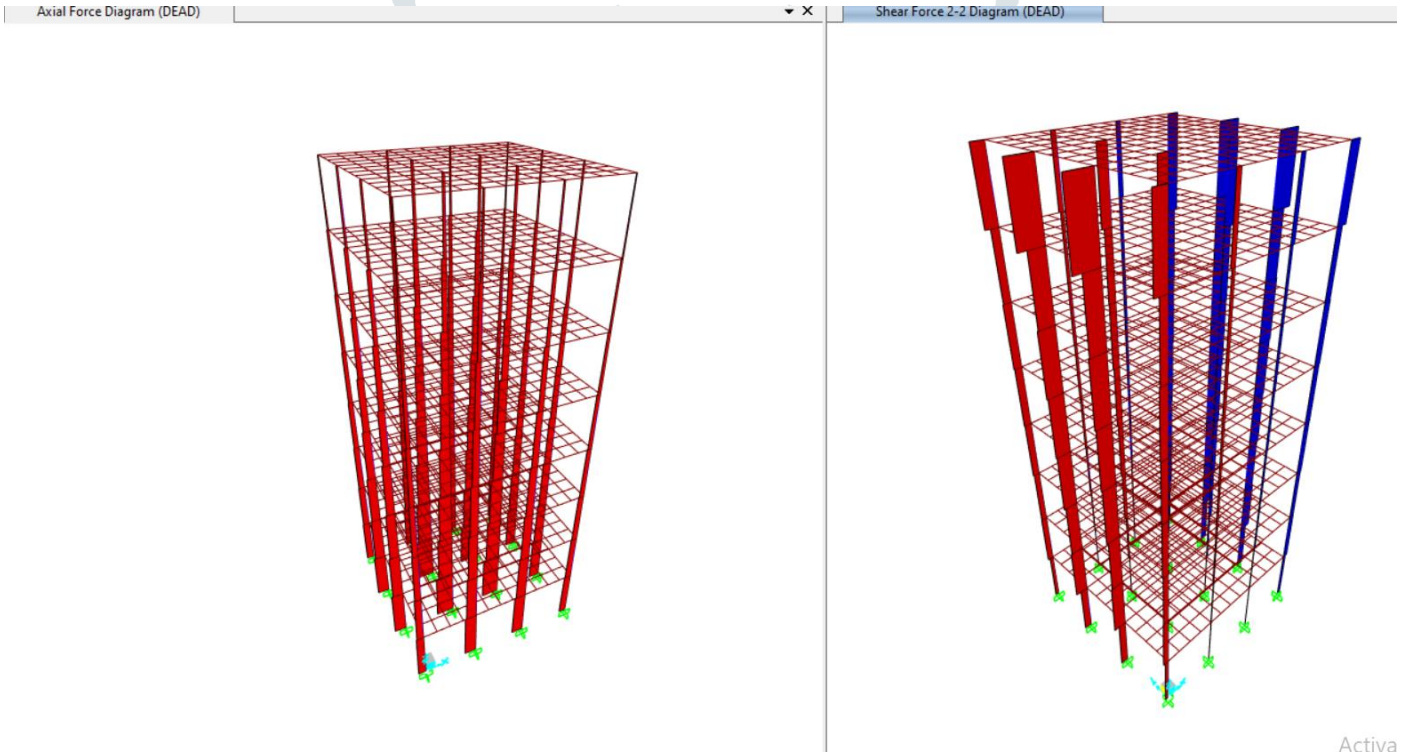


Figure 3.6: Shear Force Along XZ & YZ (G+7) Flat

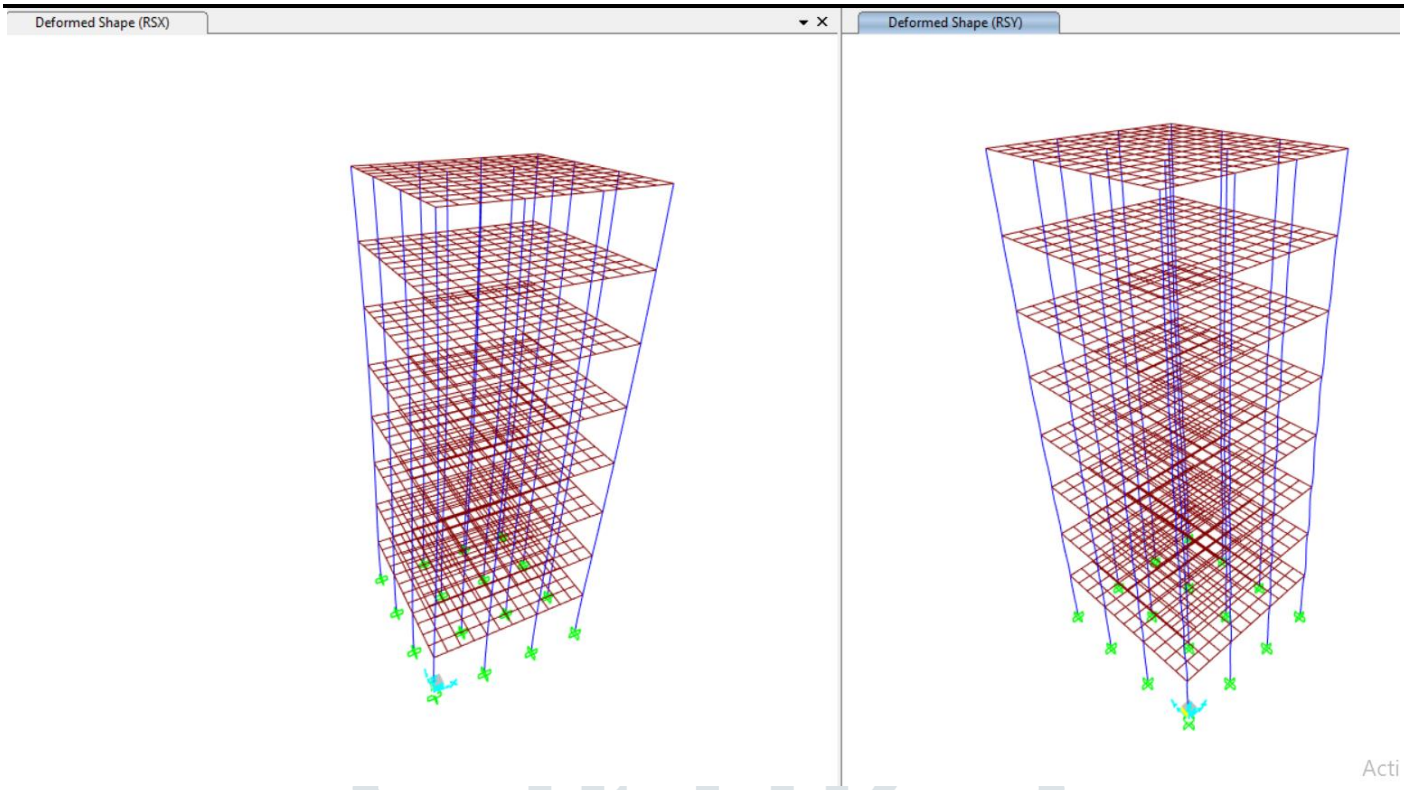


Figure 3.7: Deform Shape RSX & RSY FOR Flat (G+7)

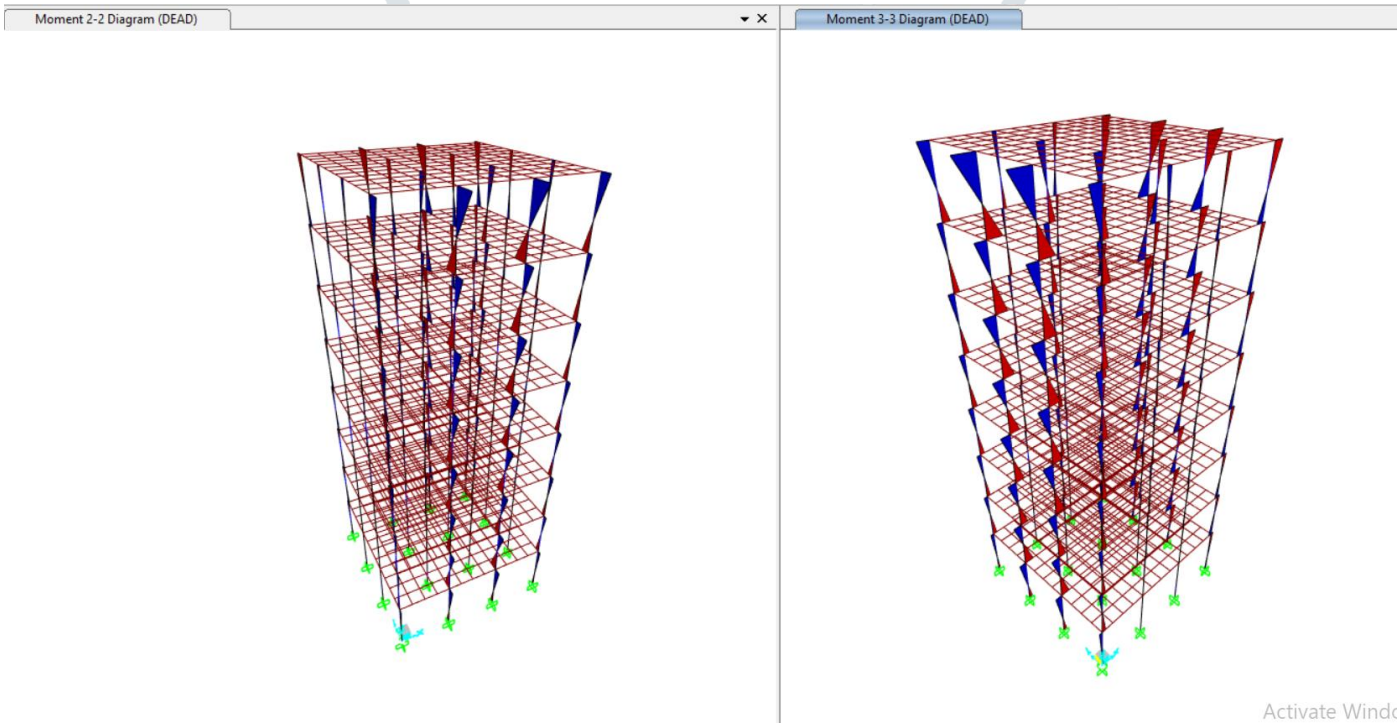


Figure 3.8: BMD 2-2 and 3-3

Structural Design Work On
SAP2000 ON PT (G+7)

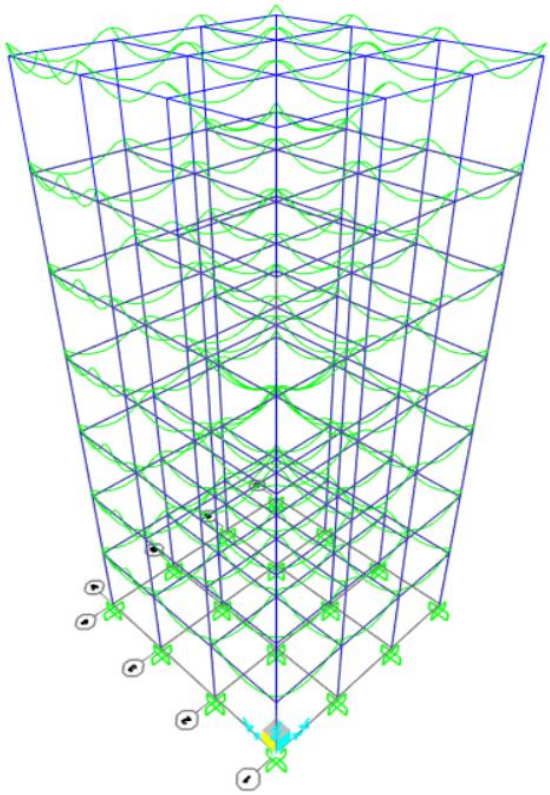


Figure 3.9: Plan of (G+7) PT

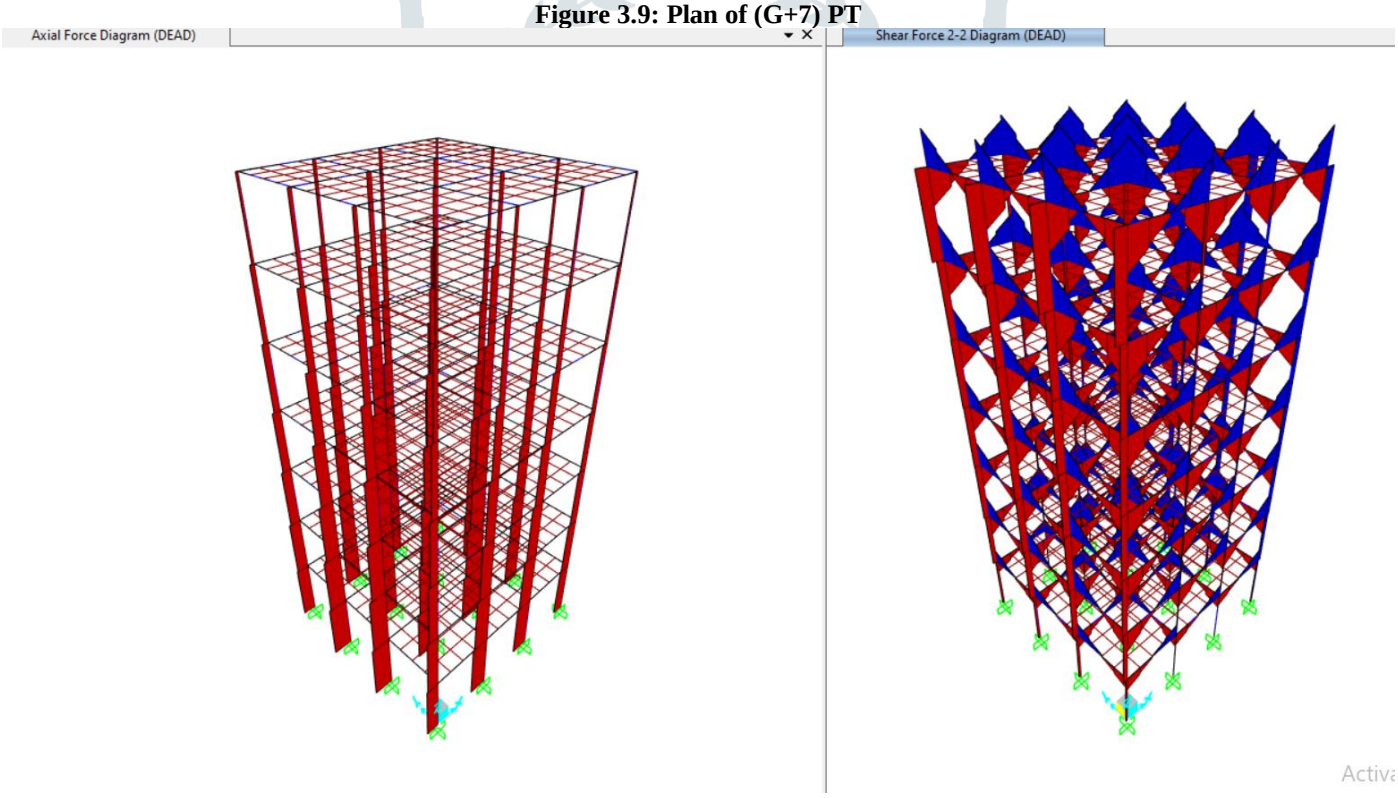


Figure 3.10: Axial Force and SFD FOR PT (G+7)

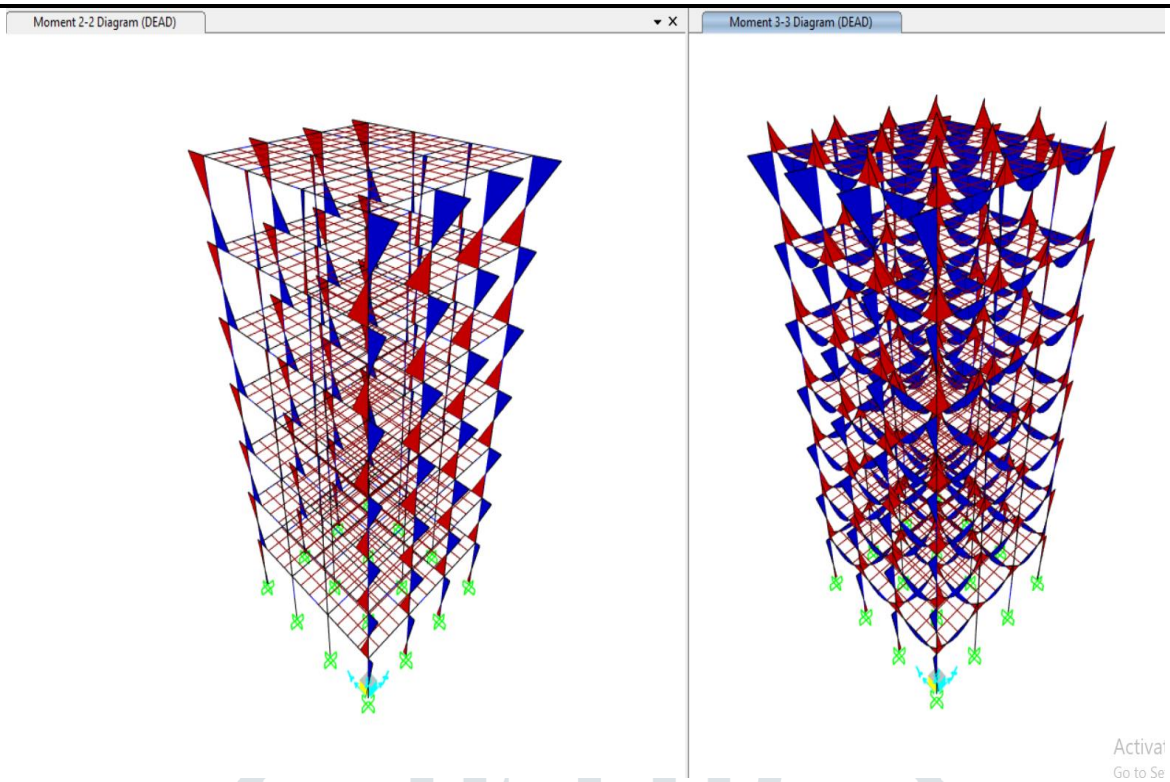


Figure 3.11: Bending Moment 2-2 and 3-3 PT (G+7)

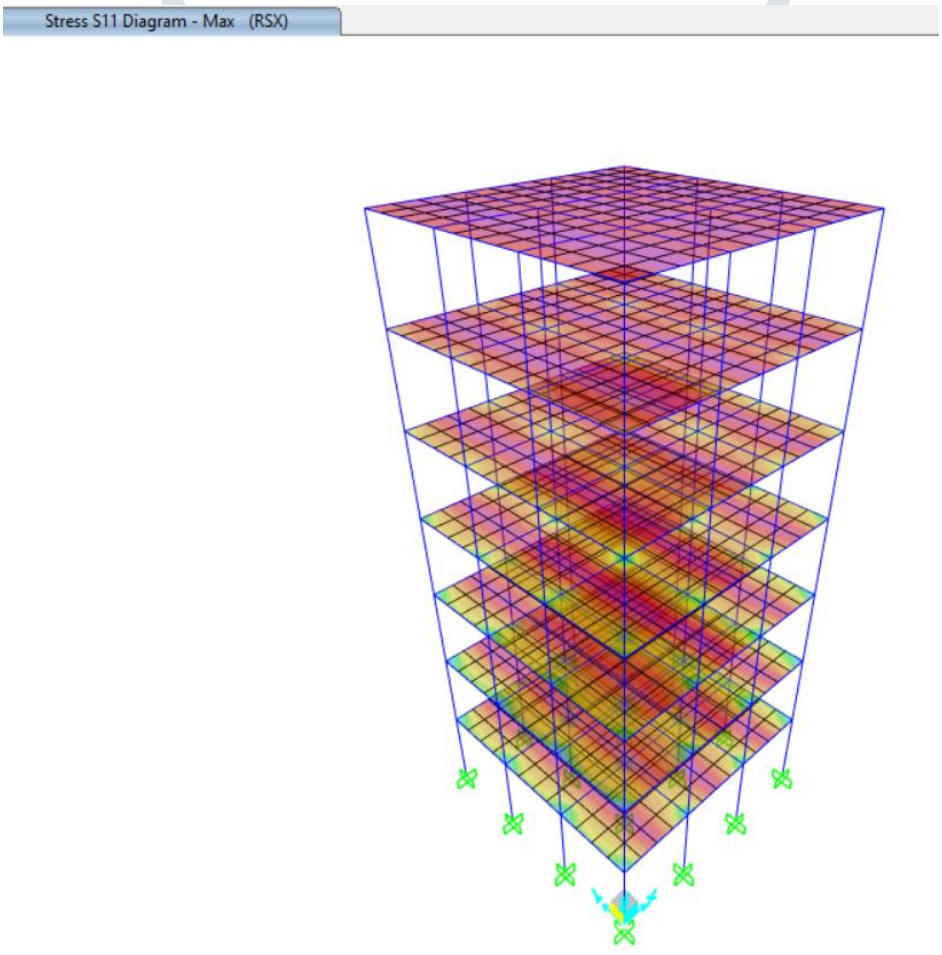


Figure 3.12: Tendon & Stress PT (G+7)

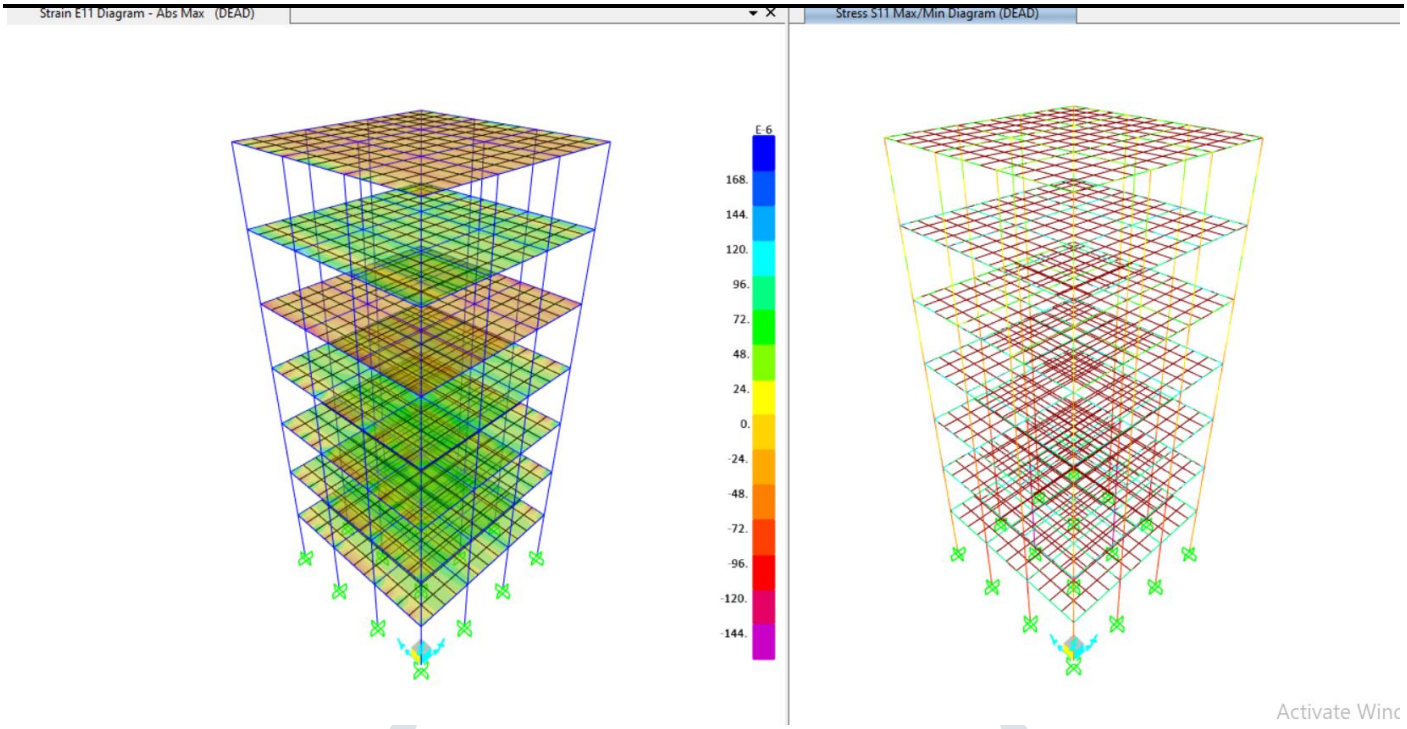


Figure 3.13: Deform Shape PT (G+7)

Material Properties and Load

- Grade of concrete M-40
- Grade of steel Fe500

Model Description

- Method of analysis – non-linear static analysis (response spectrum analysis)
- Dead load
- Live load
- Super dead load
- Earthquake x dire (IS 1893:2002)
- Earthquake y dire (IS 1893:2002)
- Seismic Zone = Zone – III
- Wind Zone = Zone – V

Earthquake and wind load data: For regular Structure

- Frame properties
- Beam 250mm x 450mm
- Column 250X 500mm
- Slab thick 150mm

For Flat Slab

- Col 400mm X 400mm
- Slab 250mm

PT slab model

- Tendon dia 300mm
- Beam 250mm x 450mm
- Column 250X 500mm
- Slab thick 150mm

Load Combinations

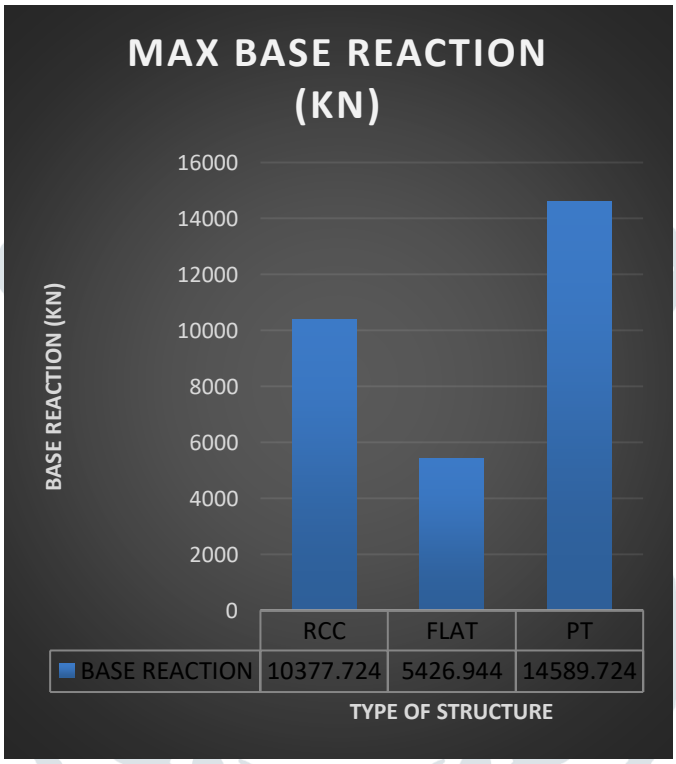
- 1.2DL+1.6LL
- 1.2DL+LL+EQx/y
- 1.2DL+LL-EQx/y
- 1.2DL+LL+EQx/y
- 1.2DL+LL-EQx/y
- 0.9DL+EQx/y
- 0.9DL-EQx/y

- 1.2DL+LL+Rsx/y
- 1.2DL+LL-Rsx/y
- 0.9DL+Rsx/y
- 0.9DL-Rsx/y

Maximum Base Reaction

Table 3.1: maximum Base Reaction

MAX BASE REACTION (KN)		
RCC	FLAT	PT
10377.72	5426.944	14589.72

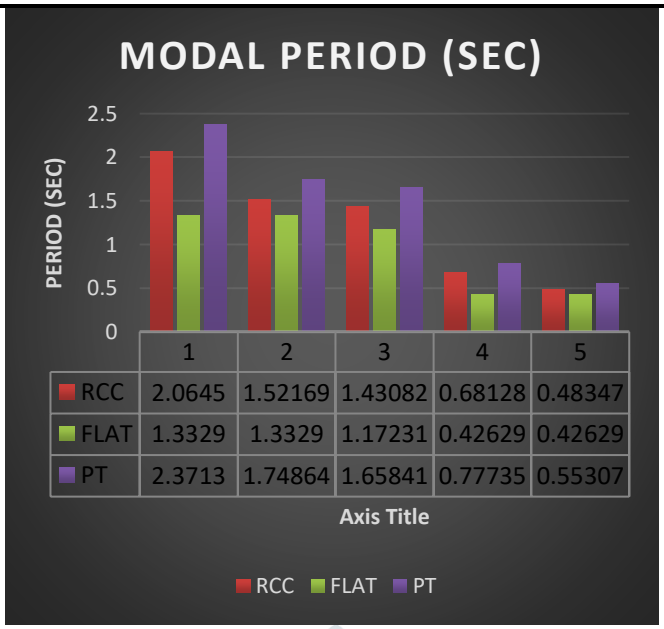


Graph 3.1: Maximum Base Reaction

Modal Period

Table 3.2: Modal Period

MODAL PERIOD			
MODAL PERIOD	**RCC**	**FLAT**	**PT**
1	2.064504	1.332897	2.371298
2	1.521694	1.332897	1.748641
3	1.430818	1.172312	1.65841
4	0.681284	0.426288	0.777351
5	0.483474	0.426288	0.553071



Graph 3.2: Modal period

IV. CONCLUSION

- The maximum base reaction of the PT slab structure is increasing by 28.87 % as compared to conventional RC framed structure and Flat slab structure is decreasing by 47.70% as compare to RC framed structure.
- The modal time period for PT slab structure is increasing by 13.08 % as compare to RC framed structured and Flat slab structure is decreasing by 35.75 % as compared to RC framed structured.
- The time period will be maximum at mode 1, 2 and 3. After mode 3, time period will reduce drastically.
- Base shear of conventional R.C. framed building is more than the flat slab building.
- Base shear in flat slab is increases constantly up to 3 floors and then it increases very slowly. And in conventional R.C. framed it increases up to 6 floors and then it decreases slowly.
- The comparative study of conventional, flat slab framed structure and post tension slab (G+7) is presented. The parameters considered are quantity and cost of beam, column and slab. Thus, based on the analysis the following conclusions are drawn.
- Weight of Flat slab structure is quite low as compared to conventional slab structure and post tension slab.
- Flat slab structures are the best solution for high rise structure as compared to conventional slab structure. And post tension slab.

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