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Comparative Analysis of RC Concrete Frames with Precast Concrete Frames

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Abstract: **The increasing urban population has led to a growing demand for high-rise buildings, demanding advancements in construction technology. Efficient use of land, slow construction process and maintaining structural safety standards in earthquake-prone areas are the main concerns in modern construction. Precast construction techniques allow prefabrication of structural components, which significantly reduces construction time and improving quality control while maintaining safety standards. In this study ETABS software is utilized for the structural analysis and design of high-rise buildings, focusing on parameters such as base shear, overturning moment, stiffness and story displacements using response spectrum analysis. The methodology includes comparison of different cases of reinforced concrete frames and precast concrete frames with varying concrete grades and dimensions. The findings shows that the performance of precast structures improves with higher-grade concrete and further increases with larger frame dimensions. This study concludes that precast structures save construction time by compromising some structural performance.**

Keywords — ETABS Software, High-Rise Buildings, Precast Concrete, Reinforced Concrete, Response spectrum analysis, Seismic Performance.

I. INTRODUCTION

Due to increased human population especially in the overcrowded cities, need for high rise building has become mandatory. They utilize limited land space in the most efficient ways, also offering essential residential and commercial facilities to users in towns. The high-rise buildings, in general, are more difficult in terms of structures, safety, and even their ability to handle earthquakes. This is particularly important considering areas that are prone to earth quakes, where building earthquake resistant remains a major concern [1]. The rapid advancement in construction technology has made compulsory to adapt efficient and sustainable construction methods to meet the increasing demand for infrastructure [8]. Conventional construction techniques, specifically cast in situ reinforced concrete construction, take more time and needs more human resource [7]. Therefore, modern techniques like precast construction and modular construction have come into more appreciation since they enable the construction of buildings with a greater reduction in construction time and better quality control with disadvantage of meeting safety standards [4].

To address these challenges, advanced software tools like ETABS are used in analysis and design. ETABS is a versatile program used for the analysis and design of buildings, providing sophisticated modelling and simulation capabilities that are cruicial for high-rise structures [8]. It allows engineers to conduct both static and dynamic analyses, including response spectrum and time-history analyses, to assess the building's behaviour under different loading conditions, including seismic loads [11]. This guarantees that the structures are not only efficient and economical but also safe and structurally suitable for the designed seismic intensity.

PRECAST STRUCTURES

Precast construction is the type of construction where structural components are first pre-fabricated in a factory or plant before being erected on the construction site [10]. This method differs from cast-in-place construction where concrete is placed at the site, and it hardens also at the site [14]. The types of precast concrete components that can be used are Precast columns, Precast beams, Precast walls, Precast slabs and others [7]. The idea of prefabricating such components off-site supports quality assurance since many of them are produced in factories, accelerates construction timelines, and decreases the amount of work done at construction sites [3]. Additionally, precast construction is often more environmentally friendly due to reduced waste and optimized material usage [9].

PURPOSE OF PRECAST STRUCTURES

The reason for adopting precast construction methods in a building project is to increase efficiency and quality of construction [7]. Precast structures are characterized by durability, quality finishes and reduced building periods [14]. This method also helps in the control of structural design of the components since they are made in a

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controlled setup [9]. In addition, precast construction is especially beneficial for structures implemented in seismically sensitive areas, as the connections and joints of precast elements demonstrate better seismic performance [14]. This method also helps to uphold sustainable construction practices since it minimizes on-site wet working, noise, and dust pollution and respects the proper use of resources [9].

APPLICATIONS

- assists in designing earthquake resistant building
- Can help engineers to make decision in terms of choosing appropriate material and design value to improve the seismic capable of structures.
- Offers guidance for the selection of concrete grades for precast concrete.
- Gives recommendations about what structural dimensions and configurations would yield better performance while reducing the costs.
- Promotion of precast concrete usage by demonstrating its effectiveness in seismic conditions

LIMITATIONS

- Results depend on assumptions made in the ETABS model, which may differ in real world scenarios.
- Concrete properties of the real world can be different, ideal properties was adopted in this study, which cannot be true all the time.
- The study focuses on specific dimensions, which may not apply to all structures.
- The study might not represent local seismic conditions accurately.
- Real world earthquake damage can vary depending on the magnitude and time.

OBJECTIVES

The main goal of the work is to evaluate the performance of RCC and PC structures for a G+15 building. The study also aims in:

- Analysing RCC and precast structures with different concrete grades (M30, M40, M45, M100), to understand how material strength improves the building's performance under seismic loads.
- Examining different precast dimensions (230x450 mm, 300x450 mm, 300x700 mm) with a fixed high-grade concrete (M100), to determine how cross-sectional size improves structural stability and performance.

SCOPE OF THE WORK

- Developing structural models for all the cases in ETABS.
- Conducting Response Spectrum Analysis to analyse seismic conditions.
- Extracting results for displacement, drifts, shear force, overturning moment, and stiffness.
- Comparing the performance of structures with different concrete grades and dimensions.
- Discuss trends and opinion based on the results.

II. LITERATURE REVIEW

K. Surender Kumar et al., (2020) [1] - G+8 building for General Commercial Apartment in Hyderabad, Telangana was analysed using ETABS and Staad.Pro softwares using response spectrum Analysis this Proposed G+8 RCC Building. Its purpose was to verify the design according to relevant codes and standards. The results showed similarity in shear force and bending moment in both the softwares. The authors concluded that both ETABS and Staad.Pro are suitable software options for analysis, both softwares reduces time required for design and analysis.

Lovneesh Sharma et al., (2020) [2] - The study compared pre-engineered steel buildings to conventional steel buildings using STAAD PRO software. The findings showed that pre-engineered buildings have several advantages. They are more cost-effective, quicker to build, and offer higher quality and more design flexibility. They also demonstrate better structural performance with lower maintenance costs. Overall, the study suggests that pre-engineered steel buildings are a better choice than conventional steel buildings.

Uma Ravi Teja Macherla et al., (2020) [3] - The study compares the cost and time efficiency of composite construction (structural steel and concrete) and precast concrete construction for high-rise buildings. Using a 16-story building in Hyderabad as a case study, study analysed construction times with Primavera P6-2017 for scheduling and calculated costs for both methods. The findings indicate that composite construction reduces the project timeline by about 33 days compared to precast construction but is slightly more expensive. Precast construction, although taking longer, proves to be more economical overall.

Al Agha et al.,(2021)[4] performed an analytical investigation on the behavior of irregular reinforced concrete buildings with shearwall and dual framed-shearwall system. The research used ETABS V16 in the analysis of the structures of the buildings. Nine different configurations of the building were modeled in 2 software – the response was analyzed using both the Equivalent Static Method and the Response Spectrum Method. The characteristics such as the base shear, fundamental natural period, displacement and the maximum bending moment evaluated .The results indicated that for the Response Spectrum Method, the obtained values were comparatively higher than those of the Equivalent Static Method other than the models where the maximum top story displacement occurred in the X direction.

Adhil Manoj Philip et al., (2021) [5] - Research

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analyses the constructability of cast in-situ, precast, and modular reinforced concrete structures using BIM. The study review advances in construction techniques, focusing on how BIM automates design. Using Autodesk Revit 2019, they create a 3D model and apply linear programming to compare cost, time, quality, and safety. Their results, based on real construction data, show that modular construction and precast is the most efficient. The study concludes that modular construction and precast offers significant benefits over traditional methods.

Saikumar et al., (2021) [6] - In this study G+12 building was modelled in ETABS. Analysis was carried out using Response Spectrum Analysis. Steel bracings and shear walls was compared for seismic performance based on parameters such as storey drift, storey shear, storey bending, time period, and frequency. Shear walls showed higher storey drift in both X and Y directions in comparison with steel bracings.

Wesam Al Agha et al., (2021) [7] - This study examines the seismic performance of irregular reinforced concrete buildings with shear walls and dual framed-shear wall systems. Using ETABS software, the study compares the Equivalent Static Method and Response Spectrum Method. nine models of G+9 and G+6 storeyed residential buildings were analyzed for results of base shear, bending moment, and displacement. The findings show that the Response Spectrum Method generally generates higher values than the Equivalent Static Method, especially in top story displacements. This shows that the Response Spectrum Method offers more safer estimates.

B. Kezia Sukeerthi et al., (2022) [8] - The study used ETABS software to design precast columns and beams for an irregular building, focusing on how they handle earthquakes and wind. It identified key beam-column connections and suggested using emulative connections that are like traditional cast-in-place connections but don't need complex methods like prestressing or welding. The research highlighted advanced materials like micro concrete and high-strength steel rebar to reduce congestion and cracking. It also looked at how the structure responds in terms of story displacement, shear, stiffness, drift, time period.

Ehtisham Uddin Syed et al., (2022) [9] - Study is on the analysis and design of buildings using Revit and ETABS software shows the importance of the increasing demand for multi-story buildings due to population growth. The paper focuses on a G+10 reinforced concrete structure, comparing the results from both software applications against manual calculations. Both Revit and ETABS follow the Indian Standard Code of Practice and significantly reduce manual workload and time. The research concludes that ETABS yields results closer to manual calculations, whereas Revit's Robot Structures offers more conservative estimates.

Srivastava et al. (2023) [10] - 3d reinforced model with composite columns G+3 residential building located in Earthquake Zone II was modelled using ETABS software and was analysed based the result of story drift, total weight, base shear, shear force, bending moment, and column axial forces. Graphs and tables were drawn for this specific G+3 building. Static analysis with load combinations was understood using this study.

Bin Zhao et al., (2023) [11] - Compares the seismic performance of simple bolt-connected precast RC frames to traditional cast-in-situ RC frames. Using 1/5-scale models in shaking table tests, it was found that precast frames show bending deformation and uniform damage distribution, while cast-in-situ frames exhibit better energy dissipation due to plastic hinges. Although precast frames perform well overall, they present some concerns in high seismic areas.

Sivakumar et al., (2023) [12] - In this study RC building (G+9) was modelled in ETABS. Seismic analysis was conducted using Response Spectrum method. Basic requirements of reinforced concrete structure for seismic analysis using Response Spectrum method understood. Structural elements designed to resist lateral seismic loads. Results include maximum storey displacement, maximum storey drift, storey shear, and storey stiffness.

Hao Li et al., (2023) [13] - This study examined how multi story precast concrete parking structures fail during earthquakes. Using the SPO2FRAG method, researchers analysed how variations in connector stiffness and the number of stories affect seismic responses and the likelihood of collapse. They discovered that these factors significantly influence structural fragility. this study showed connector failure can lead to overall structural collapse. Nonlinear static pushover analysis was used to observe plastic hinges and to assess the effectiveness of diaphragms in preventing collapse.

Xiaonong Guo et al., (2024) [14] - Experimental shaking table test was performed on Reinforced concrete frames and precast frame specimens with viscous dampers for both the frames. Study showed that Viscous dampers improve seismic performance, with slight differences between reinforced concrete and precast frames. Precast frames showed similar performance overall but exhibited differences in failure modes and loading capacities. author also concluded that further research is recommended for optimizing viscous damper application in PC frames.

Zhang et al., (2024) [15] - In this study precast concrete structures, using dry connections, such as welds, bolts, and pins are analyzed. A shaking table test on a three-story precast frame structure demonstrated excellent seismic performance, with a maximum story drift within design limits under severe earthquakes. Comparing to traditional cast-in-place joints, some dry connections showed lower strength and performance, but newer designs with bolted or post-tensioned joints showed improvements.

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Zhenli Wu et al., (2024) [16] - This study looked at how semi-rigid reinforced concrete beam-column joints with bolted angle connections perform during earthquakes. Researchers tested ten full-scale joints under cyclic loading to see how different connection details affected their behavior. results have shown these joints perform well in seismic condition, with a stable hysteresis behavior, when comparing the behaviors of joints and those of traditional steel connections. A theoretical model has been developed theoretically to predict the initial stiffness and lateral strength of a semi-rigid joint matching well the experimentally obtained results. If you want to submit your file with one column electronically, please do the following:

Ingle et al., (2024) [17] a 10-story precast building was investigated , comparing twelve modeling techniques and three hysteresis effects, and found that precast frames can perform better than monolithic frames. Emulated joints, which mimic monolithic behavior, improve the seismic performance of precast frames. Standard monolithic model will underperform in important seismic responses like top story displacement and inter-story drift. Accurate modeling ensures the safety and resilience of precast concrete structures during earthquakes.better than the monolithic frame, emphasizing the need for accurate modeling in seismic design. Research on the seismic performance of precast concrete structures shows that accurate modeling of beam-column connections is crucial.

III. METHODOLOGY

The methodology involved in this project is very simple. A simple 15 storey building with concrete column and beam are modeled using ETABS software, walls are not provided since walls have not effect on results. First 15 storey RCC building is modeled for M30 grade for normal dimensions then the same building is modeled as precast structures for increasing grades and increasing dimensions. Analysis results of each building model is recorded. Response spectrum analysis is conducted for seismic zone 3.

SPECIFICATION OF MULTI-STORY BUILDING

The basic building features are given below:

Salient Features

- Building utility: commercial building
- No of storey's: G+15

Geometric details

- Floor to floor height: 3.5 m
- Total length: 20m
- Total width: 20m
- Overall height: 52.6 m
- Floor area: 400 m^2

WORKING WITH ETABS

Open a new project and in general data set the IS codes as per requirement (i.e. IS 456: 2000 for RCC design and Use Buit-in Settings with Display Units as Metric SI select Region for Default Materials as India, select steel selections for data base as Indian, Steel Design Code as IS 800:2007, Concrete Design Code is 456:2000, i.e. M30 for columns, slabs and beams and FE 415 for reinforcement. Since earthquake loads are to be considered set the values of factors as per the code.

DEFINE STOREYS

specify number of floors its height and elevation as shown in figure

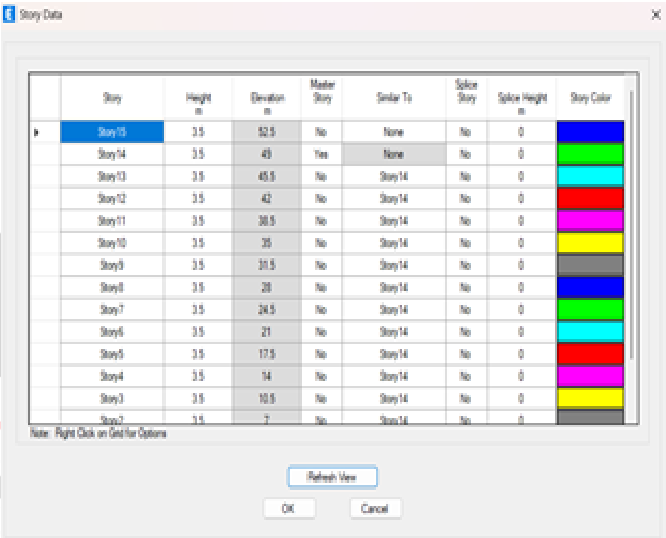
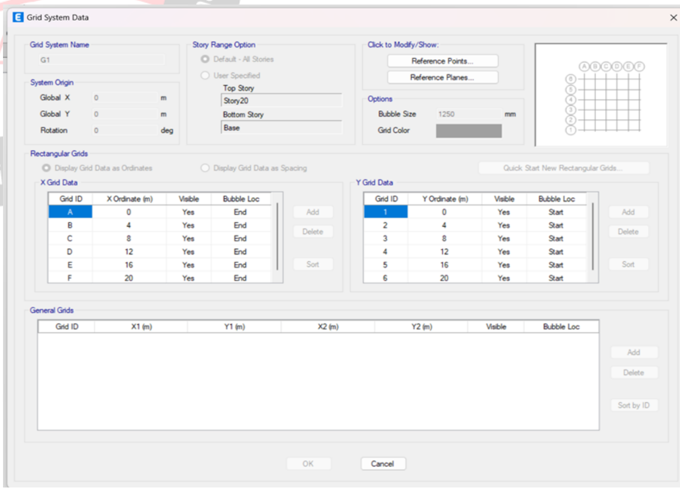


Fig 1: specify stories

3.3.3: DEFINING GRIDLINES



Specify the spacing of gridlines which is necessary for adding columns and beams.

Fig 2: Specify Gridlines

DEFINE COLUMN AND BEAM

The dimensions, materials and clear covers are specified as per the requirement and columns are plotted as per the plan for different criteria and and cases

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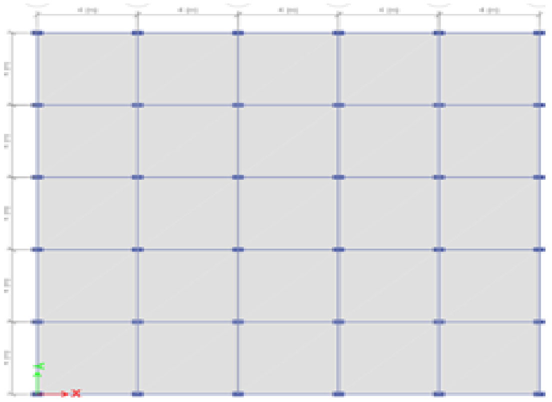


Fig 3: column layout

Specify grade of concrete

Concrete grades and its properties are defined for different cases is given in the table

Table 1: Concrete Properties for different grades

Concrete Grade	Modulus of Elasticity (GPa)	Shear Modulus (GPa)
M30	27.39	11.41
M40	31.63	13.18
M45	33.54	13.98
M100	50	20.33

3.3.4.2: SPECIFY DIMENSIONS

Dimensions of beams and columns are defined for different cases and criteria and modeled accordingly

Table 2: Frame Dimensions

Sl. No.	Section Type	Dimensions (mm)
1	RCC	230 x 450
2	Precast	230 x 450
3	Precast	300 x 450
4	Precast	300 x 700

DEFINE SLAB

Select the type of slab required and specify the depth of slab also specify the material. Which is M30 grade and depth of 150 mm

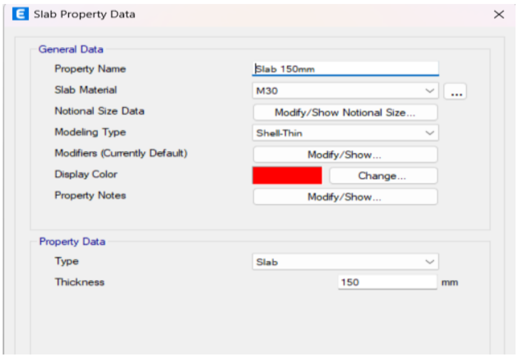
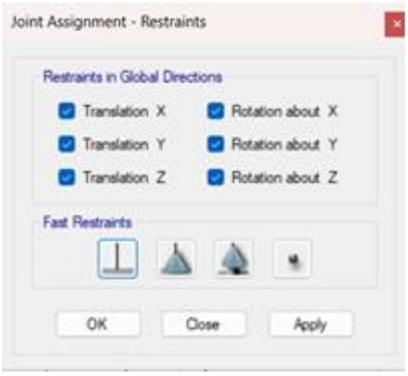


Fig 4: Defining slab thickness and grade

SUPPORT CONDITION



Specify whether the support is fixed, pinned or hinged. In our case it is fixed.

Fig 5: Assign support conditions

ASSIGNING LOADS

Loads are assigned under IS 875:2000-part1, IS 875:2000-part2, and IS 1893:2002. Applying loads with specific values, extra loads aren't important here, only live load of 4kn/m2, dead load of 13.5kN/m2 like wall load, 1kN/m2 of floor finish, and seismic load for zone III is what matters for seismic response

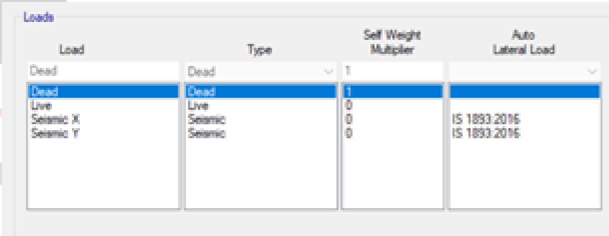


Fig 6: Load assignments

ANALYSIS OF MODEL

After applying the various loads, the load cases are defined to run analysis of the model. Once the load cases and loads are set model will be set to analyzed in ETABS software. Software will perform calculations to determine the structural response under applied loads. Results can be reviewed in the software after analysis gets completed in the form of tables or graphs.

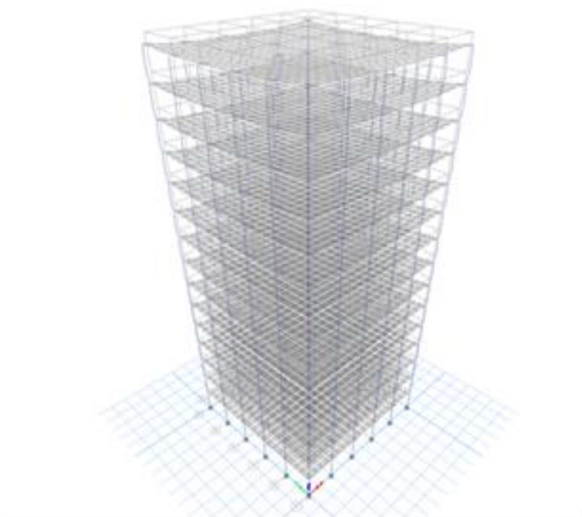


Fig 7: 3-D analysis

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VALIDATION

A simply supported reinforced beam is modeled and results are compared with manual calculations. The objective of this is to validate the results of the project.

Table 3: Beam details

Depth (D)	400mm
Breadth (b)	230mm
Span(L)	4 meters
fck	30MPa
fy	Fe500
Concrete density	25 kN/m³
Effective cover(d')	25mm
Reinforcement Diameter	16mm
effective depth (d)	367mm

SUPPORT CONDITIONS

A simply supported beam in which vertical movements are restrained but horizontal movements and rotational movements are allowed. No additional loads acts on the beam, except its own dead load.

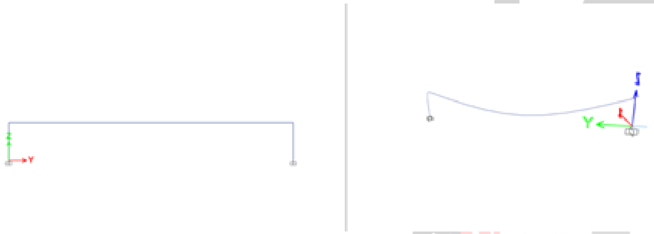

Fig 8: Simply supported beam

ETABS RESULTS

RCC beam of 230X400 mm was modelled using ETABS and analyzed using static analysis of dead load and live load results obtained were:

Max Shear force @ ends= 4.4435 kN

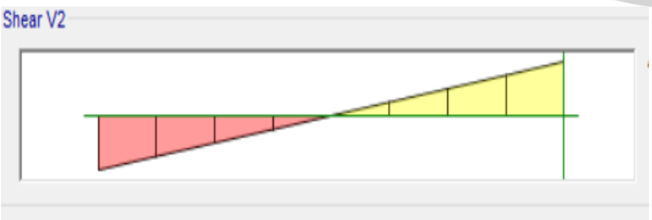

Fig 9: Shear force diagram

Max Bending moment @ center =4.5220 kN-m

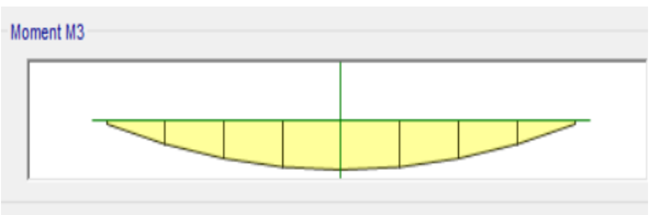

Fig 10:Bending moment diagram

Maximum Deflection =0.024mm

Fig 11:deflection diagram

MANUAL CALCULATION

Weight of the Beam (Dead Load):

$$W = V \times density$$

W=0.23m×0.4m 4m×25 kN/m3

W=9.2 kN

Dead Load per Unit Length:

$$w = \frac{W}{L}$$

$$w = \frac{9.2\,kN}{4m}$$

w=2.3 kN/m

Shear Force (Vmax):

$$Vmax = \frac{wL}{2}$$

$$Vmax = \frac{2.3\,kN \times 4\,m}{2}$$

$$\boldsymbol{Vmax} = \mathbf{4.6kN}$$

Bending Moment (*M*max):

$$M\text{max} = \frac{wL^2}{8}$$

$$M_{\text{max}} = \frac{2.3\ \text{kN/m} \times 4^2\ \text{m}^2}{8}$$

$$M_{\text{max}} = \frac{2.3 \times 16}{8}$$

$$M_{max} = \frac{36.8}{8}$$

$$\boldsymbol{M_{\text{max}} = 4.6\ \text{kN} \cdot \text{m}}$$

Deflection (*δ*max):

$$\delta_{\text{max}} = \frac{5wL^4}{384EI}$$

Modulus of elasticity:

$$E = 5000\sqrt{f_{\text{ck}}}$$

$$E = 5000\sqrt{30}$$

$$E \approx 27385\ \text{MPa}$$

Moment of inertia:

$$I = \frac{bd^3}{12}$$

$$I = \frac{230 \times 367^3}{12}$$

$$I = \frac{230 \times 49{,}368{,}703}{12}$$

$$I \approx 946{,}233{,}474\ \text{mm}^4$$

$$I \approx 946.23 \times 10^6\ \text{mm}^4$$

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Substituting E and I

$$\delta_{max} = \frac{5 \times 2.3 \times 10^3 \times 4000^4}{384 \times 27385 \times 10^3 \times 946.23 \times 10^6}$$

$$\delta_{max} = \frac{2944 \times 10^{15}}{9{,}948{,}576 \times 10^{12}}$$

$$\delta_{max} \approx 0.29 \times 10^3 \text{ mm}$$

$$\boldsymbol{\delta_{max} \approx 0.029\,mm}$$

RESULT COMPARISON

Table 4: ETABS vs Manual calculation results

	ETABS	Manual Calculation	% Variation
Max Shear Force	4.4435 kN	4.6 kN	3.46%
Max Bending Moment @ centre	4.5220 kN-m	4.6 kN-m	1.71%
Maximum Deflection	0.024 mm	0.029 mm	18.84%

- The ETABS shows conservative results compared to manual calculations.
- Both methods give very close results, there is good agreement between ETABS and manual calculation results.

RESULTS AND DISCUSSION

ANALYSIS CRITERIA

Criteria A

- **Case 1:** Reinforced concrete frame with concrete grade of M30 and frame dimensions 230x450 mm.
- **Case 2**: Precast concrete frame with concrete grade of M30 and frame dimensions 230x450 mm.
- **Case 3:** Precast concrete frame with concrete grade of M40 and frame dimensions 230x450 mm.
- **Case 4**: Precast concrete frame with concrete grade of M45 and frame dimensions 230x450 mm.
- **Case 5**: Precast concrete frame with concrete grade of M100 and frame dimensions 230x450 mm.

Criteria B

- **Case 1:** Precast concrete frames with the frame dimensions 230x450 mm and M100 concrete grade
- **Case 2**: Precast concrete frames with the frame dimensions 300x450 mm and M100 concrete grade
- **Case 3**: Precast concrete frames with the frame dimensions 300x700 mm and M100 concrete grade

DISPLACEMENTS

Displacements along x direction in mm for criteria- A (in mm)

The allowable limit of displacements between 2 stories according IS 456 2000 is 0.004 times the storey height in our case allowable drift is 14 mm. Case 2 (Precast M30) and case 3 (Precast M40) fails in the bottom stories. all other cases are well within allowable limit. Case 1 (RCC M30) shows better displacement values compared to other cases. Case 5 (Precast M100) shows better performance in precast structures.

Table 5: Displacements along X for criteria A

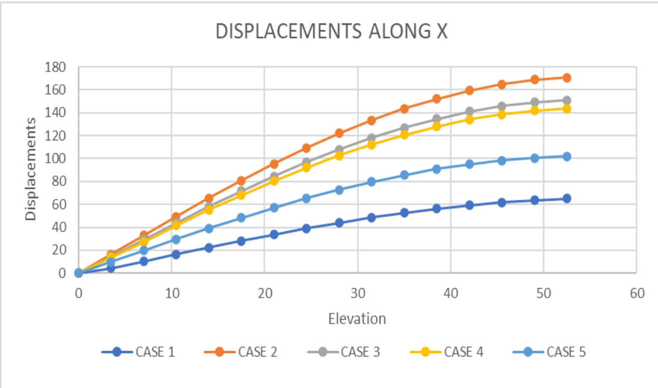

Fig 12:Displacement along X graph for Criteria-A

Displacements along Y direction (in mm) for criteria- A

Only case 1 (RCC M30) and case 5 (precast M100) shows that displacements are within allowable limit of 14 mm rest of the cases fail in bottom stories due to earth quake loading. RCC structure exhibit lower displacements Precast

Table 6: Storey Displacement Along Y for criteria -A

DISPLACEMENTS ALONG Y						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m	mm	mm	mm	mm	mm
Story15	52.5	74.1673	181.0403	161.3263	150.8923	105.0693
Story14	49	72.9113	178.9473	159.4893	149.1513	103.8653
Story13	45.5	71.0623	175.1173	156.1133	145.9463	101.6193
Story12	42	68.5943	169.5883	151.2323	141.3093	98.3553
Story11	38.5	65.5383	162.4313	144.9113	135.3023	94.1163
Story10	35	61.9323	153.7383	137.2293	128.0013	88.9573
Story9	31.5	57.8213	143.6103	128.2763	119.4913	82.9383
Story8	28	53.2553	132.1603	118.1513	109.8673	76.1253
Story7	24.5	48.2873	119.5113	106.9663	99.2333	68.5923
Story6	21	42.9753	105.7993	94.8373	87.7013	60.4193
Story5	17.5	37.3803	91.1673	81.8933	75.3933	51.6903
Story4	14	31.5683	75.7703	68.2693	62.4383	42.4983
Story3	10.5	25.6103	59.7713	54.1103	48.9733	32.9383
Story2	7	19.5883	43.3503	39.5743	34.1493	23.1173
Story1	3.5	13.6713	26.7043	24.8363	21.1313	13.1513
Base	0	0	0	0	0	0

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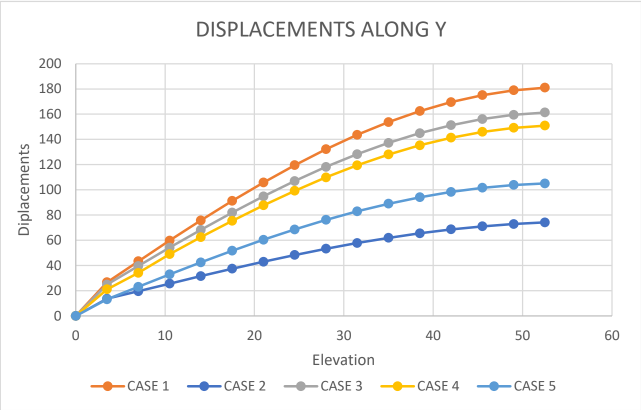

Fig 13:Displacement along Y Graph for Criteria- A

Displacements along X direction (in mm) for criteria- B

Case 3 (300x700 mm) is the most effective, exhibiting the lowest displacements and the highest stiffness, ensuring compliance with the displacement limits specified in IS 1893.Case 1(230x450 mm) and Case 2(300x450 mm), while showing some improvement with increased width, still result in displacements that exceed the allowable limits, making them less suitable for high-rise structures with M100 concrete grade.

DISPLACEMENTS ALONG X				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m	mm	mm	mm
Story15	52.5	101.815	91.187	30.76
Story14	49	100.611	90.144	30.288
Story13	45.5	98.365	88.163	29.514
Story12	42	95.101	85.268	28.445
Story11	38.5	90.862	81.496	27.096
Story10	35	85.703	76.895	25.484
Story9	31.5	79.684	71.518	23.628
Story8	28	72.871	65.425	21.549
Story7	24.5	65.338	58.682	19.27
Story6	21	57.165	51.359	16.816
Story5	17.5	48.436	43.532	14.21
Story4	14	39.244	35.284	11.483
Story3	10.5	29.684	26.701	8.663
Story2	7	19.863	17.878	5.784
Story1	3.5	9.897	8.919	2.881
Base	0	0	0	0

Table 7: Storey Displacement Along X for criteria -B

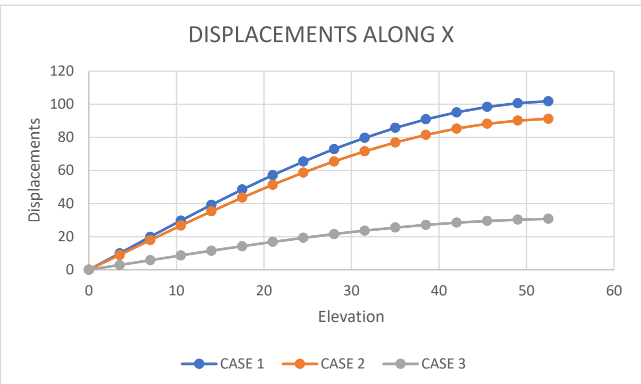

Fig 14:Displacement along X graph for Criteria-B

Displacements along y direction (in mm) for criteria- B

Displacements decreases with increasing cross-sectional dimensions of beams and columns. For a given grade of concrete (M100), selecting larger dimensions for structural elements enhances rigidity and improves the overall seismic response of the structure. case 3 (300 X 700) shows better performance even in Y direction.

DISPLACEMENTS ALONG Y				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m	mm	mm	mm
Story15	52.5	105.0693	96.007	36.104
Story14	49	103.8653	95.032	35.632
Story13	45.5	101.6193	93.055	34.858
Story12	42	98.3553	90.103	33.789
Story11	38.5	94.1163	86.214	32.44
Story10	35	88.9573	81.437	30.828
Story9	31.5	82.9383	75.827	28.972
Story8	28	76.1253	69.446	26.893
Story7	24.5	68.5923	62.361	24.614
Story6	21	60.4193	54.646	22.16
Story5	17.5	51.6903	46.379	19.554
Story4	14	42.4983	37.644	16.827
Story3	10.5	32.9383	28.533	14.007
Story2	7	23.1173	19.143	11.128
Story1	3.5	13.1513	9.581	8.225
Base	0	0	0	0

Table 8: Storey Displacement Along Y for criteria -B

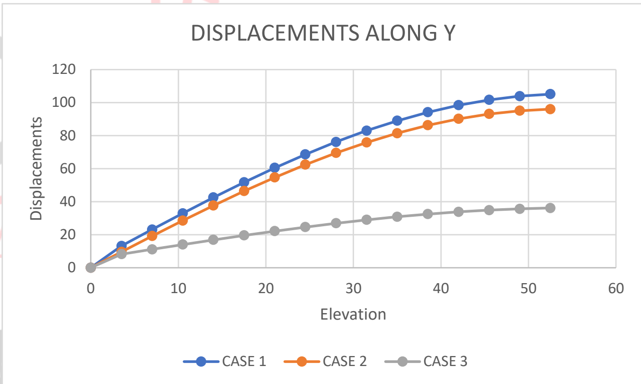

Fig 15:Displacement along Y graph for Criteria-B

STOREY DRIFTS

Maximum storey drift along X direction for Criteria -A

Case 2 (precast M30) and case 3 (precast M40) are above the limit of 0.004 storey drift. other cases show below limit of 0.004 which is safe as the grade of precast concrete increases from M30 to M100 (Cases 3, 4, and 5), the inter-story drifts consistently decrease and case RCC M30 grade shows best performance in terms of inter storey drift.

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DRIFTS ALONG X						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m					
Story15	52.5	0.000365	0.000612	0.000537	0.000509	0.000353
Story14	49	0.000542	0.001133	0.000999	0.000948	0.000665
Story13	45.5	0.000725	0.001637	0.001445	0.001373	0.000967
Story12	42	0.000897	0.00211	0.001864	0.001771	0.00125
Story11	38.5	0.001054	0.002548	0.002252	0.00214	0.001512
Story10	35	0.001196	0.002952	0.002609	0.00248	0.001755
Story9	31.5	0.001323	0.003321	0.002936	0.002791	0.001976
Story8	28	0.001434	0.003654	0.003231	0.003072	0.002176
Story7	24.5	0.001529	0.003948	0.003492	0.003321	0.002354
Story6	21	0.001606	0.004202	0.003717	0.003534	0.002506
Story5	17.5	0.001665	0.004412	0.003904	0.003712	0.002634
Story4	14	0.001704	0.004577	0.004051	0.003852	0.002735
Story3	10.5	0.001721	0.004694	0.004155	0.003951	0.002807
Story2	7	0.001692	0.004756	0.004211	0.003986	0.002848
Story1	3.5	0.001262	0.0047	0.004166	0.003965	0.002828
Base	0	0	0	0	0	0

Table 9: Storey Drifts Along X Direction for Criteria -A

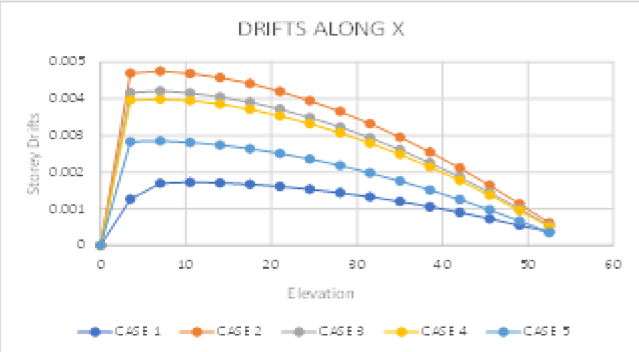

Fig 16:Drift along X graph for criteria A

Maximum storey drift along Y direction for Criteria -A

Case (RCC M30) 1 Shows the least inter-story drift values across all stories. Case 2 (Precast M30) Exhibits the highest inter-story drift values, Higher Grades of Precast Concrete (case 3 to case 5): As the grade of concrete increases, the inter-story drifts decreases. only 2 cases case 1 (RCC M30) and case 5 (precast M100) shows below the level of 0.004 other cases fail in lower stories

Table 10: Storey Drifts Along X Direction for Criteria -A

DRIFTS ALONG Y						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m					
Story15	52.5	0.000359	0.000598	0.000525	0.000497	0.000344
Story14	49	0.000528	0.001094	0.000965	0.000916	0.000642
Story13	45.5	0.000705	0.00158	0.001395	0.001325	0.000933
Story12	42	0.000873	0.002045	0.001806	0.001716	0.001211
Story11	38.5	0.00103	0.002484	0.002195	0.002086	0.001474
Story10	35	0.001175	0.002894	0.002558	0.002431	0.00172
Story9	31.5	0.001305	0.003271	0.002893	0.00275	0.001947
Story8	28	0.001419	0.003614	0.003196	0.003038	0.002152
Story7	24.5	0.001518	0.003918	0.003465	0.003295	0.002335
Story6	21	0.001599	0.004181	0.003698	0.003517	0.002494
Story5	17.5	0.001661	0.004399	0.003893	0.003701	0.002626
Story4	14	0.001702	0.004571	0.004045	0.003847	0.002731
Story3	10.5	0.001721	0.004692	0.004153	0.004035	0.002806
Story2	7	0.001691	0.004756	0.004311	0.004194	0.002847
Story1	3.5	0.001701	0.00493	0.004461	0.004338	0.002958
Base	0	0	0	0	0	0

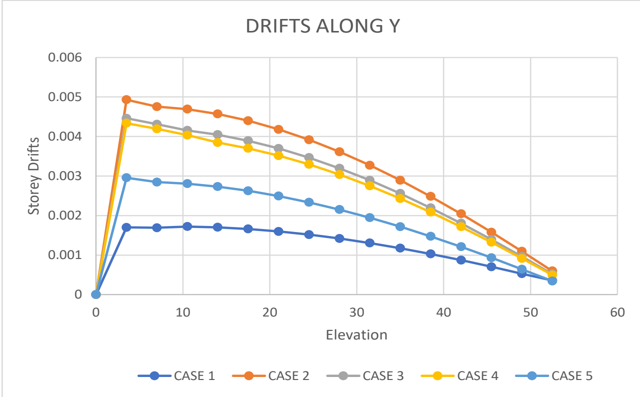

Fig 17:Drift along Y graph for criteria A

Maximum storey drift along X direction for Criteria -B

Case 3 (300x700 mm) is the most effective, exhibiting the lowest displacements and the highest stiffness, ensuring compliance with the displacement limits specified in IS 1893.Case 1 (230x450 mm) and Case 2 (300x450 mm), while showing some improvement with increased width, still result in displacements that exceed the allowable limits, making them less suitable for high-rise structures with M100 concrete grade.

DRIFTS ALONG X				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m			
Story15	52.5	0.000353	0.000305	0.000137
Story14	49	0.000665	0.000586	0.000227
Story13	45.5	0.000967	0.000856	0.000313
Story12	42	0.00125	0.001111	0.000395
Story11	38.5	0.001512	0.001348	0.000471
Story10	35	0.001755	0.001566	0.00054
Story9	31.5	0.001976	0.001766	0.000603
Story8	28	0.002176	0.001947	0.000658
Story7	24.5	0.002354	0.002108	0.000706
Story6	21	0.002506	0.002247	0.000747
Story5	17.5	0.002634	0.002363	0.000781
Story4	14	0.002735	0.002455	0.000806
Story3	10.5	0.002807	0.002522	0.000823
Story2	7	0.002848	0.00256	0.000829
Story1	3.5	0.002828	0.002548	0.000823
Base	0	0	0	0

Table 11: Storey Drifts Along X for Criteria -B

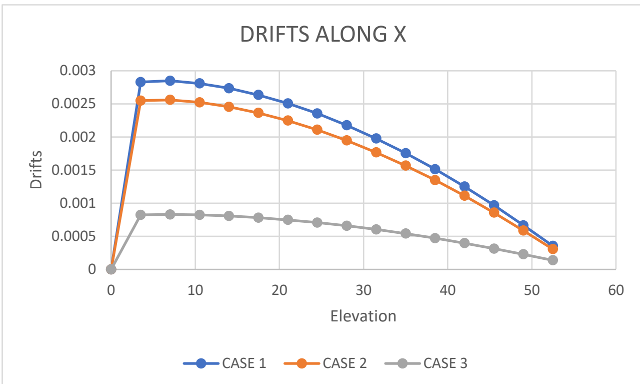

Fig 18:Drift along X graph for criteria B

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Maximum storey drift along Y direction for Criteria -B

Displacements decreases with increasing cross-sectional dimensions of beams and columns. For a given grade of concrete (M100), selecting larger dimensions for structural elements enhances rigidity and improves the overall seismic response of the structure. case 3 (300 X 700) shows better performance even in Y direction.

DRIFTS ALONG Y				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m			
Story15	52.5	0.000344	0.000279	0.000135
Story14	49	0.000642	0.000565	0.000221
Story13	45.5	0.000933	0.000843	0.000305
Story12	42	0.001211	0.001111	0.000385
Story11	38.5	0.001474	0.001365	0.000461
Story10	35	0.00172	0.001603	0.00053
Story9	31.5	0.001947	0.001823	0.000594
Story8	28	0.002152	0.002024	0.000651
Story7	24.5	0.002335	0.002204	0.000701
Story6	21	0.002494	0.002362	0.000745
Story5	17.5	0.002626	0.002496	0.000779
Story4	14	0.002731	0.002603	0.000806
Story3	10.5	0.002806	0.002683	0.000823
Story2	7	0.002847	0.002732	0.000829
Story1	3.5	0.002908	0.002737	0.000823
Base	0	0	0	0

Table 12: Storey Drifts Along X for Criteria -A

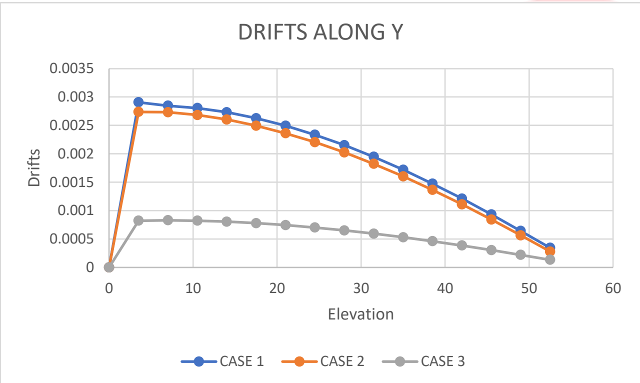

Fig 19: Drift along X graph for criteria B

SHEAR FORCE

shear force along X direction for Criteria A

Data shows that similar storey shears along different cases storey shears along x directions. Case 1 (RCC M30) shows least base shear compared to precast with increasing grades of precast from case 2 case 5 the storey shear increases but it is marginal. The allowable shear stress varies for different grades for building will experience maximum shear force in the bottom stories all cases are within limits except for case 2 (Precast M30). (shear stress =shear force /area) area of each floor is 402 m². Shear stress varies for different grades of concrete which is given as (**M30**: 3.5 MPa ,**M40**: 3.7 MPa,**M45**: 4.0 MPa,**M100**: 4.5 MPa)

SHEAR ALONG X						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m	kN	kN	kN	kN	kN
Story15	52.5	95.4035	92.9036	92.8696	92.8555	92.7573
Story14	49	257.2118	252.25	252.1816	252.1533	251.9533
Story13	45.5	410.0545	404.2623	404.1811	404.1473	403.906
Story12	42	552.0959	546.8871	546.8112	546.7794	546.5477
Story11	38.5	683.1324	679.59	679.5333	679.5092	679.3266
Story10	35	803.7609	802.659	802.6317	802.6196	802.5151
Story9	31.5	914.4154	916.3342	916.3437	916.3465	916.3413
Story8	28	1014.925	1020.345	1020.396	1020.416	1020.525
Story7	24.5	1104.736	1114.038	1114.135	1114.173	1114.406
Story6	21	1183.369	1196.783	1196.927	1196.984	1197.343
Story5	17.5	1250.553	1268.154	1268.343	1268.419	1268.9
Story4	14	1305.88	1327.683	1327.915	1328.008	1328.605
Story3	10.5	1348.362	1374.454	1374.724	1374.833	1375.533
Story2	7	1376.441	1406.978	1407.283	1407.406	1408.196
Story1	3.5	1388.827	1423.633	1423.966	1424.099	1424.96
Base	0	0	0	0	0	0

Table 13: Seismic Shear Along X Direction for Criteria A

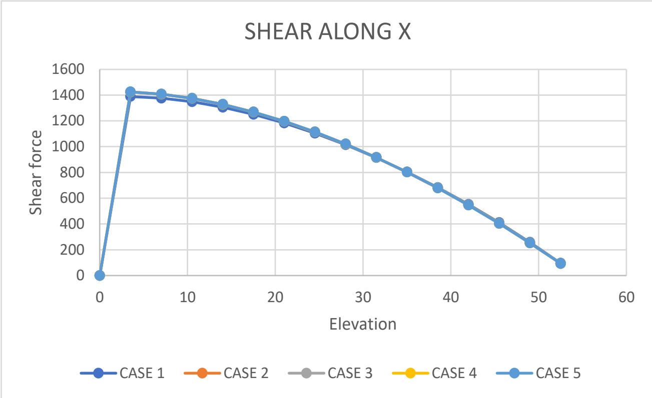

Fig 20:Shear graph along X for Criteria -A

Shear force along Y direction for Criteria A

The values for shear force are very similar across all five cases. This suggests that the type and strength of concrete (within the range provided: M30 to M100) have a minimal impact on the shear forces. The precast options (Cases 2 to 5) show slightly higher shear forces compared to RCC (Case 1), but the differences are marginal. all cases are well within shear limit except case 2(Precast M30) it fails in bottom 2 stories.

Table 14: Seismic Shear Along Y for Criteria A

SHEAR ALONG Y						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m	kN	kN	kN	kN	kN
Story15	52.5	93.9963	92.5671	92.5536	92.5482	92.5123
Story14	49	254.2198	251.3382	251.3116	251.3009	251.2301
Story13	45.5	405.7973	402.3586	402.3273	402.3147	402.2312
Story12	42	547.5351	544.2607	544.2313	544.2194	544.1401
Story11	38.5	679.8156	677.2513	677.2284	677.2192	677.1566
Story10	35	802.8183	801.4099	801.3976	801.3925	801.3568
Story9	31.5	916.0944	916.2144	916.2159	916.2165	916.2164
Story8	28	1019.216	1021.13	1021.148	1021.155	1021.197
Story7	24.5	1112.007	1115.866	1115.902	1115.916	1116.005
Story6	21	1194.087	1199.973	1200.028	1200.05	1200.189
Story5	17.5	1264.696	1272.646	1272.722	1272.753	1272.943
Story4	14	1323.069	1333.058	1333.155	1333.193	1333.436
Story3	10.5	1368.485	1380.439	1380.555	1380.602	1380.897
Story2	7	1399.738	1413.591	1413.727	1413.781	1414.126
Story1	3.5	1405.09	1430.75	1430.905	1430.966	1431.36
Base	0	0	0	0	0	0

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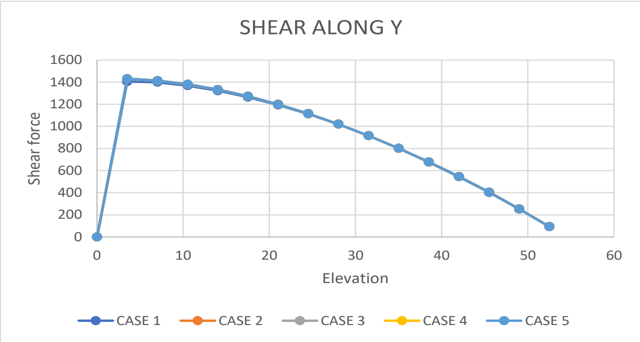

Fig 21:Shear graph along Y for Criteria -A

shear force along X direction for Criteria B

Case 1 (230x450 mm) Exhibits the lowest shear forces at each story level, indicating lower stiffness and higher flexibility. Case 2 (300x450 mm) Shows higher shear forces compared to Case 1, reflecting increased stiffness due to the larger cross-sectional area. Case 3 (300x700 mm) displays the highest shear forces at each story, indicating the highest stiffness and resistance to lateral loads among the three cases.

SHEAR ALONG X				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m	kN	kN	kN
Story15	52.5	92.7573	96.6696	107.8476
Story14	49	251.9533	260.1055	285.1074
Story13	45.5	403.906	416.0574	455.255
Story12	42	546.5477	562.4118	615.8932
Story11	38.5	679.3266	698.6235	765.4463
Story10	35	802.5151	824.9932	903.1718
Story9	31.5	916.3413	941.767	1028.996
Story8	28	1020.525	1048.659	1143.204
Story7	24.5	1114.406	1144.989	1246.07
Story6	21	1197.343	1230.099	1337.519
Story5	17.5	1268.9	1303.545	1416.935
Story4	14	1328.605	1364.847	1483.162
Story3	10.5	1375.533	1413.057	1534.693
Story2	7	1408.196	1446.636	1570.001
Story1	3.5	1424.96	1463.892	1587.898
Base	0	0	0	0

Table 15: Seismic Shear Along Y for Criteria B

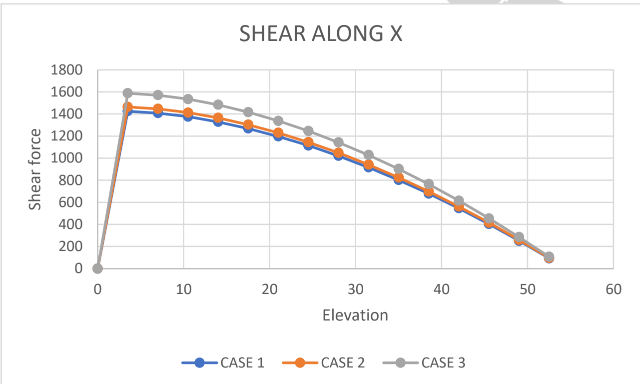

Fig 22:Shear graph along X for Criteria -B

Shear force along Y direction for Criteria B

Increasing the cross-sectional dimensions of beams and columns results in higher shear forces throughout the structure, reflecting the increased stiffness and improved seismic performance. Shear force was not increased to this level when grades of concrete was increased. so increasing dimensions was necessary

Table 16: Seismic Shear Along Y for Criteria B

SHEAR ALONG Y				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m	kN	kN	kN
Story15	52.5	92.5123	97.6276	108.9183
Story14	49	251.2301	262.4106	286.8699
Story13	45.5	402.2312	418.985	455.3247
Story12	42	544.1401	565.9767	613.764
Story11	38.5	677.1566	703.6251	762.4618
Story10	35	801.3568	832.0323	900.9449
Story9	31.5	916.2164	950.6831	1028.808
Story8	28	1021.197	1059.053	1145.817
Story7	24.5	1116.005	1156.87	1251.409
Story6	21	1200.189	1243.689	1344.976
Story5	17.5	1272.943	1318.699	1425.929
Story4	14	1333.436	1381.058	1493.322
Story3	10.5	1380.897	1429.98	1546.075
Story2	7	1414.126	1464.238	1583.028
Story1	3.5	1431.36	1482.018	1602.358
Base	0	0	0	0

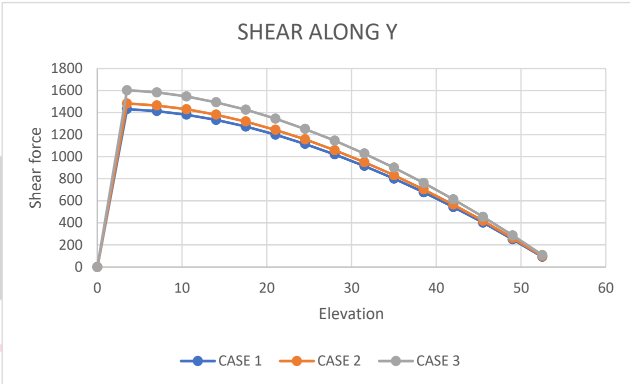

Fig 23:Shear graph along Y for Criteria -B

OVERTURNING MOMENT

Overturning moment along X for criteria A

The stabilizing moment for the building is 2483923.59kN-m multiplying the factor of safety 1.5 to our overturning moments value will be well below the stabilizing moment in all cases. Case 1 (RCC M30) grade shows more over turning moment in comparison to precast. Overturning moment decreases with increasing grade of concrete in precast from case 2 to case 5 but it is very marg.

OVERTURNING MOMENT ALONG X						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m	kN-m	kN-m	kN-m	kN-m	kN-m
Story15	52.5	0	0	0	0	0
Story14	49	328.987	323.985	323.9377	323.9187	323.793
Story13	45.5	1218.623	1203.561	1203.421	1203.365	1202.992
Story12	42	2637.672	2610.71	2610.462	2610.362	2609.701
Story11	38.5	4549.3	4511.266	4510.919	4510.78	4509.853
Story10	35	6917.591	6871.325	6870.907	6870.739	6869.615
Story9	31.5	9708.51	9658.419	9657.97	9657.789	9656.571
Story8	28	12887.88	12839.66	12839.23	12839.06	12837.88
Story7	24.5	16420.07	16380.42	16380.08	16379.94	16378.96
Story6	21	20268.26	20244.53	20244.33	20244.25	20243.65
Story5	17.5	24394.64	24394.44	24394.47	24394.48	24394.43
Story4	14	28759.83	28790.83	28791.15	28791.28	28791.98
Story3	10.5	33322.45	33392.08	33392.77	33393.05	33394.69
Story2	7	38039.08	38154.31	38155.44	38155.89	38158.66
Story1	3.5	42864.07	43031.17	43032.82	43033.47	43037.52
Base	0	47748.7	47973.06	47975.26	47976.14	47981.62

Table 17: Overturning moment Along X for Criteria

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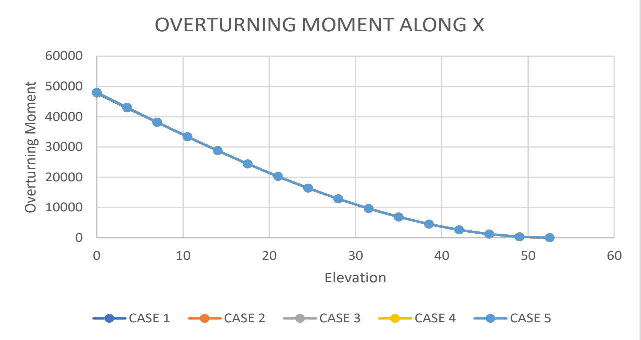

Fig 24:Overturning moment graph along X for Criteria -A

Overturning moment along Y for criteria A

The overturning moment for the building stories shows minimal variation across different cases of concrete type and strength (RCC M30 to Precast M100). The precast options (Cases 2 to 5) show slightly higher overturning moments compared to RCC (Case 1), but the differences are marginal. All the cases are well within stabilizing moment.

Table 18: Overturning moment Along Y Direction for Criteria A

OVERTURNING MOMENT ALONG Y						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m	kN-m	kN-m	kN-m	kN-m	kN-m
Story15	52.5	0	0	0	0	0
Story14	49	333.9124	325.1627	325.0436	324.9944	324.6506
Story13	45.5	1234.067	1207.986	1207.627	1207.479	1206.437
Story12	42	2668.538	2622.358	2621.718	2621.452	2619.569
Story11	38.5	4597.912	4534.052	4533.152	4532.777	4530.098
Story10	35	6980.906	6905.896	6904.809	6904.355	6901.07
Story9	31.5	9777.95	9701.291	9700.131	9699.643	9696.051
Story8	28	12951.89	12885.18	12884.09	12883.62	12880.1
Story7	24.5	16466.65	16423.04	16422.17	16421.79	16418.77
Story6	21	20285.48	20279.32	20278.85	20278.63	20276.58
Story5	17.5	24370.19	24416.63	24416.73	24416.74	24416.13
Story4	14	28681.24	28795.72	28796.55	28796.86	28798.16
Story3	10.5	33178.01	33375.76	33377.5	33378.17	33381.81
Story2	7	37818.33	38114.14	38116.91	38118	38124.35
Story1	3.5	42557.5	42965.51	42969.45	42971	42980.37
Base	0	47348.22	47881.07	47886.24	47888.3	47900.89

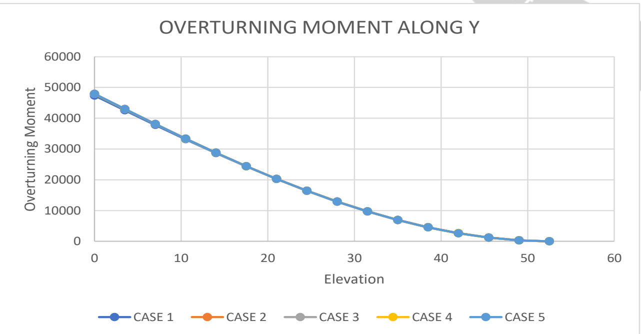

Fig 25:Overturning moment graph along Y for Criteria -A

Overturning moment along X for criteria B

Case 3 (300x700 mm) demonstrates the highest overturning moments, Case 1 (230x450 mm), while having the lowest overturning moments, may still be adequate if the design moments are within acceptable limits according to IS 456:2000. Case 2 (300x450 mm) offers a balance between improved resistance to overturning moments and manageable design requirements.

Table 19: Overturning moment Along X Direction for CriteriaB

OVERTURNING MOMENT ALONG X				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m	kN-m	kN-m	kN-m
Story15	52.5	0	0	0
Story14	49	323.793	341.6966	381.2141
Story13	45.5	1202.992	1260.019	1385.021
Story12	42	2609.701	2725.301	2976.553
Story11	38.5	4509.853	4701.661	5117.789
Story10	35	6869.615	7153.583	7772.664
Story9	31.5	9656.571	10047.1	10905.01
Story8	28	12837.88	13347.88	14477.02
Story7	24.5	16378.96	17019.91	18449.65
Story6	21	20243.65	21025.65	22782.47
Story5	17.5	24394.43	25326.25	27433.32
Story4	14	28791.98	29881.09	32358.25
Story3	10.5	33394.69	34647.26	37511.29
Story2	7	38158.66	39579.56	42843.81
Story1	3.5	43037.52	44630.3	48304.3
Base	0	47981.62	49748.43	53837.73

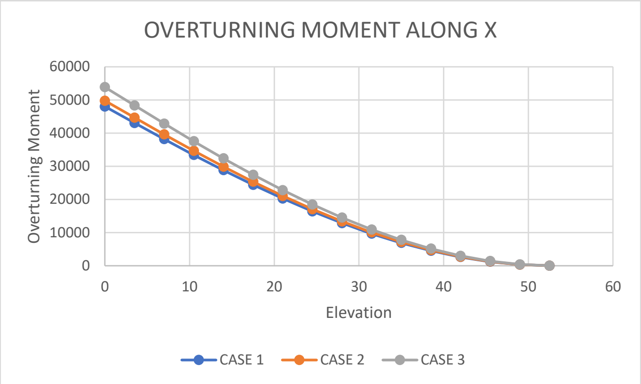

Fig 26:Overturning moment graph along X for Criteria -B

Overturning moment along Y for criteria B

While increasing the cross-sectional dimensions (as in Case 3) enhances the stiffness and the load-carrying capacity. There is significant variations based on cross-sectional dimensions when compared to change in grades.

OVERTURNING MOMENT ALONG Y				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m	kN-m	kN-m	kN-m
Story15	52.5	0	0	0
Story14	49	324.6506	338.3435	377.4667
Story13	45.5	1206.437	1248.659	1375.318
Story12	42	2619.569	2704.295	2968.488
Story11	38.5	4530.098	4670.238	5123.123
Story10	35	6901.07	7108.46	7799.181
Story9	31.5	9696.051	9981.541	10953.18
Story8	28	12880.1	13253.66	14540.59
Story7	24.5	16418.77	16889.52	18517.54
Story6	21	20276.58	20852.78	22841.46
Story5	17.5	24416.13	25105.12	27470.78
Story4	14	28798.16	29606.31	32363.82
Story3	10.5	33381.81	34314.47	37477.33
Story2	7	38124.35	39185.83	42765.11
Story1	3.5	42980.37	44173.82	48177.18
Base	0	47900.89	49228.22	53659.79

Table 20: Overturning moment Along Y for Criteria B

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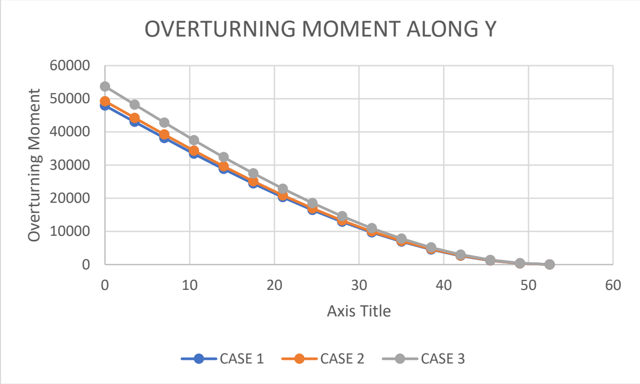

Fig 27:Overturning moment graph along Y for Criteria -B

STIFFNESS

Stiffness along X directions for criteria A

Case 1 (RCC M30) has better stiffness value compared to precast cases. It shows that the stiffness value increases with increasing grades along x directions case 5 (Precast M100) shows better stiffness than Case 2 precast M30. suggesting to use higher grades.

Table 21: Stiffness along X Direction for Criteria A

STIFFNESS ALONG X						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m	kN/m	kN/m	kN/m	kN/m	kN/m
Story15	52.5	94764.85	43678.39	49677.69	52377.55	75218.89
Story14	49	135650.6	64053.17	72535.44	76339.88	108258.2
Story13	45.5	161492	71064.52	80366.38	84534.04	119408.8
Story12	42	175877.8	74596.64	84304.86	88652.39	124985.9
Story11	38.5	185202.9	76753.57	86708.21	91164.71	128380.6
Story10	35	192012.6	78257.74	88383.41	92915.54	130743.2
Story9	31.5	197471	79415.47	89672.14	94262.17	132557.7
Story8	28	202164.2	80374.34	90738.81	95376.46	134056.5
Story7	24.5	206431.3	81215.77	91674.04	96353.12	135367.1
Story6	21	210515	81993.15	92537.15	97254.05	136572.6
Story5	17.5	214618.5	82746.36	93372.31	98125.35	137734.2
Story4	14	218927.6	83506.6	94213.95	99002.84	138899.3
Story3	10.5	223832.8	84299.76	95090.44	99916.01	140106.1
Story2	7	232499	85159.68	96037.58	100901.5	141398
Story1	3.5	314648.7	87216.97	98233.38	103156.7	144101.8
Base	0	0	0	0	0	0

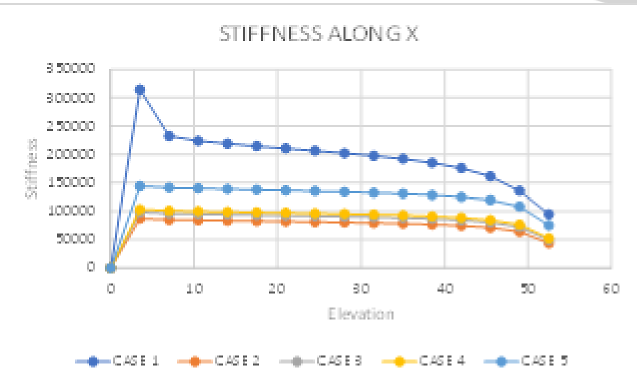

Fig 28:Stiffness graph along X for Criteria -A

Stiffness along Y directions for criteria A

The stiffness shows significant variation between RCC and precast options, with RCC M30 providing the highest stiffness values. Among precast options, stiffness increases with the grade of concrete, with Precast M100 showing the highest stiffness.

Table 22: Stiffness graph along X for Criteria -A

STIFFNESS ALONG Y						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m	kN/m	kN/m	kN/m	kN/m	kN/m
Story15	52.5	57465.15	22928.11	25887.19	27220.35	38538.35
Story14	49	71476.03	28530.64	32139.62	33763.75	47507.87
Story13	45.5	79433.03	30047.23	33830.47	35532.65	49927.63
Story12	42	83464.55	30758.2	34622.88	36361.52	51060.43
Story11	38.5	85963.51	31180.69	35093.71	36854.01	51733.35
Story10	35	87729.19	31470.19	35416.29	37191.4	52194.23
Story9	31.5	89093.9	31688.21	35659.16	37445.4	52540.95
Story8	28	90230.7	31865.29	35856.32	37651.56	52822.04
Story7	24.5	91245.05	32019.2	36027.55	37830.53	53065.55
Story6	21	92202.47	32160.62	36184.7	37994.73	53288.32
Story5	17.5	93146.64	32296.4	36335.39	38152.08	53501.07
Story4	14	94115.17	32431.98	36485.61	38308.84	53712.17
Story3	10.5	95152.69	32572.34	36640.84	38470.72	53929.14
Story2	7	96433.91	32724.9	36808.91	38645.71	54161.4
Story1	3.5	109142.6	33343.18	37465.72	39319.05	54960.06
Base	0	0	0	0	0	0

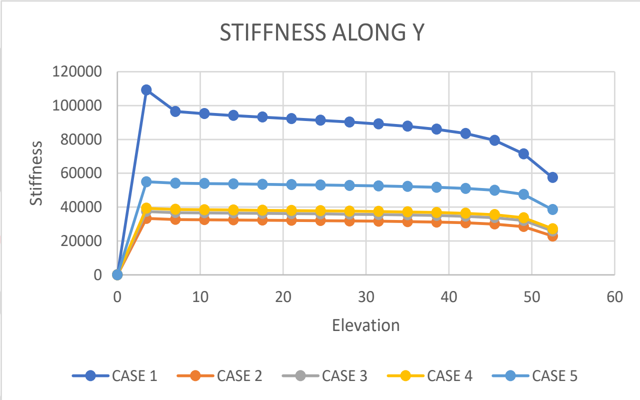

Fig 29:Stiffness graph along Y for Criteria -A

Stiffness along X directions for criteria B

Stiffness increases significantly with the dimensions of the structural elements. Case 3 (300x700 mm) exhibits the highest stiffness values. Case 1 (230x450 mm) has the lowest stiffness values.

STIFFNESS ALONG X				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m	kN/m	kN/m	kN/m
Story15	52.5	75218.89	97061.61	226437.8
Story14	49	108258.2	138228.4	361460
Story13	45.5	119408.8	152122.5	417404.5
Story12	42	124985.9	159062.9	447826.9
Story11	38.5	128380.6	163283.1	467075.4
Story10	35	130743.2	166218.4	480656
Story9	31.5	132557.7	168472.8	491143.6
Story8	28	134056.5	170335.1	499901.4
Story7	24.5	135367.1	171963.3	507708.8
Story6	21	136572.6	173460.5	515036.9
Story5	17.5	137734.2	174902.9	522192.7
Story4	14	138899.3	176348.9	529409.2
Story3	10.5	140106.1	177845.3	536908.7
Story2	7	141398	179441.3	544947.9
Story1	3.5	144101.8	182506.2	555483.8
Base	0	0	0	0

Table 23: Stiffness along X Direction for Criteria B

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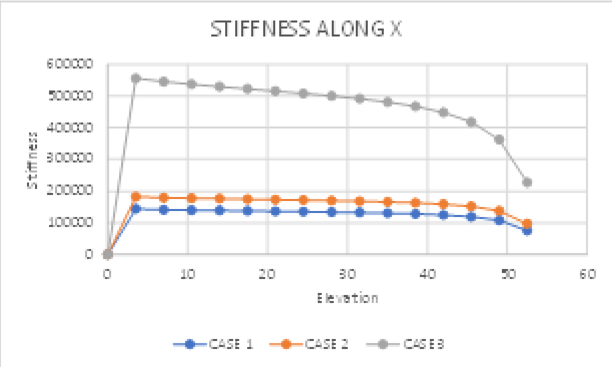

Fig 30:Stiffness graph along X for Criteria -B

Stiffness along Y directions for criteria B

Larger cross-sectional dimensions significantly enhance stiffness, which is beneficial for reducing deflections and increasing the overall stability of the structure. This shows that stiffness increases when grades are increased and also with increasing cross sectional dimensions.

Table 24: Stiffness along Y Direction for Criteria B

STIFFNESS ALONG Y				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m	kN/m	kN/m	kN/m
Story15	52.5	38538.35	66518.48	108503.4
Story14	49	47507.87	86371.77	139390.9
Story13	45.5	49927.63	92239.64	148715.7
Story12	42	51060.43	95062.8	153260.7
Story11	38.5	51733.35	96762.85	156019.2
Story10	35	52194.23	97936.64	157921.3
Story9	31.5	52540.95	98824.93	159361.3
Story8	28	52822.04	99548.39	160538.8
Story7	24.5	53065.55	100177.5	161561.6
Story6	21	53288.32	100754.6	162497.2
Story5	17.5	53501.07	101307.1	163392.5
Story4	14	53712.17	101856.4	164281.1
Story3	10.5	53929.14	102421.8	165192.2
Story2	7	54161.4	103024.4	166155.7
Story1	3.5	54960.06	104498.6	167879.3
Base	0	0	0	0

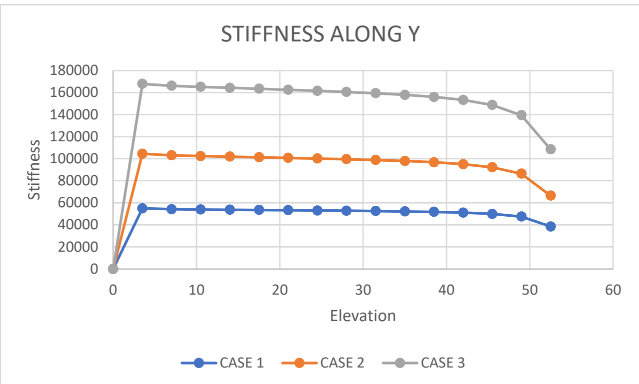

Fig 31:Stiffness graph along Y for Criteria -B

ACCELERATIONS

Storey accelerations along X direction for criteria A

The allowable storey accelerations is 0.1 times of acceleration due to gravity which will be equal to 980 mm/sec² all the cases are well below this limit Case 5 (Precast M100) shows the best performance with the lowest acceleration values, suggesting the highest structural stiffness and best dynamic response. Precast concrete structures (Cases 2, 3, 4, and 5) generally exhibit better dynamic performance than the RCC structure (Case 1).

Table 25: Storey Accelerations Along X for criteria A

ACCELERATION ALONG X						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m	mm/sec²	mm/sec²	mm/sec²	mm/sec²	mm/sec²
Story15	52.5	224.47	220.2	219.76	219.57	218.35
Story14	49	216.88	215.13	214.73	214.55	213.46
Story13	45.5	205.51	205.76	205.4	205.24	204.26
Story12	42	193.1	194.84	194.52	194.38	193.51
Story11	38.5	182.07	184.71	184.42	184.29	183.51
Story10	35	172.55	175.71	175.44	175.32	174.61
Story9	31.5	162.92	166.52	166.27	166.16	165.5
Story8	28	151.93	155.89	155.67	155.57	154.97
Story7	24.5	140.02	144.06	143.86	143.76	143.22
Story6	21	128.53	132.23	132.04	131.95	131.45
Story5	17.5	117.43	120.74	120.57	120.49	120.02
Story4	14	104.23	107.77	107.62	107.55	107.12
Story3	10.5	85.46	90.18	90.06	90.01	89.66
Story2	7	59.23	65.74	65.67	65.63	65.4
Story1	3.5	26.93	34.64	34.62	34.61	34.53
Base	0	0	0	0	0	0

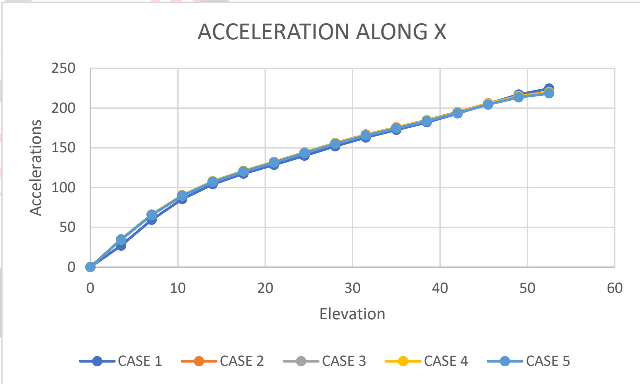

Fig 32:Accelerations graph along X for Criteria -A

Storey accelerations along Y direction for Criteria A

The slight reduction in acceleration with higher concrete grades (e.g., from M30 to M100) in precast structures shows that higher grades will increase the comfort of occupants. Higher Accelerations in RCC is Due to higher stiffness . Stiffer structures tend to respond with higher accelerations under dynamic loads. all the cases are well below the allowable limit.

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ACCELERATION ALONG Y						
Story	Elevation	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
	m	mm/sec²	mm/sec²	mm/sec²	mm/sec²	mm/sec²
Story15	52.5	221.16	218.17	218.01	217.93	217.92
Story14	49	214.79	213.2	213.05	212.98	212.99
Story13	45.5	204.35	203.84	203.71	203.65	203.68
Story12	42	194.19	194.43	194.31	194.25	194.3
Story11	38.5	185.28	186.06	185.95	185.9	185.95
Story10	35	175.72	176.96	176.86	176.82	176.87
Story9	31.5	165.1	166.65	166.56	166.52	166.58
Story8	28	154.87	156.47	156.38	156.35	156.4
Story7	24.5	144.87	146.41	146.33	146.3	146.35
Story6	21	133.2	134.75	134.68	134.65	134.7
Story5	17.5	119.83	121.32	121.26	121.23	121.29
Story4	14	106.45	107.72	107.67	107.65	107.69
Story3	10.5	91.39	92.7	92.66	92.64	92.68
Story2	7	68.99	70.98	70.96	70.95	70.99
Story1	3.5	36.01	38.99	39	39	39.07
Base	0	0	0	0	0	0

Table 26: Storey Accelerations Along Y for criteria B

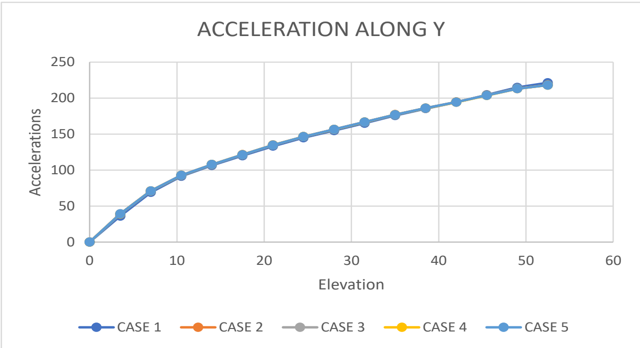

Fig 33:Accelerations graph along Y for Criteria -A

Storey accelerations along X direction for Criteria B

Case 3 (300x700 mm) Despite having the highest stiffness and lowest displacements, it experiences the highest accelerations. This suggests that the stiffer structure (Case 3) is more sensitive to high-frequency components of the seismic input, leading to higher accelerations. Case 1 (230x450 mm) The lowest accelerations indicate that it is more flexible structure.

ACCELERATION ALONG X				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m	mm/sec²	mm/sec²	mm/sec²
Story15	52.5	218.35	218.66	229.89
Story14	49	213.46	213.77	224.76
Story13	45.5	204.26	205.39	215.05
Story12	42	193.51	194.58	203.53
Story11	38.5	183.51	182.73	192.55
Story10	35	174.61	171.16	182.56
Story9	31.5	165.5	160.66	172.32
Story8	28	154.97	151.22	160.63
Story7	24.5	143.22	141.94	147.68
Story6	21	131.45	131.43	134.56
Story5	17.5	120.02	118.26	121.55
Story4	14	107.12	101.43	106.83
Story3	10.5	89.66	80.57	87.29
Story2	7	65.4	56.01	60.7
Story1	3.5	34.53	28.67	27.27
Base	0	0	0	0

Table 27: Storey Accelerations Along X Directions for criteria B

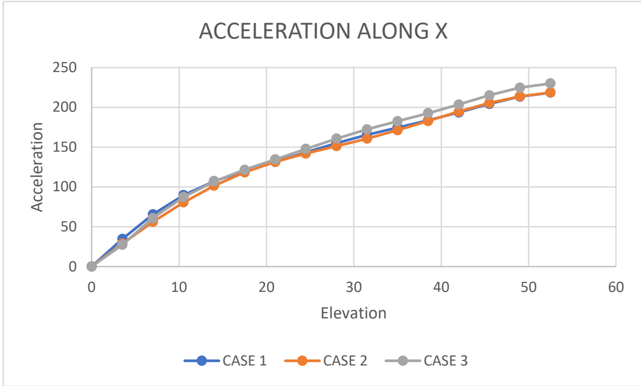

Fig 34:Accelerations graph along X for Criteria -B

Storey accelerations along Y direction for Criteria B

Below graph and table shows that increasing cross sectional area or increasing grade of concrete doesn't increase or decrease accelerations significantly. Accelerations increases marginally with increasing dimensions.

Table 28: Storey Accelerations Along Y for criteria B

ACCELERATION ALONG Y				
Story	Elevation	CASE 1	CASE 2	CASE 3
	m	mm/sec²	mm/sec²	mm/sec²
Story15	52.5	217.92	220.18	221.76
Story14	49	212.99	214.12	216.48
Story13	45.5	203.68	204.43	206.85
Story12	42	194.3	195.74	197.18
Story11	38.5	185.95	186.85	188.54
Story10	35	176.87	176.98	179.2
Story9	31.5	166.58	167.52	168.69
Story8	28	156.4	157.59	158.33
Story7	24.5	146.35	146.47	148.12
Story6	21	134.7	135.36	136.31
Story5	17.5	121.29	123.13	122.72
Story4	14	107.69	108.46	108.93
Story3	10.5	92.68	93.11	93.67
Story2	7	70.99	73.89	71.7
Story1	3.5	39.07	42.65	39.47
Base	0	0	0	0

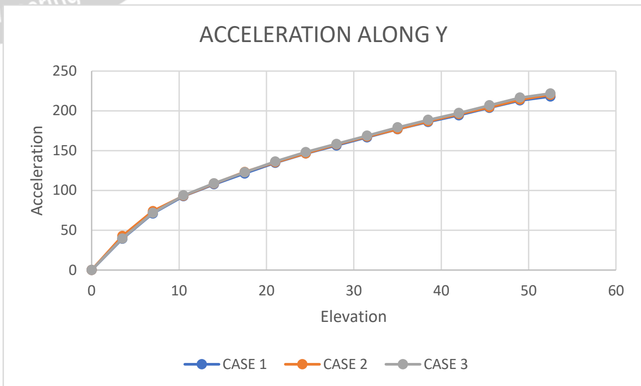

Fig 35:Accelerations graph along Y for Criteria -B

IV. CONCLUSION

As per the result of a 15 -storey building under earthquake loads, RCC framed structures are compared with precast structure with different grades and dimensions of frames.

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- First RCC framed structure is compared with different grades of precast framed structures results showed that RCC frame out performed every precast structures in most of the aspects.
- The result also showed that Precast structure showed better performance with increasing grades in terms of displacements, drifts and stiffness. Shear force, overturning moment and acceleration had no major impact by changing grade.
- In the second criteria precast structures with M100 grade (showed better results in first criteria) was analyzed with increasing frame dimensions the result demonstrated that building showed better performance for increased grades in all aspects except acceleration of building. Even though the acceleration remained constant it was well within the safety limits. Various research suggests that retrofitting is necessary to improve accelerations of building.

In conclusion RCC frames showed better performance overall. Precast frames with higher dimensions and grades showed better performance than RCC regular sized frames with lower grades which can save construction time but it comes with increased cost. The choice between conventional RCC framed construction or Precast frames entirely depends on time, budget and availability of resources.

REFERENCES

[1] Kumar, K. S., Lingeshwaran, N., & Jeelani, S. H. (2020). Analysis of residential building with STAAD.Pro & ETABS. Materials Today: Proceedings, 33(1), 1221-1228. https://doi.org/10.1016/j.matpr.2020.08.329.

[2] Sharma, L., Taak, N., & Mishra, P. K. (2020). A comparative study between the pre-engineered structures and conventional structures using STAADPRO. Materials Today: Proceedings, 29, 1102-1108. https://doi.org/10.1016/j.matpr.2020.12.942.

[3] Macherla, U. R. T., & Karri, S. C. (2020). Comparative analysis on composite construction (structural steel and concrete) and precast concrete construction WRT cost and time. Materials Today: Proceedings, 33(1), 170-178. https://doi.org/10.1016/j.matpr.2020.03.742.

[4] Philip, A. M., & Kannan, M. R. (2021). Constructability assessment of cast in-situ, precast and modular reinforced concrete structures. Materials Today: Proceedings, 27, 2191-2197. https://doi.org/10.1016/j.matpr.2020.09.528.

[5] Al Agha, W., & Umamaheswari, N. (2021). Analytical study of irregular reinforced concrete building with shear wall and dual framed-shear wall system by using equivalent static and response spectrum method. Materials Today: Proceedings, 43(2), 2232-2241. https://doi.org/10.1016/j.matpr.2020.12.525.

[6] Saikumar, S., & Mandava, N. (2021). Comparative analysis of earthquake resistant building design by considering bracings and shear wall system in ETABS software. Materials Today: Proceedings, 45(2), 7893-7899. https://doi.org/10.1016/j.matpr.2021.11.490.

[7] Al Agha, W., & Umamaheswari, N. (2021). Analytical study of irregular reinforced concrete building with shear wall and dual framed-shear wall system by using equivalent static and response spectrum method. Materials Today: Proceedings, 43(2), 2232-2241. https://doi.org/10.1016/j.matpr.2021.05.005.

[8] Sukeerthi, B. K., & Rao, B. D. V. C. M. (2022). Evaluation of critical connections in an irregular precast building. Materials Today: Proceedings, 71(2), 332-338. https://doi.org/10.1016/j.matpr.2022.09.315.

[9] Syed, E. U., & Manzoor, K. M. (2022). Analysis and design of buildings using Revit and ETABS software. Materials Today: Proceedings, 65(2), 1478-1485. https://doi.org/10.1016/j.matpr.2022.04.463.

[10] Srivastava, V., Joshi, R., Kumar, K., Resatoglu, R., Zain, M., & Singh, A. (2023). Effect of seismic load on behaviour of RCC, composite and light steel building analysed using ETABS software: A comparative study. Materials Today: Proceedings, 33(1), 1221-1228. https://doi.org/10.1016/j.matpr.2023.03.564.

[11] Zhao, B., Yi, J., Li, X., Tian, Y., & Lu, X. (2023). Experimental recognition of seismic performance of simple bolt-connected precast frame by comparing with equal stiffness cast-in-situ frame. Journal of Building Engineering, 72, 107689. https://doi.org/10.1016/j.jobe.2023.107689.

[12] Sivakumar, S., Shobana, R., Aarthy, E., Thenmozhi, S., Gowri, V., & Kumar, B. S. C. (2023). Seismic analysis of RC building (G+9) by response spectrum method. Materials Today: Proceedings, 72, 2915-2921. https://doi.org/10.1016/j.matpr.2023.03.659.

[13] Li, H., & Zhou, W. (2023). Seismic fragility assessment of multistory precast concrete parking structures. Journal of Building Engineering, 70, 106366. https://doi.org/10.1016/j.jobe.2023.106366.

[14] Liu, W., Guo, X., Liu, W., Ji, M., & He, W. (2024). The influences of viscous dampers on the seismic performance of RC/PC frames: Comparable experiments. Structures, 33, 106438. https://doi.org/10.1016/j.istruc.2024.106438.

[15] Zhang, R., Guo, T., Wu, Y., Li, A., Zhu, R., & Yang, T. Y. (2024). Shaking table test of a dry-connection fully precast frame structure system. Journal of Building Engineering, 87, 109134. https://doi.org/10.1016/j.jobe.2024.109134.

[16] Wu, Z., Lu, X., Bao, H., Li, L., & Lu, Z. (2024). Experimental response of semi-rigid reinforced concrete beam-column joints with bolted angle dissipating connections. Journal of Building Engineering, 90, 109345. https://doi.org/10.1016/j.jobe.2024.109345.

[17] Ingle, A. S., Bharti, S. D., Shrimali, M. K., et al. (2024). Modeling of precast building frames for seismic response analysis. Journal of Vibration Engineering & Technologies. https://doi.org/10.1007/s42417-024-01367-3.

[18] Bureau of Indian Standards. (1987). IS 875, Part 2: Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures: Part 2 Dead Loads. New Delhi, India.

[19] Bureau of Indian Standards. (1987). IS 875, Part 1: Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures: Part 1 Live Loads. New Delhi, India.

[20] Bureau of Indian Standards. (2000). IS 456:2000: Plain and Reinforced Concrete - Code of Practice. New Delhi, India.

[21] Bureau of Indian Standards. (2002). IS 1893, Part 1: Criteria for Earthquake Resistant Design of Structures: Part 1 General Provisions and Buildings. New Delhi, I

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