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Analysis of Precast Building by Response Spectrum Method Using ETABS

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ABSTRACT: Precast concrete is an alternative to cast-in-situ concrete. While cast-in-situ concrete is cast in its actual location, precast concrete is cast at another location, either at the building site or in a factory, and is then lifted to its final resting place and fixed securely. This means that unlike cast-in-situ construction, which is monolithic or continuous, precast concrete buildings are made of separate pieces that are bolted or connected together. This paper describes a case study, which has been done to investigate the effect of modeling of the vertical joints between the wall panels in a precast emulative wall system building. The design and detailing of the connections are especially important to the performance and integrity of the precast structural system.

KEYWORDS: Storey Drift, Max Storey Displacement and Model Mass Participation.

I. INTRODUCTION

India is the world's fastest developing country with an economic growth rate averaging 7.5% for last 5 years. We are currently on the verge of large-scale urbanization hence facing a huge demand for building houses. The construction industry contributes to about 10% of Gross Domestic Production (GDP) of the nation, registering an annual growth of about 9%. To cope up with this housing necessity, the country needs to build 30 to 35 thousand units of houses per day at least for the next 8 years. Housing is the primary need of every human being. With the rapidly growing population, and to fulfill the aforementioned housing demand, a more reliable, faster, sustainable method of construction is deemed necessary by the construction industry. The concept of "built it fast" in the most economical way has not changed since the beginning; however, new technologies have been developed to suit the modern world construction. One such solution is "precast concrete construction technology". Precast technologies is not only helping contractors and builders get their buildings faster and more economically but it also helps to reduce construction waste and produce high quality, energy efficient buildings which results in long term benefits to projects. Precast constructions have been a common construction method in United States of America and many European countries. On the other hand Precast for residential construction has been used in India for only less than a decade, but it has been growing very fast in the past 5 years. Recently, there have been any new developers and contractors who have switched from traditional construction to precast to keep up with this new trend in the Indian residential market.

Precast concrete is an alternative to cast-in-situ concrete. While cast-in-situ concrete is cast in its actual location, precast concrete is cast at another location, either at the building site or in a factory, and is then lifted to its final resting place and fixed securely. This means that unlike cast-in-situ construction, which is monolithic or continuous, precast concrete buildings are made of separate pieces that are bolted or connected together.

II. RELATED WORK

Depending on the types of members used, the precast systems can be classified into bearing wall system, moment resisting frame system and dual system. In wall system, the structure is mainly composed of structural walls which

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Vol. 8, Issue 10, October 2019

transfer the vertical and horizontal forces to the foundation. The transfer of flexural capacity requires continuity of vertical reinforcement through the height of the wall and it can be provided with coupling of bars or vertical post-tensioning. Moment resisting frame system comprises of beams and columns in which the connections are either equivalent monolithic or jointed. Dual system is a combination of shear walls and moment resisting frames to resist the lateral loads. The stability for the structure is provided by shear walls/cores. Connections are the most crucial part in precast structures. The challenge in designing precast systems is to find an economical and practical method to connect the members with adequate strength and ductility for the earthquake loading. The behaviour of the structure mostly depends on the behaviour of connections. FIB Bulletin 27 (2003) broadly classifies precast connections into two categories as “equivalent monolithic (emulative)” connections and “jointed” connections. This classification is based on the nature of connections between the members. In equivalent monolithic systems, the connections between the members are designed to emulate the behaviour of cast-in-place concrete construction. The protruding longitudinal reinforcing bars from the members are spliced, welded or mechanically connected and then concrete is cast in the joint region. This is also termed as a wet connection. As in any other system, seismic considerations are crucial in precast buildings. Precast concrete can be used successfully in structures designed for earthquake resistance, provided careful attention is given to conceptual and detailed design, and to fabrication and erection. The seismic performance of a structure is mainly related to its lateral strength, stiffness, ductility and unity of the components. The structural behaviour of a precast concrete system is greatly different from that of a comparable monolithic cast-in-place system. The main structural difference between cast-in-place buildings and precast buildings lies in their structural continuity. The structural continuity of conventional cast-in-place buildings is inherent while in the precast systems, members should be assembled and connected to produce a structural system capable of resisting gravity loads as well as the lateral forces due to wind or earthquake. The design and detailing of the connections are especially important to the performance and integrity of the precast structural system.

III OBJECTIVE OF RESEARCH

The aim of the theses is to formulate a structural system which can adequately resist loads due to gravity, wind and earthquake with maximum efficiency. Building movements needs to be restrained as per codal limitations. The primary structural members consist of Hollow core slabs, Cast in-situ structural topping, precast beams and precast concrete walls used for resisting vertical loads. Lateral loads from wind and earthquake are resisted by shear walls. Structural concrete topping is provided to act as diaphragm in order to transfer the lateral loads within the horizontal plane to the shear walls. The report lists down all the design standards, codes, technical literature and materials that shall form the basis for subsequent detailed design.

The project is a residential building with ground floor plus 19 storeys above ground. The building construction is envisaged maximizing the utilization of precast construction method. This report summarizes the design philosophy, primary assumptions, methods of analysis / design.

● CASE STUDY

Introduction

The selected building is G+19 storey tower, consisting rcc shear wall structure. This case study is based on the drawings, design report and computational models.

Building Description

It is a irregular building with plan dimensions 28.92*32.2m. The total height is 59m. Figure 1 shows the ETABS plan view of the typical floor of the selected building. The appropriate type of precast system for the given height of building is the wall system, which gives adequate lateral load resistance. Advantages like fast and repetitive construction, good quality and finish due to factory controlled production, cost competitiveness etc., supported the

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 10, October 2019

selection of the system. The typical floors have a projection of approximately 1m on two sides with respect to the ground storey. To avoid the complicated details of a precast cantilever supporting system at the first floor level, conventional cast-in-place construction was adopted for the ground storey.

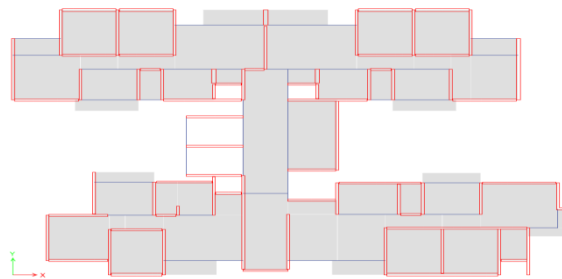


FIGURE 1. ETABS VIEW OF THE FLOOR PLAN OF THE BUILDING

Structural Stability

The stability of the structure was considered against the gravity loads, lateral loads from wind and Earthquake. The precast design followed an emulation of cast-inplace system. The wall joints are such that an entire wall acts as an equivalent monolithic system under lateral loads. The connections between different panels are wet connections, and are able to transfer in-plane shear, flexural tension and compression.

Model

3D Model is made in ETABS software with all geometry & cross-sections of structural elements assigned as per drawings and material properties assigned as given in Cl.2.2.1.

The live, superimposed & wind loads are assigned as specified in the report based on functionality of the space. The load combinations are created as specified in the report.

Stiffness Modifiers are applied as mentioned below according IS CODE 1893 section 6.4.3.1

ELEMENT TYPE	MODELLED AS	STIFFNESS MODIFIER
Slabs	Shell	1
Beams	Frame	0.35
Columns	Frame	0.70
Walls	Shell	0.70

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 10, October 2019

1	Beams	40MPa
2	Wall Precast	40MPa
3	Precast Slabs	40MPa
4	Structural Topping	40MPa

- **Cement Type**

For Super structure- OPC grade 43/53 subject to mix design approval.

For Sub structure - The grade of cement shall be based on the presence of chemicals present in the soil, and recommended in the soil investigation report.

- **Reinforcement**

Reinforcement bars shall be have minimum yield strength $f_y = 500\text{MPa}$ and minimum elongation of 14.5% as per **IS 13920** with specifications according to **IS 1786:2008 High Strength Deformed Steel Bars and Wires for Concrete Reinforcement-Specifications**.

III. EXPERIMENTAL RESULTS

Model Mass Participation

MODEL MASS PARTICIPATION RATIO								
Case	Mode	Period	UX	UY	Sum Ux	Sum UY	RZ	Sum RZ
		sec						
Modal	1	1.637	0.0022	0.6574	0.0022	0.6574	0.0006	0.0006
Modal	2	1.384	0.3695	0.0003	0.3717	0.6577	0.3254	0.326
Modal	3	1.248	0.3286	0.0025	0.7003	0.6602	0.3599	0.6859
Modal	4	0.37	0.0622	0.0919	0.7625	0.7521	0.0125	0.6984
Modal	5	0.367	0.0534	0.0762	0.8159	0.8283	0.0331	0.7316
Modal	6	0.344	0.0001	0.0018	0.816	0.8301	0.000003912	0.7316
Modal	7	0.325	0.0468	0.004	0.8628	0.8341	0.1077	0.8392
Modal	8	0.307	0.0012	0.0042	0.864	0.8383	0.0077	0.8469
Modal	9	0.267	0	0.0027	0.864	0.8411	0.0008	0.8478
Modal	10	0.176	0.0442	0.0003	0.9081	0.8413	0.0085	0.8563
Modal	11	0.159	0.0074	0.0073	0.9155	0.8486	0.0188	0.8751
Modal	12	0.155	0.0007	0.0522	0.9162	0.9008	0.0056	0.8807
Modal	13	0.111	0.0268	0.003	0.943	0.9038	0.002	0.8827
Modal	14	0.095	0.0063	0.025	0.9492	0.9288	0.0027	0.8854
Modal	15	0.059	0.0272	0.0198	0.9765	0.9486	0.0011	0.8865
Modal	16	0.05	0.013	0.0315	0.9895	0.9801	0.0014	0.8879

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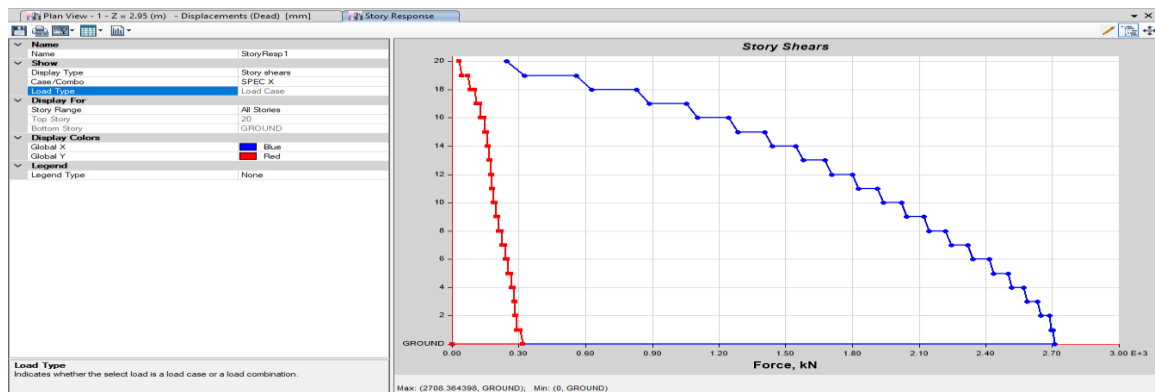
Vol. 8, Issue 10, October 2019

In buildings located in Seismic Zones II and III, it shall be ensured that the first three modes together contribute at least 65 percent mass participation factor in each principal plan direction. And, in buildings located in Seismic Zones IV and V, it shall be ensured that,

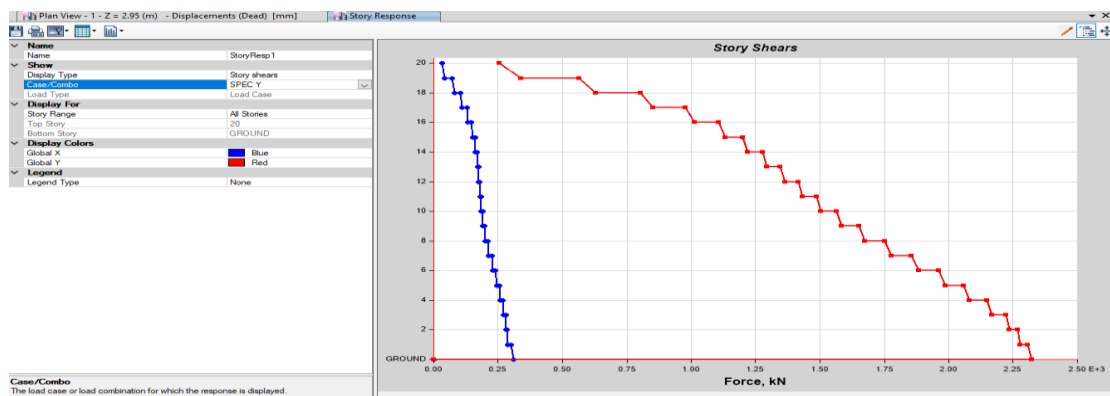
- 1) *the first three modes together contribute at least 65 percent mass participation factor in each principal plan direction, and*
- 2) *the fundamental lateral natural periods of the building in the two principal plan directions are away from each other by at least 10 percent of the larger value.*

As building is assumed in Zone 2 , so according to clause the model mass participation of first three modes is greater than 65%.

Storey Shear Profile(Spec x)



Storey Shear Profile(Spec y)



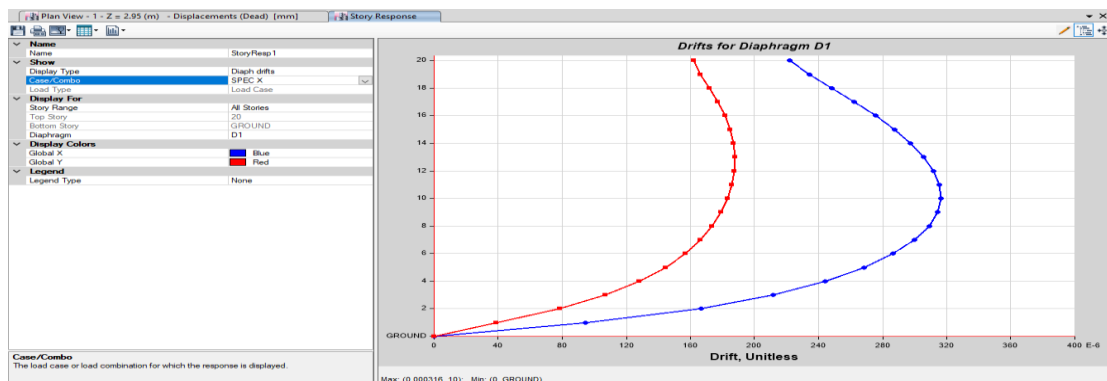
International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

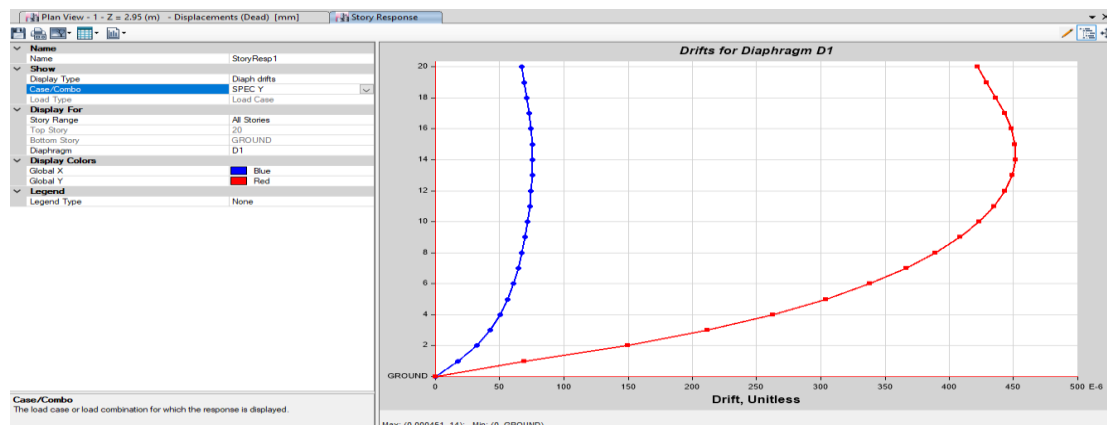
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Vol. 8, Issue 10, October 2019

Storey Drift Profile(Spec x)



Storey Drift Profile(Spec y)



As per code 1893 (clause no 7.11.1) storey drift in any storey shall not exceed 0.004 times the storey height .under the action of design base shear V_B with no load factors, that is with partial safety factor for all load taken as 1. Hence, Max. Drift is greater than 0.004 so **ok**.

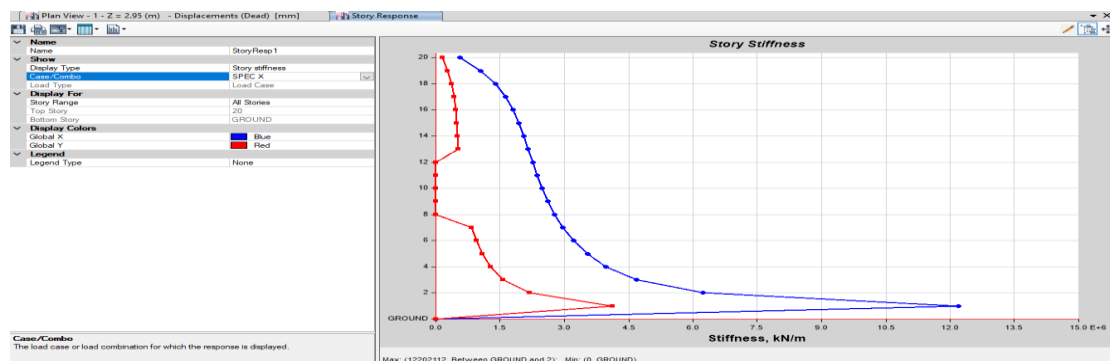
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(A High Impact Factor, Monthly, Peer Reviewed Journal)

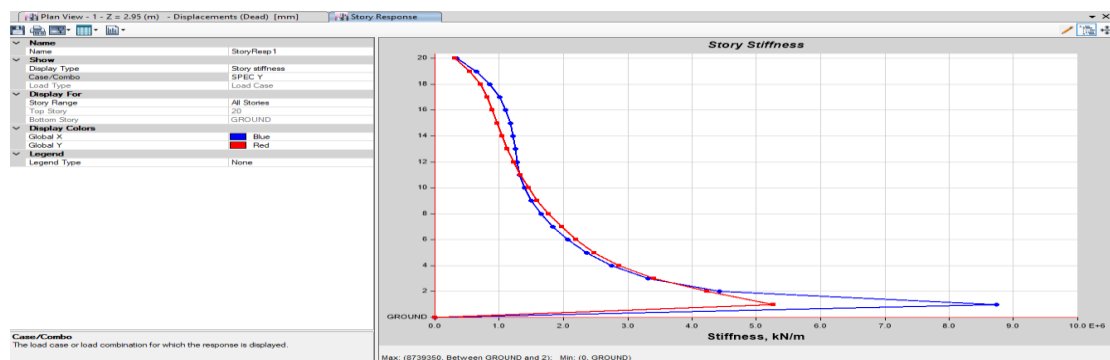
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Vol. 8, Issue 10, October 2019

Storey Stiffness Profile(SpecX)



Storey Stiffness Profile(SpecY)



As per code 1893 clause:-

7.10.3 When the RC structural walls are provided, they shall be designed such that the building does NOT have:

Lateral stiffness in the open storey(s) is less than 80 percent of that in the storey above; and

CHECKS (AS PER TALL BUILDING CODE)

- **CLAUSE 5.1.2 (Slenderness Ratio):-** The maximum values of the ratio of height to minimum base width B shall not exceed values given in the table below:

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 10, October 2019

Table 2 Maximum Slenderness Ratio (H/B_t)
(Clause 5.1.2)

Sl No.	Seismic Zone	Structural System					
		Moment Frame	Structural Wall		Structural Wall + Moment Frame	Structural Wall + Perimeter Frame	Structural Wall + Framed Tube
(1)	(2)	(3)	Located at Core (4)	Well-Distributed ¹⁾ (5)	(6)	(7)	(8)
i)	V	NA	8	9	8	9	9
ii)	IV	NA	8	9	8	9	9
iii)	III	4	8	9	8	9	10
iv)	II	5	9	10	9	10	10

Result:- The height of building is 59.0 m and the width of building is 21.59 m so ratio of (H/B) is 2.73

which is less than 10 as marked in the above table . Hence this clause is OK.

- **CLAUSE 5.2.2 (Plan Aspect Ratio):-** The maximum plan aspect ratio (L_t/B_t) of the overall building shall not exceed 5.

Result:- The length of building is 28.92 m and the width of the building is 21.59 m so their ratio is 1.33 which is less than 5. hence OK

- **CLAUSE 6.2 (Wind Effect):-** A building with height greater that 150m or complexities in plan or elevation geometry or sited on complex topography with group effect or interference effect or whose time period is greater than 5 sec than no dynamic analysis required.

Result: - As the building doesn't fall in any of the category as mentioned in above clause so we do not need to do DYNAMIC WIND ANALYSIS.

IV. CONCLUSION

Precast concrete inherently provides versatility, efficiency, and resiliency resulting in improved quality, performance, and sustainability. Failure of precast concrete buildings during past earthquakes has raised a question mark in the construction of precast concrete buildings. The proposed system enables easy construction work by minimizing cast-in-place concrete volume and eliminating the need for formworks, welding, bolting and pre stressing.

- As per code 1893 (clause no 7.11.1) storey drift in any storey shall not exceed 0.004 times the storey height .under the action of design base shear V_B with no load factors, that is with partial safety factor for all load taken as 1. Hence, Max. Drift is greater than 0.004 so **ok**.
- As per code 1893 lateral stiffness of storey shall not be less than 80% of storey above.
- As per code 1893 (clause no 7.11.1), As building is assumed in Zone 2 , so according to clause the model mass participation of first three modes is greater than 65%.
- As per tall building code 16700 (clause no 5.1.2) The height of building is 59.0 m and the width of building is 21.59 m so ratio of (H/B) is 2.73 which is less than 10 as marked in the above table . Hence this clause is OK.
- As per tall building code 16700 (clause no 5.2.2), the length of building is 28.92 m and the width of the building is 21.59 m so their ratio is 1.33 which is less than 5. hence OK

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 10, October 2019

So present study represent precast building analysis, all checks like- drift, soft storey, model mass participation ratio are within limits. And we can consider so many other aces like changes in wall orientation and can analysis the model and check the result.

REFERENCES

1. Bindurani.P, A. Meher Prasad,and Amlan K. Sengupta . “Analysis of Precast Multistoreyed building – a case study”, *International Journal of Innovative Research in Science, Engineering and Technology*, Volume 2, Special Issue 1, December2013.
2. Fabio Biondini, Alessandro Palermo and Giandomenico Toniolo, “Seismic Performance of concrete structures exposed to corrosion: case studies of low-rise precast buildings”, *Journal of Structure and Infrastructure Engineering*, Vol. 7, January–February2011.
3. Ghosh S. K, Nakaki, Suzanne Dow and Krishnan Kosal. “Precast Structures in Region of High Seismicity”, *International Journal of Civil, Architectural, Structural, Urban Science and Engineering*, Vol.6, November 2006.
4. J. Witzany, T.Cejka and R. Zigler. “Prefabricated Multi-story structure exposed to Engineering Seismicity”, *Journals of Challenges, Opportunities and Solutions in Structural Engineering and Construction*, October.2010.
5. Khare R. K., M. M. Maniyar, Uma S. R. and Bidwai V.B. “Seismic Performance and Design of Precast Concrete Building Structures: An Overview”, *Journal of structural engineering*, Vol.3 ,December2011
6. Nuno Filipe Barata Feliciano, “Seismic Design of Precast Concrete Industrial Buildings”, *Journal of Department of Civil Engineering of Instituto Superior Técnico*, August2011.
7. Stefano pampanin, “Emerging solution for high seismic performance ofprecast/ prestressed concrete building”, *Journal of Advanced Concrete Technology*, Vol.3, June2010.
8. INDIAN STANDARD (IS: 16700-2017) Criteria for structural safety of Tall Concrete Buildings.
9. Purna Nautiyal, “A Comparative Study of The Effect of Infill walls on Seismic Performance of Reinforced Concrete Buildings” *International Journal of Civil Engineering & Technology (IJCIET)*, 4(04),2013.
10. Gary Robinson Design and performance of precast concrete structures, 2014.
11. INDIAN STANDARD (IS: 1893- 2016)Criteria For Earthquake Resistant Design Of Structures.