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Benefits of Backstay Effect in Design of Podium Structure for Tall Building as Per IS 16700:2017

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Abstract: *In a multi-functional tall building, generally the building has a more extensive plan area and higher lateral resistance at the lower story level than the above story levels. So, the scope of this study is to understand the realistic behaviour of such structures under lateral loads considering the backstay effect as per IS: 16700(2017). The present work focus on the effect of podium structure of single tower structure connected by a common podium at the interface level under seismic load. For this purpose, the simulation model with varying tower height and podium height is created in the ETABs and it is analysed for the equivalent static and response spectrum method. In this study, the effect on the top displacement of the tower connected with podium structure under equivalent static and response spectrum method of analysis is observed. The backstay forces that are developed to resist the lateral overturning actions at the interface when the lateral horizontal forces are transferred from the tower to the podium are studied. The unfavourable effect of podium on the shear force distribution at and above the interface level of the structural wall is observed. The positioning of the tower on the podium structure is found to be the reason for the differential displacement between the structural walls.*

Keywords: Tall structures, Podium, Backstay effect, Floor diaphragm, Structural wall

I. INTRODUCTION

Any bottom portion of a tall structure that is larger in the floor plan and contains a significantly increased seismic force resistance when compared to the portion of the tower above can be considered as a podium structure. Many tall structures have an arrangement in which the below few storeys have a larger floor plan than the towers above, this type of construction is common in multi-storey buildings where the lower part of storeys often used for retail stores, parking lot, meeting rooms etc. The recent studies focused on the effects of the podium on the distribution of shear forces in tower structure and focused on the backstay effects due to the podium structure.

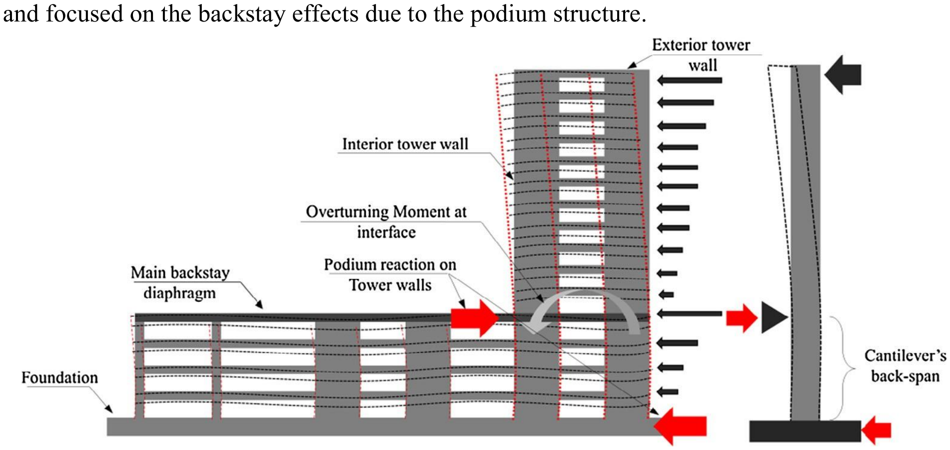

Fig. 1. Backstay action in a podium-tower sub-assemblage

They focused on the effects of a setback on the dynamic response of the structure and design criteria to improve the response of setback building for lateral forces. The backstay effect which is most perceptible in buildings with a distinct lateral system (ex: shear wall, core wall) which are connected with the base structure. It has been found that ample amount

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of study has been carried out on the displacement parameter for single tower connected by a podium structure in which the number of storeys in the podium structure is varied. Lacks detailed study on backstay, strutting action and differential displacement occurring at the podium tower interface level. To encounter this limitation the present study has been carried out. In this present investigation the top displacement behaviour of the single tower structure with increasing the number of stories in the podium structure is carried out. To determine the optimum placement of the tower on the podium structure the strutting action and the differential displacement developed at the interface level of the tower positioned centrally and the tower which is offset from the centre of the podium are studied. The amount of backstay forces developed at the podium tower interface level are also presented in this paper.

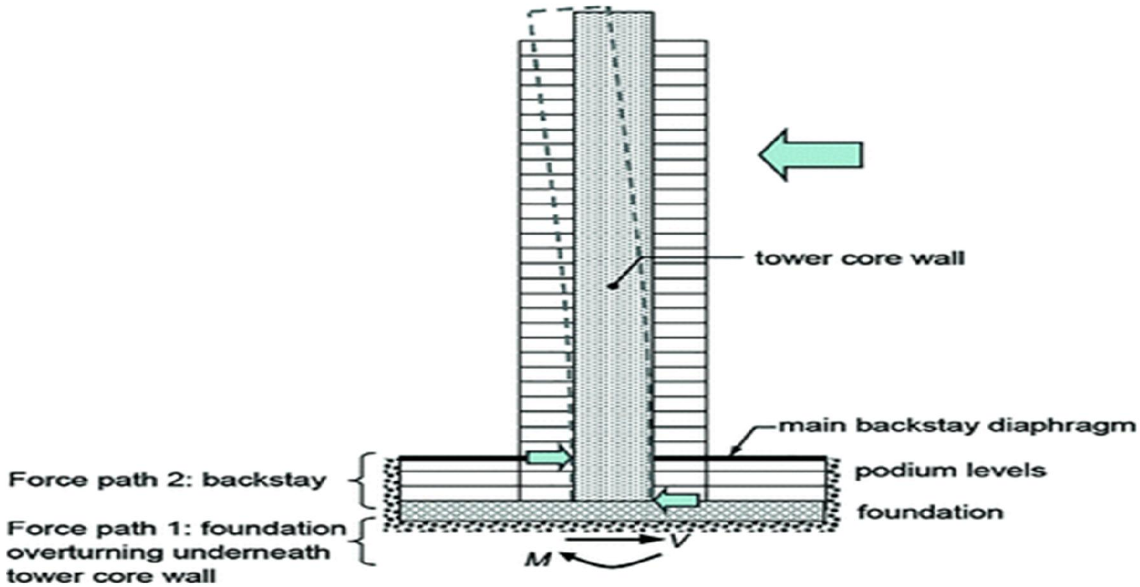

Fig-2:- Load paths in Lateral Overturning Resistance of Tall Buildings with Podium

II. OBJECTIVE

To understand the phenomena of the Backstay effect observed in the tower-podium type structures by considering the provisions given in the Indian standards (IS 16700: 2017).

With this parameters different models will be prepared & Compare

1. Tower Only
2. Single tower with Podium
3. Multiple towers with common (Sharing) podium etc.
4. Cut-outs in the diaphragms with podium and tower together.

III. METHODOLOGY

25 storey RCC lateral load resisting structures with and without podiums are modelled using the extended 3D analysis of building system (ETABS) software. Each floor is taken as 3m height. The number of storeys in the podium structure is also varied from one to three storeys. The two cases are considered in this study are as follows,

Case 1: The tower structure without a podium structure, where the base dimension of the architectural plan is 30m×30m.

Case 2: The tower structure with podium structure, where the architectural plan area for tower structure is 30m×30m and plan area of podium structure is 114m×114m.

IV. ANALYSIS

CSI ETABS 2018 software was used for the analysis of the said 25 storey structure. The whole study was performed considering Earthquake load and Gravity Loads. Diaphragm have been modelled as Semi-Rigid because they transfer the loads acting on it (transverse & in plane) through out of plane to study the Backstay Effect these factors are to be considered and understood.

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LOAD AND SEISMIC FACTOR	
Dead Load	1.5 kN/m^2
Live Load	3 kN/m^2
Seismic Zone	III
Zone Factor	0.16
Response reduction factor	5
Importance factor	1.2
Soil condition	Medium

Table 1: Load and Seismic Factor

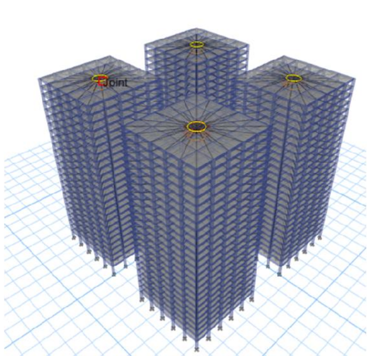

Fig 3: 3d view of tower

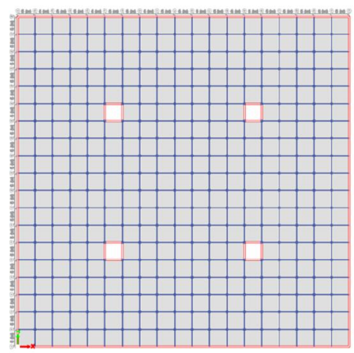

Fig4: Podium Plan

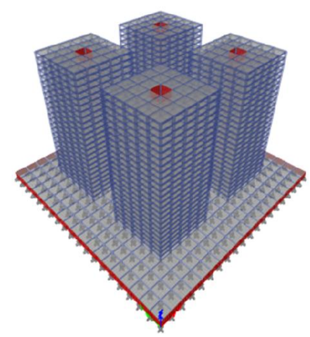

Fig5: 3d view of building

Concrete Grade for slabs is M40 and different sizes of thickness considered are 150 mm, 200 mm. Concrete Grade for Beams is M55 and sections are (300x750) mm. Concrete Grade for Columns is M60 and sections used are (900x900) mm. Concrete Grade for Structural Wall is M40 and sections are 300 mm.

V. RESULT

Following 4 ETABS Models were prepared.

- Model 1: T: Tower only
- Model 2: T+P1: Tower + 1 storey podium
- Model 3: T+P2: Tower + 2 Storey Podium
- Model 4 : T+P3: Tower + 3 Storey Podium

As per tall building code clause 5.4 for lateral drift for factored earth quake load factored combination the drift is limited to h_i / 250.For dynamic analysis displacement for scaled factor of base shear for bare frame h_i/250 theoretical limit was calculated to be 300 mm. It was found that bare frame displacement was found to be within the limits for dynamic analysis. The Top storey displacement for only tower is 207.80 mm and Four Storey podium Displacement is 157 mm. The top storey displacements for rigid decreased about 20 to 25 % when back stay diaphragm effect was considered. This is because increase in stiffness and mass due to backstay diaphragm.

Inter storey drift = 0.004 x H (Floor height 3000 mm). Storey drift limitation as per IS 1893-2016 clause 7.11.1 shall not exceed 0.004 times the storey height under the action of design base shear V_b. As per IS 16700- 2017 the storey tall building code the drift is taken as limited as h_i/400. Drift limit 0.004 x 3000 = 12.0 mm.

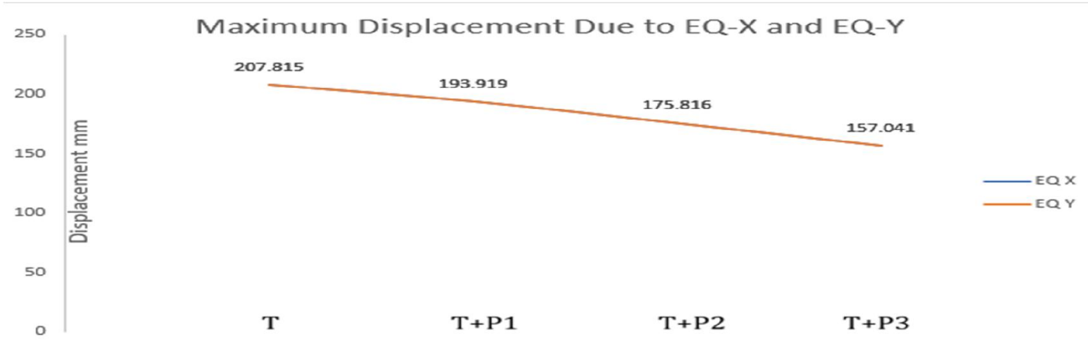

Fig 6: Maximum Displacement

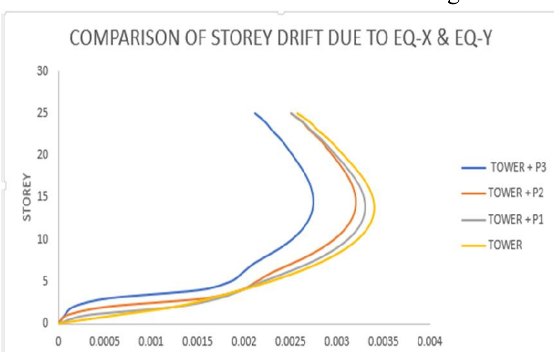

Fig 7: Storey Drift

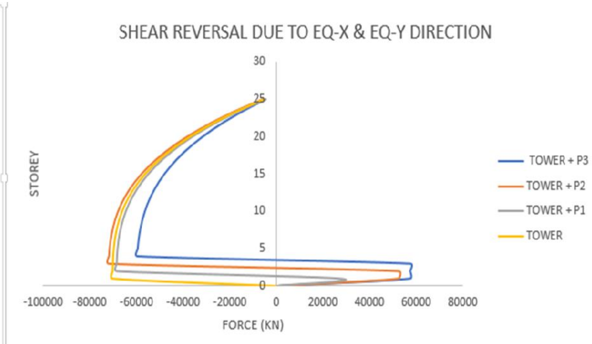

Fig 8: Storey Shear

Fig8: showed maximum shear reversal. From the results obtained, and Fig9: maximum Bending Moment in case of only Tower was observed at the Base level while considering Backstay (Podium + Tower), maximum Bending Moment was observed at the main Backstay level. Similar Shear Reversals were observed in case of both the Lateral directions.

Shear reversal is critical because shear force changes direction within the podium levels, and same lateral load resisting element helps resist the changing shear force.

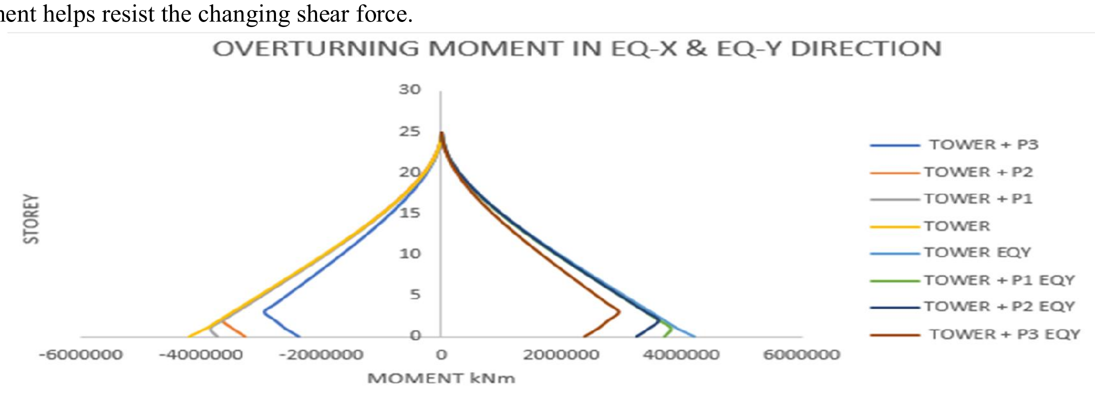

Fig 9: Overturning moment

VI. CONCLUSION

- The effect of backstay diaphragm results in increased mass therefore resulting in proportional increase in base shear. For low rise structure the stiffness of building the benefit of backstay diaphragm were not much when compared to high structure.
- There was 20 -25 % of reduction in displacement with consideration of backstay effect with backstay diaphragm effect in Three storey podium when compared to Tower only.
- Displacement gradually reduces more with effect of backstay and retaining wall.

- The effect of backstay diaphragm had the drift with in permissible limit (0.004 times floor height).
- The increase in podium height also lead to a rise in the backstay force at the Tower podium interface level.

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BIOGRAPHY

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