RESPONSE SPECTRUM METHOD TO STUDY OF BACKSTAY EFFECT ON TALL RC SHEAR WALL STRUCTURE MODELED WITH BASEMENTS

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Abstract - To study the base shear, top storey displacement, shear force in shear wall for the increase in basement floor, from one to four basements for 27 floor structure. To study the base shear, top storey displacement, and shear force in shear wall for the increase in slab thickness at main back stay level for the four basements with 27 floor structure by sensitivity analysis. To study the base shear, top storey displacement, and shear force in shear wall for the increase in area of podium for the four basements with 27 floor structure by sensitivity analysis. Methods: This research endeavors to scrutinize and contrast the performance of a 27-story tall shear wall building through Dynamic Analysis utilizing the Response Spectrum Method. Employing the E-TABS software, and following the IS 1893 (2016) and IS 16700 (2017). Finding: For increase in basement floor: base shear increases, top storey displacement decreases and shear force increase in shear wall above grade level for the first four storey and gradually decrease in upper floors. For the increases in slab thickness at main back stay level for the four basements with 27 floor structure by sensitivity analysis: Top Storey displacement increase. For the increases in area of basement for the four basements with 27 floor structure by sensitivity analysis: base shear increases, slight increase in top storey displacement, over turning moments decreases. Novelty: The present study shows the behavior of tower when it is modeled with the basement and to understand the changes in base shear, top storey displacement, shear force in shear wall by adopting the upper bond and lower bond stiffness modifiers as per IS16700 (2017), which play important role in stability of the structure and designing of high-rise structure. For the study the tower consists of only Structural wall which resists the later force generated by earthquake.

Index Terms - Backstay effect, Basement, Main back stay level, Response spectrum method, sensitivity analysis.

I. INTRODUCTION

Tall buildings, often considered architectural marvels, have become iconic symbols of modern urban landscapes around the world. These towering structures are not only impressive in terms of their height but also serve as a testament to the advancements in engineering and construction techniques. However, with the increasing demands for height and innovation, engineers and architects are faced with complex challenges in ensuring the safety, stability, and functionality of these monumental structures. Building layouts are often driven by architectural considerations aimed at maximizing the building's net usable area. In addition, the rising real estate prices in most of the world's metropolitan areas require that the economic factor prevail when planning a building with twenty floors or more. In podium-to-tower contact, horizontal forces are transmitted from the tower to the ground. Reactive pressures are created at the podium tower contact to resist tipping. The backward span of a suspension corresponds to the reaction mechanism. In theory, the specified backstay mechanism can create high-intensity shear stress in the structural wall (tower wall) of the podium. The in-plane stiffness of the floor slab connecting the two walls determines the magnitude of the shear force generated. The "Backstay Effect" can result in massive force transfers and a significant shift in the redistribution of base shear and bending moments below the podium diaphragm. Because of the overturning resistance supplied mostly by plinth to the tower, the lateral force resistant parts of the tower notice a shift in direction of the Base shear at the ground - floor interface level and below, the Back-Stay effect is also known as Shear-Reversal. Sensitivity Method is a tool for evaluating a building's behavior under various situations by progressively altering the stiffness attributes of its structural parts. The below-grade podium receives the upper Bound and lower Bound modifiers. Structural elements alone, with RC Cracked section parameters added to the building structural elements as per Table 6 of IS 16700:2017, page no. 7 When an earthquake occurs, the fissures in the sections will develop. Because the true scope of crack formation cannot be determined, and because once cracks form, the element starts to lose its original stiffness, varying rigidity modifiers are adapted to various structural elements to consider the effect of rupturing on section stiffness, and thus on the behavior and evaluating results of a structure of the building

II. LITERATURE SURVEY

Kishan B. Champaneriya et al. (2021), It was concluded that by increasing the podium height the backstay forces could be increased. It was also concluded that by increasing the thickness of the podium membranes and the area of the podium, the backstay forces can be increased [1].as in my study area of basement and podium slab thickness and basements level has more variation to study the behavior of the structure in terms of base shear, Top storey displacement, shear force in shear wall. Kush Shah et al. (2020), The axial forces generated in beams near podium cutouts are almost three times higher than actual, which needs to be verified when designing the building. The main finding of this study is that when modeling a tower with podium, one should model the podium with tower completely to analyze the actual results. This approach can lead to better strength, serviceability, and economy [2] in my study at the podium level the axial force in the beams are almost four times greater than actual because the beams are connected the shear wall which has in-plane stiffness is more when compare to the column which was used by the kush Shah study and also the study of Shear force variation along the shear wall is studied for different geometric condition of structure which was not studied in the past paper from 2019 and before. Geetha et al. (2019). In the case of the response spectrum approach, the top displacement decreases after incrementing at a certain point and then remains independent of the podium height. The backstay effect is imposed by the podium at the podium–tower interface level and so, the backstay forces at the tower and podium interface rise as the podium stories increase. They also observed that the behavior of the structure was more critical when the tower was offset from the center, [3] for my study the tower is kept in geometric senter of the basement to study the behavior of the shear wall.

III. Methodology

1.1. Geometric parameters

One building plan of 27 typical storey of residential building plan is considered for the study and named as Tower [T]. The tower is in rectangular in shape with the base dimension of 11.78m along X-Direction and 48.4m along Y-Direction. The. For the study of back stay effect the Basement dimension is 40mX70m for the objective 1. The tower is in center of Basement dimension. Different models have been prepared with increasing basement floor form the tower to tower with four Basement, for the tower the shear wall is distributed and consist of shear wall and beam- slab system. The placement of shear wall is as per the plan of the building. Basement floor is surrounded by retaining wall which serve as function of shear wall. For the study soil interaction in not taken into the account, the basement floor consists of column and beam-slab system.to study the objective 2, four basement and tower are modeled with specified dimension of the tower and basement above. Different models are prepared with the slab thickness of 125mm,150mm,180mm and 200mm at main back stay level .to study the objective 3, four basement and tower is modeled with specified dimension of the tower above and basement area of 40mX70m, 50mX75m and 60mX80m, the location of the tower is in center of basement area. In all the cases the tower walls are extended to the basement.

1.2. Modelling

For the study E-Tabs 2018 software is used which has an update with the Indian standard of earthquake resistant design guidelines code IS1893: 2016 [4]. the location of the shear wall is as per the plan of building the design consideration for the study is described in Table 1 and model description are described in Table 2

Table 1: Design Data of Statement Problem

Number of stories of Tower	**27**
Strength of Concrete for Shear wall & column	M45
Strength of Concrete for beam -slab	M30
Reinforced Steel Strength	Fe500D
Horizontal Members Dimension	300mm*750mm
Vertical Member Dimension	300mm*750mm
Zone factor (Z)	0.16
Damping ratio	5%
Typical Floor height for tower	3.0m
Typical Floor height for basement	4.0m
Ground floor height	4.0m
Slab thickness	125mm
Importance factor	1.2
Response reduction factor (R)	5
Soil type	III (Medium Soil)

Table 2: Model Description of Statement Problem

Model No.	Nomenclature	Description
1	T	Tower - 27 Storey without Basement
2	T+1B	Tower with one Basement with main backstay level slab thickness of 125mm and area of basement of 40mX75m
3	T+2B	Tower with Two Basement with main backstay level slab thickness of 125mm and area of basement of 40mX75m
4	T+3B	Tower with Three Basement with main backstay level slab thickness of 125mm and area of basement of 40mX75m
5	T+4B	Tower with Four Basement with main backstay level slab thickness of 125mm and area of basement of 40mX75m
6	T+4B(150mm)	Tower with Four Basement main back stay level slab thickness of 150mm and area of basement of 40mX75m
7	T+4B(180mm)	Tower with Four Basement main back stay level slab thickness of 180mm and area of basement of 40mX75m
8	T+4B(200mm)	Tower with Four Basement main back stay level slab thickness of 200mm and area of basement of 40mX75m
9	T+4B(50mX75m)	Tower with Four Basement with slab thickness at main back stay level of 180mm and basement area of 50mX75m
10	T+4B(60mX80m)	Tower with Four Basement with slab thickness at main back stay level of 180mm and basement area of 60mX80m

IV. CONCLUSIONS

In the study of back stay effect in the present work which has unique tower geometric shape of rectangular and the lateral load resisting system consists of only shear walls which will take only in-plane moments and the effect of tower modelled with basement gives over effect which will be similar to the practical construction, The models considered from Table 2, the following conclusion are drawn:

1.The increase in basement floor leads to increase in base shear by 49.2% for Model 5. Decrease in Top storey displacement by36.6% for Model 5. Decrease in overturning moments by 20% at base and 30.3% at main back stay level for Model 5. Sudden increase in shear forces in shear wall in first five storey above ground level the variation of shear force creates more stress in the wall at interface of basement and tower.

2.For increase in basement floor the stability of tower increases by 50.3% for Model 5.

3.For increase in slab thickness at main backstay level, the base shear increased by 34.6% for Model 8. Top storey displacement increases 6.3% for Model 8. over turning moments are increased by 42.6%for Model 8 by using the upper bound and lower bond stiffness modifiers.

4.For increase in Area of basement the base shear increased by 70% for Model 10, top storey displacement is increased by 10% for Model 10. Over turning moments are decreased by 70% for Model 10.

5.In all the cases the shear force variation in shear wall is complex at main backstay level. The shear force is low at the base and sudden increase in shear force in first five stores of the tower above the main podium level.

6.The main purpose of the study is to analyse the behaviour of the tower when modelled with basement and limitation of the study it is analysed only for the seismic effect and not considering the wind loads, because earthquake and wind does not act simultaneously.

7.The study can improved by considering different structural systems such as to control the top storey displacement use of outrigger systems at critical storey level, and an innovative study can be made by change the basement RC structure system to structural steel and studying the behaviour of the structure, for the further study, in tower instead of RC beams as structural steel beams can be consider and study the behaviour of the tower elements.

8. Improper mass participation in first three modes when tower is modelled with the basements, which leads to the irregularity as per IS1893.

V. REFERENCES

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