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Dynamic Analysis of Linked Twin Tall RCC Structures with Different Plans

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ABSTRACT: As construction field is growing day by day. High rise building has major role in this development. Due to the increase in population, the building numbers are increasing. So the accessibility of land is decreased and preference for high rise structure is increased. The height of building increases then the effect of dynamic load (seismic and wind load) was high. To reduce the action of dynamic loads Twin-Tower came into picture. In this a 40-storey building of two different plans were analysed. The shapes considered for the analysis were square and rectangular. The shapes were compared by providing links at different locations. With area of single structure as constant 1600sqm. Here the dynamic forces analysed in the direction of link were provided. By comparing the shapes best one will be found out. The ETABS software used to model the structures. The parameters considered in the analysis were storey displacement, drift and stiffness.

KEYWORDS: High rise building, Twin-Tower, Linked structure, Structure without link, Dynamic analysis, ETABS.

I. INTRODUCTION

High rise building have vital role in the modern cities. High rise buildings are the solution to the ever increasing demands of spaces. The height of the structure increased there is always an issue due to cantilever action. The height will be affected by lateral forces resulting from seismic and wind forces. It is important to make the tall building stiffer and resist the lateral forces. So the twin tower is an option to make the structure stiffer and effective. Twin tower is a pair of structures that were connected by using links. The link makes the structure stiffer and reduces. The seismic and wind forces were calculated in the direction of link provided.

Lateral loads and earthquake loads need to be considered when designing a structure. In different parts of the world there are differences in the effect of lateral and earthquake loads. In the field of structural engineering, high rise building must be able to withstand gravity as well as lateral loads. Structural safety, comfort ability and serviceability of the building is the responsibility of structural engineers. Twin tower plays an important role to give structural stability. Twin tower structure reduces the deflection at higher levels due to lateral loads. By linking the structures a new way of transportation formed letting people walk across the city without touching the ground, using streets in sky.

II. LITERATURE REVIEW

Sayed Mohamoud et al ^[10] done a horizontally connected high rise buildings under earthquake loadings. In this paper the seismic response of twin tall buildings horizontally connected at different height was studied. From the study they concluded that most unfavourable location of the sky bridge is the top of the building structure. They investigated that link bridge at the top floor reduces the peak displacement up to 29% and increase the shear up to 50%.

Chaurasiya et al ^[2] analyzed the efficient twin tower high rise building subjected to seismic loading. They considered G+12 'I' shaped building with 13 different cases. The story drift value was maximum in 12th floor twin structure than 5th floor twin structure. The displacement value for the twin tower cases was lesser in 12th floor twin structure.

Rishabh Sisodia et al ^[9] analysed G+30 symmetric structure which was an office building connected with one steel bridge at different levels to find the action of seismic loads on the structure using E-tabs. From the study it showed that the story displacement reduced in tower and imparting better durability and long life of the multi-tower. When the seismic forces and wind forces act on the tower the connections serves as the stiffener for both the towers. The most optimum connection was founded at 15th floor.

Afiya V N et al ^[1] presented a study on various buildings with connecting structures under lateral loading conditions such as seismic loads. In this project the software ETABS was used for modelling the structures. G+9 RCC twin tower structure with connecting corridors at different storey levels with varying spans of corridors was analysed. The result



analysed were storey displacement, storey drift, overturning moments, base shear, axial and bending moment. They concluded that the horizontal displacement and drifts under seismic loading in Y direction is larger than the displacement and drifts in X direction. Overturning moment depends on location and span of the corridors. The effort to maximum base shear is larger in X direction than Y direction.

Imad Shakir Abbood et al^[4] used finite element modelling technique. A linked building system 40-storey RC frame wall structures horizontally coupled by structural links. They used 4 models. They concluded that the twin tower linked at mid-height floors resulted largest displacement when compared with other cases. When compared with single tower model the displacement decreased by around 6% in twin tower linked at last top 2 floors. The story drift is less in single tower model than other models.

III.OBJECTIVES

- To understand twin tower structure.
- To analyse the effect of wind and seismic loads on twin tower structure.
- To understand the behaviour of various twin tower structure with varying plans.

IV.METHODOLOGY

- Literature reviews.
- Selecting different plan twin tower structures for comparative study.
- Top, bottom and middle location of twin tower structure are chosen to give the link and compared without link structure.
- Perform analysis on the building models by using ETABS software and a comparative study is to be done.
- The variation in considered parameters noted to find the best one.
- Concluding from the results.

V. STRUCTURE MODELLING

Twin tower was modelled using ETABS software. 40 storey building of height 140m with storey height of 3.5m was considered. The total area of the twin tower was 3200sqm. The dimension of column for all typical floors was 800mm x 800mm. For beam which was 500mm x 700mm. The proposed slab thickness was 120mm for all typical floors. Shear wall of thickness 300mm was used. Concrete of grade M50 is used for all columns and M40 used for remaining. Fe500 was the steel grade.

Here adopted two different plans .i.e. square and rectangular. To analyse the impact of without linked and linked building system. The links were provided at three different location .i.e. bottom, middle and top. Total eight models considered for the analysis. The dimension of square plan twin tower structure considered was 40m x 40m which have 8-bays in both x and y direction. The rectangular plan twin tower structure of dimension 20m x 80m was used. In rectangular plan twin tower structure there are 4-bays in x-direction and 16 bays in y-direction. Bay width in both x and y direction was 5m.

Table 1 shows the details of the model cases used for the analysis. Fig 1 shows the floor plan of the square and rectangular shaped structure. Fig 2 and Fig 3 were the elevation view of square shaped structures and rectangular shaped structures.

Table1 Details of models

Model Name	Model Description
Model 1	Square plan twin tower with no link
Model 2	Square plan twin tower with bottom link
Model 3	Square plan twin tower with middle link
Model 4	Square plan twin tower with top link
Model 5	Rectangular plan twin tower with no link
Model 6	Rectangular plan twin tower with bottom link
Model 7	Rectangular plan twin tower with middle link
Model 8	Rectangular plan twin tower with top link

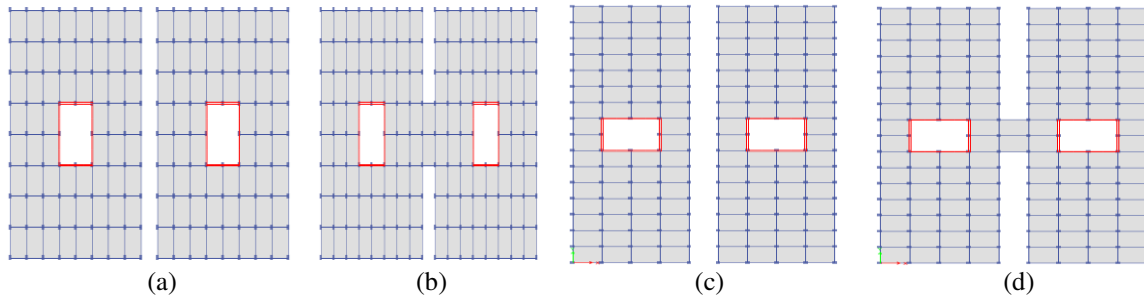


Fig.1. plan view of (a) square plan twin tower structure without link floors (b) square plan twin tower structure linked floors (c) rectangular plan twin tower structure without link floors (d) rectangular plan twin tower structure linked floors

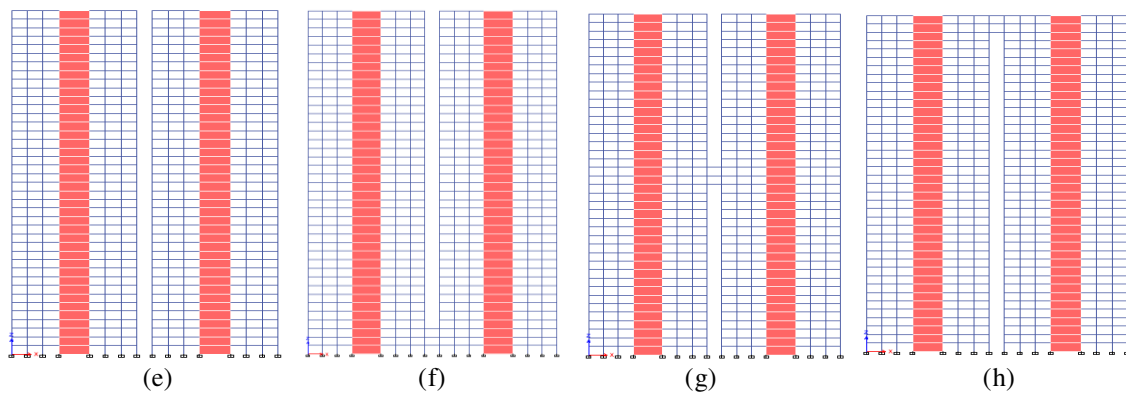


Fig.2. Elevation view of square plan twin tower structure (e) no link (f) link at bottom (g) link at middle (h) link at top

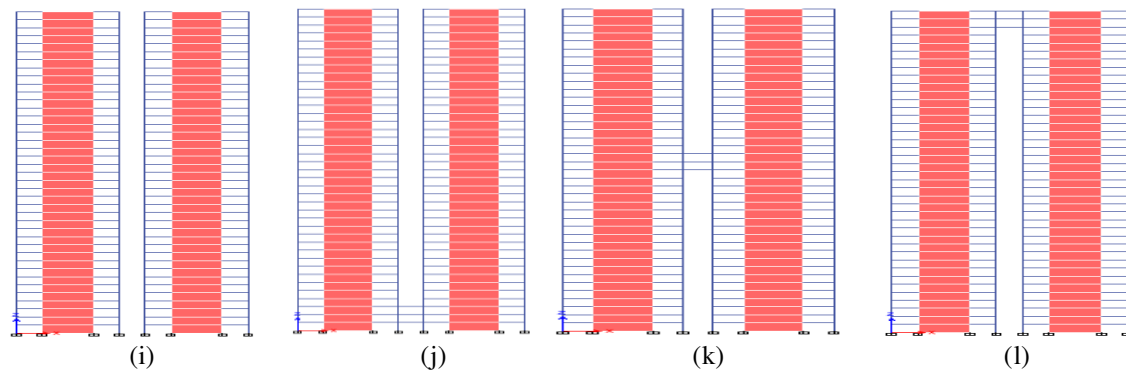


Fig. 3. Elevation view of rectangular plan twin tower structure (i) no link (j) link at bottom (k) link at middle (l) link at top

VI. LOADING

- Live load : 4kN/m^2
- Floor finish: 1.5kN/m^2
- External wall load: 12kN/m
- Internal wall load: 6kN/m
- External wall parapet load: 6kN/m
- Seismic parameters: Zone V ($Z=0.36$), Importance factor: 1.5, Response reduction factor:5, Damping: 5%, Site type: II.
- Wind parameters: Wind speed:50m/s, Terrain category:2, Importance factor:1



VII. ANALYSIS RESULTS

The analysis using ETABS is being carried out with the Indian code .i.e. IS875:2015, IS1893:2016, and IS456:2000. The result in terms of displacement, drift and stiffness are compared for all models in the direction of link provided. Table 2 shows the analysis results of the models along the direction of link provided.

Table 2 Analysis Results

Model	Displacement in mm		Drift		Stiffness in kN/m	
	EQ	WL	EQ	WL	EQ	WL
1	132.808	59.818	0.001170	0.000544	494.874x10 ⁵	516.162x10 ⁵
2	132.858	59.732	0.001171	0.000544	497.454x10 ⁵	518.506x10 ⁵
3	130.775	58.294	0.001152	0.000535	496.407x10 ⁵	517.214x10 ⁵
4	130.363	58.269	0.001158	0.000538	496.052x10 ⁵	516.953x10 ⁵
5	189.212	197.809	0.001653	0.001673	447.513x10 ⁵	479.501x10 ⁵
6	189.064	197.436	0.001652	0.00167	450.555x10 ⁵	482.263x10 ⁵
7	180.266	188.597	0.001566	0.001593	451.578x10 ⁵	482.447x10 ⁵
8	179.337	187.874	0.001572	0.001608	450.820x10 ⁵	481.184x10 ⁵

From the analysis results the displacement of model 4 .i.e. Square plan twin tower with top link shows reduction in displacement when compared with other square plan twin tower structure. Considering square plan twin tower structure drift value is reduced in model 3 .i.e. Square plan twin tower with middle link and stiffness is higher in model 2.i.e. Square plan twin tower with bottom link. In rectangular case also displacement is lower in model 8 .i.e. rectangular plan twin tower with top link, drift value is reduced in model 7 rectangular plan twin tower with middle link and stiffness is higher in model 7 rectangular plan twin tower with middle link. From this the structures with link which shows better performance than structures without link.

VIII. COMPARISON OF RESULTS

Storey displacement is the lateral movement of the structure caused by lateral forces. It is a critical parameter of structural design. Fig 4 graph shows the maximum variation of storey displacement for square shaped structure and rectangular shaped structure along the direction of link provided.

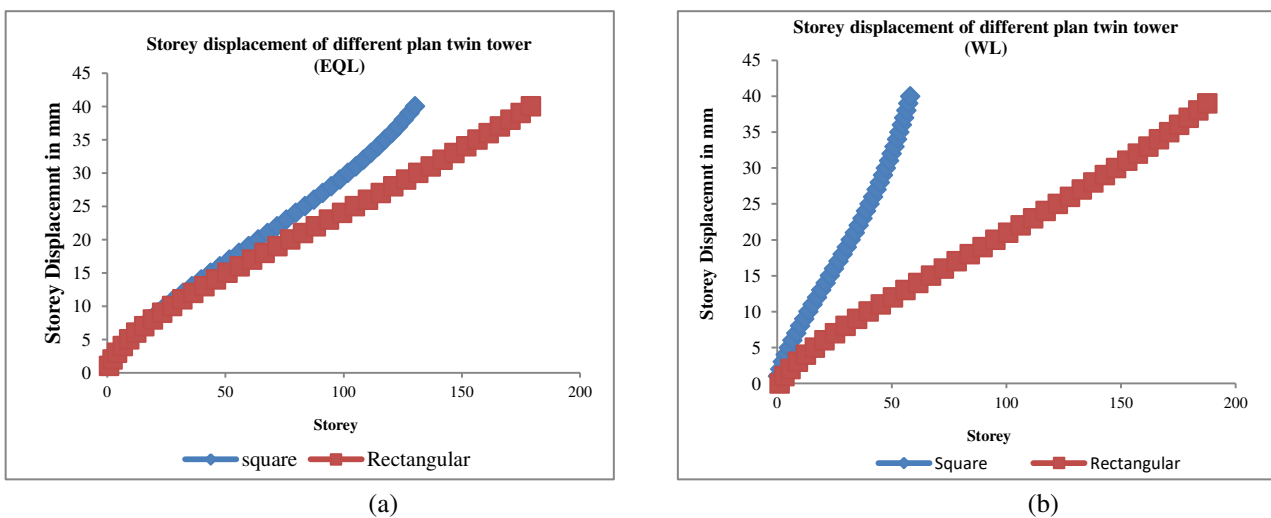


Fig 4 Maximum Storey Displacement (a) for earthquake load (b) for wind load

Storey drift is the relative displacement of a storey with respect to the adjacent storey. Fig 5 graph shows the maximum variation of storey drift for square plan twin tower structure and rectangular plan twin tower structure along the direction of link provided.

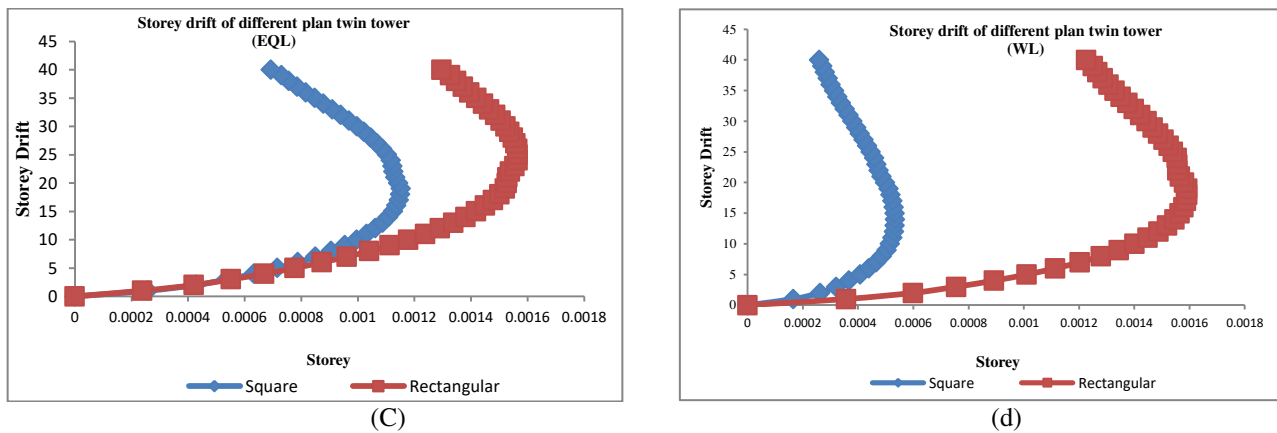


Fig 5 Maximum Storey Drift (c) for earthquake load (d) for wind load

In general stiffness is a measure of the resistance offered by an elastic body to deformation. A fig 6 graph shows the maximum variation of stiffness for square plan twin tower structure and rectangular plan twin tower structure along the direction of link provided.

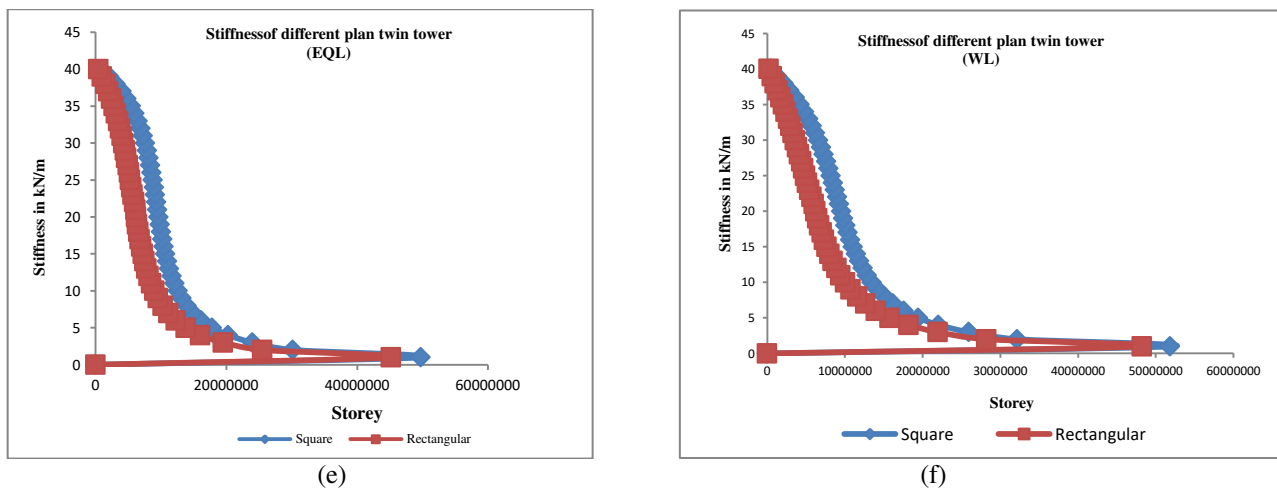


Fig 6 Stiffness (e) for earthquake load (f) for wind load

By comparing the results from the graphs the square plan twin tower linked structures shows better performance than rectangular plan twin tower structures. The displacement, drift and stiffness of square plan twin tower structures are better than the results of rectangular plan twin tower structure. The displacement of square plan twin tower structure decreased 27.43% than rectangular structure in earthquake load. In case of wind load Square plan twin tower structure is reduced about 68.29% than rectangle. The drift value of square plan twin tower structure decreased about 26.44% than rectangular plan twin tower in earthquake load and 66.42% than rectangle in wind load. The value of stiffness in square plan twin tower structure is 10.16% greater than rectangle under earthquake load and 7.47% greater than rectangle plan in wind load.

IX. CONCLUSION

The dynamic analyses were conducted in square and rectangular plan twin tower connected by using links. From analysis the square plan twin tower shows better result than that of rectangular plan twin tower. Square plan twin tower structures linked at top show least value in storey displacement. Storey drift is also least in square plan twin tower structures linked at middle. The stiffness value also shows better result in the case were the square plan twin tower structures linked at bottom. From the comparison of analysis result square plan twin tower linked structures is recommended as a better option in tall building than rectangular plan twin tower linked structures.



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