Stability Analysis Of Shear Wall At Different Locations In Multi-Storeyed Geometrically Irregular Building Using ETABS

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Abstract - Many buildings in the present scenario have irregular configurations both in plan and elevation. This in future may subject to devastating earthquakes. In case, it is necessary to identify the performance of the structures to withstand against disaster for both new and existing one. The current version of the IS: 1893 (part I) -2002 requires that practically all multi-storied buildings be analyzed as three-dimensional systems. This is due to the irregularities in plan or elevation or in both.

In this study we have introduced shear wall in the multi-storey building. A fix plan irregularity is considered in the structure. To see the effect of building with and without shear wall (shear wall having different shape, with constant area is to be taken). The study as a whole makes an effort to evaluate the effect of shear wall in irregular RCC buildings, in terms of dynamic characteristics and the influencing parameters which can regulate the effect on Story Displacement, Drifts of adjacent stories, Excessive Torsion, Base Shear, etc.

Keywords— CSI-ETABS, Moment resisting frame, RC shear wall, Seismic loading, Story drift, Structural irregularity.

I. INTRODUCTION

The rapid growth of urban population and limitation of available land, scarcity and high cost of available land, the taller structures are preferable now days. As the height of structure increases then the consideration of lateral load is very much important. For that the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. The lateral load resisting systems that are widely used are rigid frame, shear wall, diagrid structural system, wall frame, braced tube system, outrigger system and tubular system. Recently shear wall systems and diagrid structural system are the most commonly used lateral load resisting systems. Shear walls have very high in plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications. Diagrid structural system is adopted in tall buildings due to its structural efficiency and flexibility in architectural planning. Diagrid–diagonal grid structural systems are widely used for tall buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. Hence the diagrid, for structural effectiveness and aesthetics has generated renewed interest from architectural and structural designers of tall buildings.

ETABS is an engineering software product created by Computer and Structure, Inc.'s software that caters to multi-story building analysis and design. Modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS.

II. LITERATUREREVIEW

This particular section of the paper reflects the previous studies &conclusions on influence of using shear wall in structures subjected to seismic loads. Also this reflects the previously work done to improve the seismic behavior of structures and various loading and failure scenarios.

Agarwal and Shrikhandem[1](2011) This paper discussed that reinforced concrete multi-storied buildings in India, for the first time, have been subjected to a strong ground motion shaking during Bhuj earthquake of January 26, 2001 resulting in a considerable damage. It has been observed that the principal reasons of failure are due to soft story, floating columns, mass irregularities, poor quality of construction material and faulty construction practices, inconsistent earthquake response, soil and foundation effect and pounding of adjacent structures. This chapter presents description of types of construction, types of damage and causes of damage in selected multi-storied reinforced concrete buildings and lessons learnt from the failure.Modifications needed in the design practices to minimize earthquake damages have also been proposed.

Sardar and Karadi[2](2013) As mentioned by the author shear wall is a structural element used to resist horizontal forces parallel to the plane of the wall. Shear wall has highly in plane stiffness and strength which can be used to simultaneously resist large horizontal loads and support gravity loads. Shear Walls are specially designed structural walls include in the buildings to resist horizontal forces that are induces in the plane of the wall due to wind, earthquake and other forces. They are mainly flexural members and usually provided in high rise buildings to avoid the total collapse of the high rise buildings under seismic forces. In this project, study of 25 storey building in zone V is presented with some investigation which is analyzed by changing various location of shear wall for determining parameters like storey drift, storey shear and displacement is done by using standard package ETAB. Creation of 3D building model for both linear static and linear dynamic method of analysis and influence of concrete core wall provided at the center of the building

Sud et al.[3](2014) This study focuses onshear walls being one of the most basic lateral load resisting elements in an earthquake resistant building. To avoid torsion in buildings, shear walls must be placed symmetrically in plan. In this paper, a five-storey RC building located in seismic zone-V is considered with four shear walls. Five different configurations of shear walls viz. bare frame, shear wall symmetrically placed at exterior bays (centrally), at core and adjacently placed in exterior of the building, are considered.

The frame with shear walls at core and centrally placed at exterior bays showed significant reduction of order 29% to 83% in lateral displacement. The reduction in bending moments is approximately 70% to 85% for interior and perimeter columns respectively. Shear and axial forces in columns have reduced by 86% and 45% respectively. Based on such results, the best placement of shear walls in building plan is suggested.

M.Ashrafet al.[4](2008) A study has been carried out to determine the optimum configuration of a multi-storey building by changing shear walls location. Four different cases of shear wall position for a 25 storey building have been analyzed as a space frame system using a standard package ETAB subjected to lateral and gravity loading in accordance with UBC provisions. It is found that columns and beams forces are found to increase on grids opposite to the changing position of shear wall away from the centroid of the building. Twisting moments in members are observed to be having increasing trend with enhancement in the eccentricity between geometrical centroid of the building and shear wall position. Stresses in shear wall elements have more pronounced effect in elements parallel to displaced direction of shear wall as compared to those in perpendicular direction. The lateral displacements of the building are uniform for a zero eccentricity case. On the contrary, the drift is more on grids on one side than that of the others in case of eccentric shear wall position. It is concluded that the shear wall should be placed at a point by coinciding centre of gravity and centroid of the building.

Swaddiwudhiponget al.[5](2003) In this particular studya computer program for the analysis of tall buildings comprising frames and shear walls coupled together is presented. Both static and free vibration analyses of the buildings of both uniform and no uniform sections on either rigid or flexible foundation are considered. The governing equations are formulated through the continuum approach treating the structures as shear-flexure cantilevers. Both polynomial and transcendental displacement functions are employed to approximate the true displacement field. The method is shown to be simple yet powerful.

III. OBJECTIVES OF THE STUDY

- Analysis of building using different type of Shear wall patterns at different location in the building.
- Obtaining the nodal displacement, overturning moment, Story Drift for different shapes of shear wall for V seismic zone with the help of CSI - Etabs 2018.
- To see the optimum location of Shear Wall in the building.
- To do the analysis of building using different shapes of Shear Wall in building using CSI-Etabs 2018

IV. METHODOLOGY

For this study, a 20-story building with a 3-meters height for Each story, irregular plan is modeled. These buildings were designed in compliance to the Indian Code of Practice for Seismic Resistant Design of Buildings IS 1893:2016. The buildings are assumed to be fixed at the base and the floors acts as rigid diaphragms. The different sections of shear walls are taken and their area is kept constant for different shapes. Storey heights of buildings are assumed to be constant including the ground storey. The buildings are modeled using software ETAB Nonlinear v 9.5.0. Eight different models were studied with different positioning of shear wall in building. Models are studied in v zones comparing lateral displacement, story drift, overturning moment, Shear force are being compared between each models.

The eight different building models that have been taken are given below:-

- Model 1 – Model with no Shear wall.
- Model 2 – Model with L-Shape Shear wall.
- Model 3 - Model with Shear wall at all corners.
- Model 4 –Model with Rectangular-Shape Shear wall.
- Model 5 - Model with Shear wall at centre.
- Model 6 - Model with Shear wall at L-shape diagonal.
- Model 7 - Model with I-Shape Shear wall.
- Model 8 - Model with Shear wall at corners.

Table No.1

Preliminary data adopted in the analysis**:-**

S.No.	**Specification**	**Details**
1	No. of stories	G+20
2	Plan area	1188mm^2
3	Grid spacing	6m X 6m
4	Floor to Floor Height	3m
5	Beam size longitudinal and transverse direction	250x500 mm2
6	Column size	300x600 mm2
7	Thickness of slab	150 mm
8	Thickness Shear Wall	200 mm
9	Thickness of Internal wall	230 mm
10	Grade of Concrete	M25
11	Grade of steel	Fe415
12	Zone factor (Z)	0.36
13	Importance factor (I)	1.5
14	Response reduction factor (R)	5
15	Soil Strata	Medium
16	Dead load	2KN/m
17	Live load	5KN/m^2
18	Wall load	12KN/m^2

V. OBSERVATION AND RESULTS

From the study and analysis carried out in this research work it can be that as we change the position and Shape of Shear wall, having similar area will reduce the effect of irregularity and thus two best and most fit position of shear wall to be placed are Model-7(Model with I-Shape Shear wall) and Model-8(Model with Shear wall at corners).

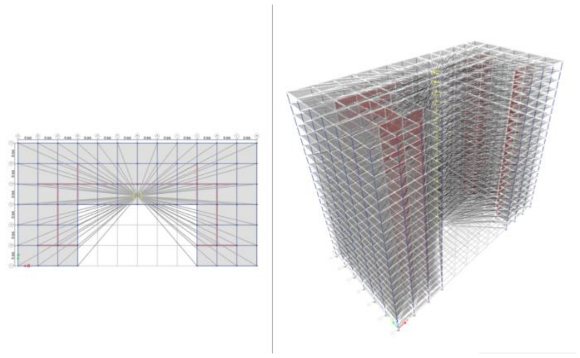

Figure No. 1(Model-7)

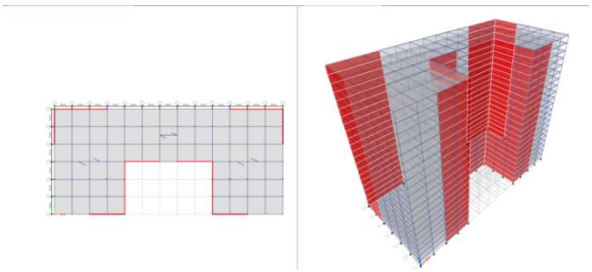

Figure No. 2 (Model-8)

Different seismic responses are recorded for the modeling systems which are Story Displacement, Story Drift, Story overturning moment and Story Shear force.Different load combination are applied and the max response we get is for the loading 1.5 (DL + EQX).The maximum parameter recorded (i.e. Model-8) for the following analysis up to the top of the story level are shown below:-

Table No. 2
Maximum parameters recorded

Story	Story displacement in X-axis (mm)	Story drift (mm)	Overturning moment (KN-m)	Story shear force (KN)
	Model-8 (Model with Shear wall at corners)			
Story20	49.942	0.00054	289411.14	-5261.84
Story19	48.368	0.00058	684848.23	-10650.9
Story18	46.667	0.00061	1086781.3	-15487.5
Story17	44.835	0.00066	1506210.4	-19801.7
Story16	42.87	0.0007	1943135.5	-23623.3
Story15	40.774	0.00074	2397556.6	-26982.1
Story14	38.549	0.00078	2869473.7	-29908
Story13	36.2	0.00082	3358886.8	-32430.8
Story12	33.734	0.00086	3865795.8	-34580.5
Story11	31.158	0.00089	4390200.9	-36386.8
Story10	28.481	0.00092	4932102	-37879.6
Story9	25.716	0.00095	5491499.1	-39088.7
Story8	22.875	0.00097	6068392.2	-40044.1
Story7	19.973	0.00098	6662781.3	-40775.6
Story6	17.028	0.00099	7274666.4	-41313
Story5	14.061	0.00099	7904047.5	-41686.2
Story4	11.096	0.00098	8550924.5	-41925.1
Story3	8.164	0.00095	9215297.6	-42059.4
Story2	5.302	0.00091	9897166.7	-42119.1
Story1	2.564	0.00086	10596532	-42134.1
Base	0	0	11012982	0

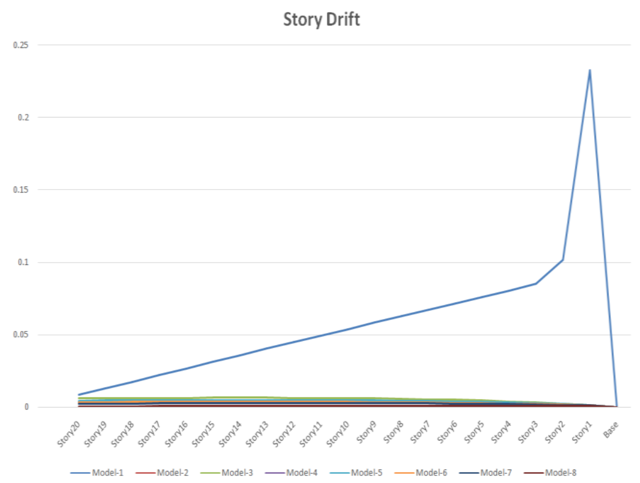

Figure No. 3 (Graph of storey drift)

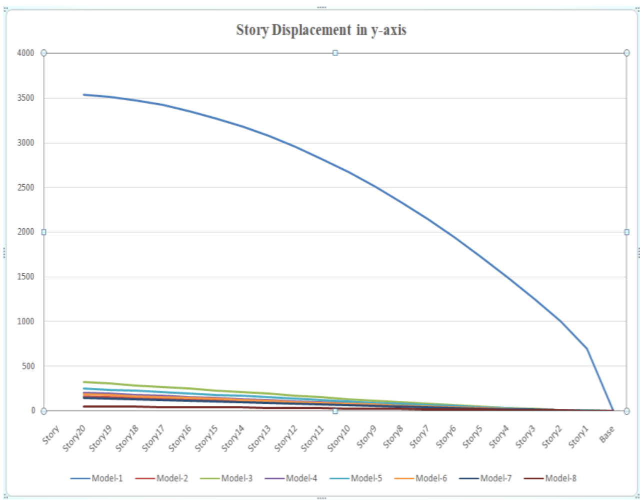

Figure No. 4 (Graph storey displacement in Y axis)

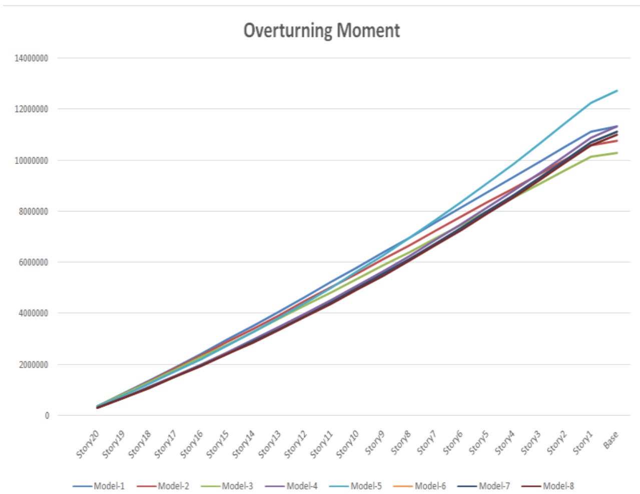

Figure No. 5 (Graph of overturning moment)

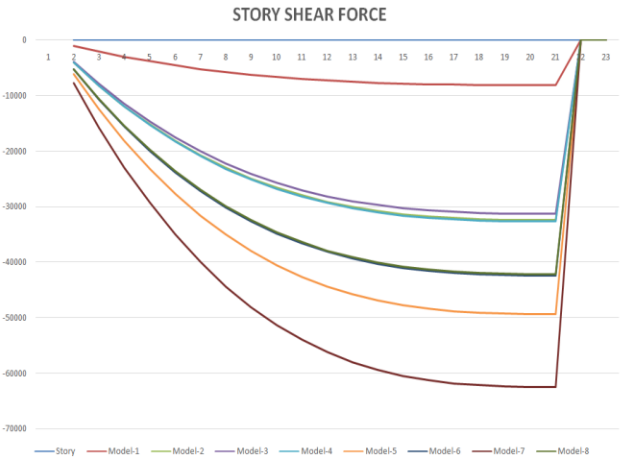

Figure No. 6 (Graph of storey shear force)

VI. CONCLUSION AND DISCUSSION

In this study we introduced shear walls in the multi-storey building. A fix plan irregularity is considered in the structure, to see the effect of building with and without shear wall (shear wall having different shape, with constant area is to be taken). In this study we have discussed about the performance of G+20 multi-storey building under seismic loading. Structural irregularities are important factors which decreases the seismic performance of the structures. The study as a whole makes an effort to evaluate the effect of shear wall in irregular RCC buildings, in terms of dynamic characteristics and the influencing parameters which can regulate the effect on Story Displacement, Drifts of adjacent stories, Excessive Torsion, Base Shear, etc.

- It is observed from the above analysis that the displacement in x-axis and y-axis observed in first model (which is without shear wall building) shows maximum displacement compared to the remaining models having shear wall at different locations.
- It can be observed that the min. displacement and story drift has occurred in Model-7 and Model-8. As the Shape of Shear wall is as I-Section for model-7 at the center and at corners. By providing shear wall the stability of model is increased against lateral loading. Therefore, the displacement and story drift are reduced if the Shear wall is provided at center or at corresponding corners.
- It can be observed that the maximum stiffness has occurred in model-7 and model-8. As the filling is more therefore, the stiffness is also higher.
- We obtained min. overturning moment values for models-7 and model-8. The maximum overturning moment has occurred at the base of the building and it is observed that it is maximum if no shear wall is provided.
- The best location of shear wall a in multi-story building obtained from the CSI-Etabs 2018 is in model-8 (shear wall near the core of the building) & then in the model-7 (I-shape shear wall placed at the center of the building).

From the above discussion it is observed that as we change the position and Shape of Shear wall, having similar area will reduce the effect of irregularity against the lateral loading in model-8 and model-7 of G+20 RC building in V seismic zone, the story displacement, story drift, overturning moment is effectively reduced. It is also observed that by changing the location, story stiffness get effected

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