Effect of Shear Wall on Overall Performance of Multi-Storied Buildings

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Abstract- *Performance of structures under frequently occurring earthquake ground motions resulting in structural damages as well as failures have repeatedly demonstrated the seismic vulnerability of existing buildings, due to their design based on gravity loads only or inadequate levels of lateral forces. This necessitates the need for design based on seismic responses by suitable methods to ensure strength and stability of structures. Shear wall systems are one of the most used lateral load resisting systems in high rise buildings. This study aims at comparing various parameters such as story drift, story shear, deflection, etc. of a building under lateral loads based on strategic positioning of shear walls. In this project a parametric model of symmetric building configuration has been selected for study, 6 models of different structural configuration have been generated, combining frame and shear walls. Models started with first bare frame model, planar shear wall model with x and y orientation, corner L shaped shear walls and Central core wall with and without openings at each successive floor level.*

I. INTRODUCTION

An Earthquake is a sudden slipping or movement of a portion of the earth's crust or plates, caused by a sudden release of stresses. Earthquake epicenter are usually less than 25 miles below the earth surface and are accompanied and followed by a series of vibrations Hybrid Reinforced Concrete

EARTHQUAKE AND ITS TYPES

Most earthquakes in the world occur along the boundaries of the tectonic plates and are called Inter- plate Earthquakes. A number of earthquakes also occur within the plate itself away from the plate boundaries, called Intra-plate Earthquakes. Earthquakes are recorded by instrument called seismographs. The recording they made is called a seismogram.

: EARTHQUAKE ENVIRONMENT EFFECTS

Earthquake environmental effects are the effects caused by an earthquake on the natural environment, including surface faulting, tectonic uplift and subsidence, tsunamis, soil liquefactions, ground resonance, landslides and ground failure, either directly linked to the earthquake source or provoked by the ground shaking. These are common features produced both in their near and far fields, routinely recorded and surveyed in recent events, very often remembered in historical accounts and preserved in the stratigraphic record (paleo earthquakes).

: SOFT STOREY

Reinforced-concrete framed structure in recent time has a special feature i.e. the ground storey is left open for the purpose of social and functional needs like vehicle parking, shops, reception lobbies, a large space for meeting room or a banking hall etc. Such buildings are often called open ground storey buildings or soft story buildings. Again when a sudden change in stiffness takes place along the building height, the story at which this drastic change of stiffness occurs is called a soft story.

: SHEAR WALLS

Shear walls are vertical elements of the horizontal force resisting system. Shear walls are constructed to counter the effects of lateral load acting on a structure. In residential construction, shear walls are straight external walls that typically form a box which provides all of the lateral support for the building. When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces.

Effect of Shear Wall

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. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation.

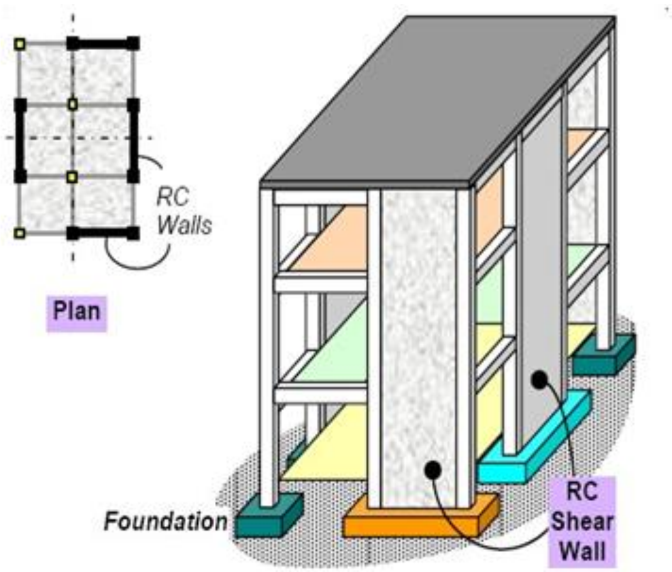

Fig 1.6: Shear walls in building

Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. They could be placed symmetrically along one or both directions in plan. Shear walls are more effective when located along exterior perimeter of the building – such a layout increases resistance of the building to twisting.

II. REVIEW OF LITERATURE

Overview

GENERAL

Various research works and experiments have been carried out since a long time all over the globe to understand or to evaluate the effect of seismic forces on existing RC building in high seismic zones. The concept of modeling and analysis techniques used for this purpose has also been getting improved with advancement of engineering and technology as well as with past experience.

COLLECTION OF LITERATURE

A study on ***"Seismic Performance Evaluation of Multi- storied RC framed buildings with Shear wall"*** by **SHAIK KAMAL MOHAMMED AZAM** and **VINOD HOSUR{1}.**A comparison of structural behaviour in terms of strength, stiffness and damping characteristics is done by arranging shear walls at different locations/configurations in the structural framing system. The elastic (response spectrum analysis) as well as in-elastic (nonlinear static pushover analysis) analyses are carried out for the evaluation of seismic performance

Study on ***"Effect of shear wall location in buildings subjected to seismic loads"*** *by* **LAKSHMI K.O et.al[1]** Performance of structures under frequently occurring earth quake ground motions resulting in structural damages as well as failures have repeatedly demonstrated the seismic vulnerability of existing buildings, due to their design based on gravity loads only or inadequate levels of lateral forces.

Study carried on **"*effect of change in shear wall location on storey drift of multistory building subjected to lateral loads*"** *by* **Shahzad Jamil Sardar et.al[3].** Shear wall is a structural element used to resist horizontal forces parallel to the plane of the wall. Shear wall has highiy 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.

III. METHODOLOGY

ANALYSIS METHODS

In this project two types of analysis had been used namely:-

: EQUIVALENT STATIC ANALYSIS:-

This is a linear static analysis. This approach defines a way to represent the effect of earthquake ground motion when series of forces are act on a building, through a seismic design response spectrum. This method assumes that the building responds in its fundamental mode. The applicability of this method is extended in many building codes by applying factors to account for higher buildings with some higher modes, and for low levels of twisting. To account for effects due to "yielding" of the structure, many codes apply modification factors that reduce the design forces.

: RESPONSE SPECTRUM:-

In order to perform the seismic analysis and design of a structure to be built at a particular location, the actual time history record is required. However, it is not possible to have such records at each and every location. Further, the seismic analysis of structures cannot be carried out simply based on the peak value of the ground acceleration as the response of the structure depend upon the frequency content of ground motion and its own dynamic properties. To overcome the above difficulties, earthquake response spectrum is the most popular tool in the seismic analysis of structures.

There are computational advantages in using the response spectrum method of seismic analysis for prediction of displacements and member forces in structural systems. The method involves the calculation of only the maximum values of the displacements and member forces in each mode of vibration using smooth design spectra that are the average of several earthquake motions.

This chapter deals with response spectrum method and its application to various types of the structures. The codal provisions as per IS: 1893 (Part 1)-2002 code for response spectrum analysis of multi-story building is also summarized. According to IS 1893-2002 the Response spectrum curve is given as

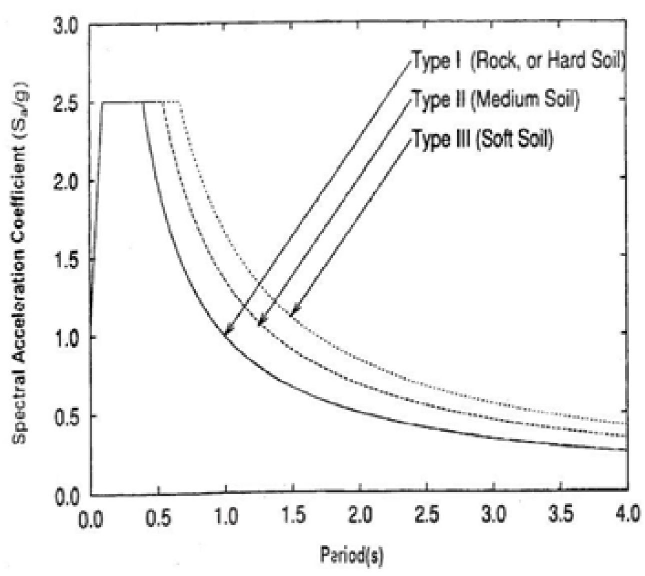

Fig : 3.2 response spectrum curve

: RESPONSE SPECTRA

Response spectra are curves plotted between maximum response of SDOF system subjected to specified earthquake ground motion and its time period (or frequency). Response spectrum can be interpreted as the locus of maximum response of a SDOF system for given damping ratio. Response spectra thus helps in obtaining the peak structural responses under linear range, which can be used for obtaining lateral forces developed in structure due to earthquake thus facilitates in earthquake-resistant design of structures.

: IS CODE RECOMMENDATIONS:-

The representation of the maximum response of idealized single degree freedom systems having certain period and damping, during earthquake ground motion. The maximum response is plotted against the undamped natural period and for various damping values, and can be expressed in terms of maximum absolute acceleration, maximum relative velocity, or maximum relative displacement.

IV. RESULTS& DISCUSSIONS

GENERAL

In this chapter we will discuss about the results which we obtained from ETABS after analyzing the models and results have been given in a tabular form and graphical representation for better understanding.

The Following parameters have been studied and the results are extracted from the computer program.

1) Storey Displacement
2) Storey Drift
3) Base shear
4) Fundamental Time Period
5) Mode shapes.

: STOREY DISPLACEMENT: -

Storey displacement is the lateral movement of the structure caused by lateral force. The deflected shape of a structure is most important and most clearly visible point of comparison for any structure. No other parameter of comparison can give a better idea of behavior of the structure than comparison of storey displacement.

As far as possible the displacement must be within the limits as specified by codal provision, otherwise leading to sever damage to buildings system.

Table No-4.2: Displacement in longitudinal Direction

Roof Displacements in mm												
STOREY	MODE L 1		MODE L 2		MODE L 3		MODE L 4		MODE L 5		MODE L 6	
	U X	U Y	U X	U Y	U X	U Y	U X	U Y	U X	U Y	U X	U Y
11	32.6	32.0	22.1	22.1	25.2	32.9	31.8	25.7	16.4	15.5	17.2	16.4
10	31.6	30.9	20.4	20.4	23.5	32.1	31.0	23.9	14.8	14.1	15.6	14.9
9	30.1	29.3	18.5	18.5	21.6	30.7	29.7	22.0	13.1	12.5	13.9	13.3
8	28.0	27.1	16.4	16.4	19.5	28.6	27.7	19.7	11.4	10.9	12.2	11.6
7	25.4	24.4	14.2	14.2	17.0	26.1	25.3	17.2	9.7	9.2	10.3	9.9
6	22.4	21.4	11.8	11.8	14.3	23.1	22.5	14.4	7.9	7.6	8.5	8.2
5	19.2	18.1	9.3	9.3	11.4	19.8	19.3	11.5	6.2	5.9	6.7	6.4
4	15.6	14.4	6.9	6.9	8.5	16.1	15.7	8.5	4.6	4.4	5.0	4.8
3	11.8	10.6	4.6	4.6	5.7	12.1	12.0	5.6	3.1	3.0	3.4	3.3
2	8.0	7.0	2.5	2.5	3.1	8.2	8.1	3.1	1.8	1.7	2.0	1.9
1	4.4	3.7	1.0	1.0	1.2	4.6	4.5	1.2	0.8	0.8	0.9	0.9

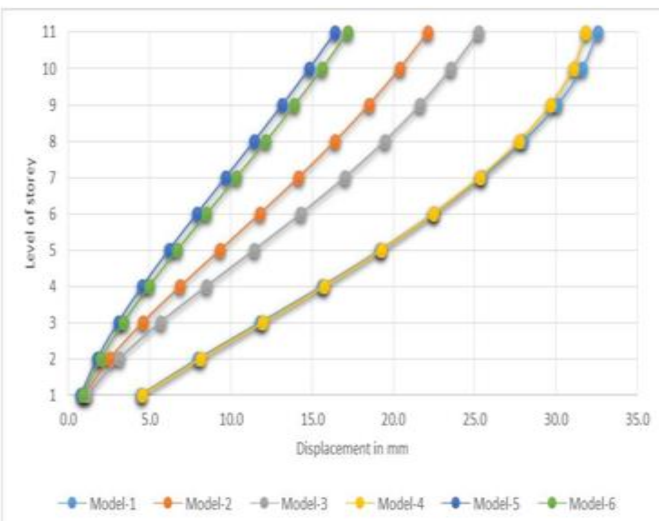

Chart No-4.2 Displacement in Longitudinal Direction.

Table-4.3 Displacement in Transverse Direction.

Roof Displacements in mm												
STOREY	MODE L 1		MODE L 2		MODE L 3		MODE L 4		MODE L 5		MODEL 6	
	U X	U Y	U X	U Y	U X	U Y	U X	U Y	U X	U Y	U X	U Y
11	32.6	32.0	22.1	22.1	25.2	32.9	31.8	25.7	16.4	15.5	17.2	16.4
10	31.6	30.9	20.4	20.4	23.5	32.1	31.0	23.9	14.8	14.1	15.6	14.9
9	30.1	29.3	18.5	18.5	21.6	30.7	29.7	22.0	13.1	12.5	13.9	13.3
8	28.0	27.1	16.4	16.4	19.5	28.6	27.7	19.7	11.4	10.9	12.2	11.6
7	25.4	24.4	14.2	14.2	17.0	26.1	25.3	17.2	9.7	9.2	10.3	9.9
6	22.4	21.4	11.8	11.8	14.3	23.1	22.5	14.4	7.9	7.6	8.5	8.2
5	19.2	18.1	9.3	9.3	11.4	19.8	19.3	11.5	6.2	5.9	6.7	6.4
4	15.6	14.4	6.9	6.9	8.5	16.1	15.7	8.5	4.6	4.4	5.0	4.8
3	11.8	10.6	4.6	4.6	5.7	12.1	12.0	5.6	3.1	3.0	3.4	3.3
2	8.0	7.0	2.5	2.5	3.1	8.2	8.1	3.1	1.8	1.7	2.0	1.9
1	4.4	3.7	1.0	1.0	1.2	4.6	4.5	1.2	0.8	0.8	0.9	0.9

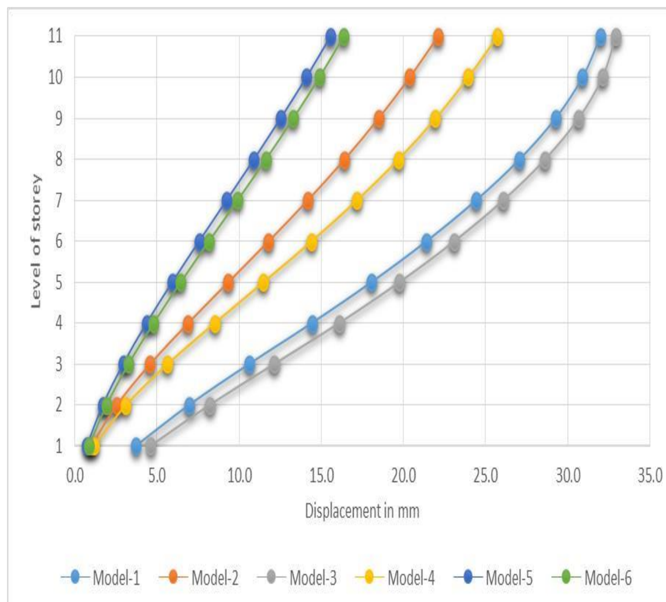

Chart No-4.3 Displacement in Transverse Direction

it can be seen from above figures, the displacement of the stories of structures is reduced by developing MODEL-2,4,5,6.The displacement in Model-2 Has been reduced by 32.22 % in comparison of Model-1, Model-3 has been reduced to22.7%.Model-4 has been reduced by 2.45%, Model-5 has been reduced by 49.7%, Model-6 has been reduced by 47.24%.

According to this work, the reduction of displacement of stories is due to increase of stiffness of structure as well as decrease of velocity and acceleration of structure. In other words by creating theMODEL-2, 3,4,5,6 the

response of structure such as velocity and acceleration can be reduced and it is the cause of reduction of displacement.
MODEL-2 and MODEL-3 reveals the same results when we compare with MODEL-1, therefore it can be stated that, orientation of shear walls will play a major rule in designing seismic resistant structures. Models with L-shapes shear walls shows better results than any other, therefore arranging shear wall away from the rigid center will enhance the lateral stability of the structure and can considerably reduce the seismic hazardous.

Models with core walls and core walls openings are showing the same results, hence it can be stated that, opening in lift elevator, doesn't make much difference on overall performance of the building systems.

Comparison is made along longitudinal direction only. Transverse direction comparison can also be made and results can be compared, since the building is symmetrical along both orthogonal direction, only longitudinal direction's comparison has made.

V. CONCLUSIONS

1. Model-1 shows highest time period and lowest base shear, it indicates it has got least stiffness as compare to other five Models.
2. MODEL-2 and MODEL-3 reveals the same results when we compare with MODEL-1, therefore it can be stated that, orientation of shear walls will play a major rule in designing seismic resistant structures.
3. Models with L-shapes shear walls shows better results than any other, therefore arranging shear wall away from the rigid center will enhance the lateral stability of the structure and can considerably reduce the seismic hazardous.
4. When we compare bare frame model with other models, it shows highest storey displacements at top storey, when we add planar or L- shaped shear wall displacement got reduced considerably hence provision of shear wall reduces storey displacements and make the structure stiff .
5. Models with core walls and core walls openings are showing the same results, hence it can be stated that, opening in lift elevator, doesn't make much difference on overall performance of the building systems.

VI. ACKNOWLEDGEMENT

The We sincerely thanks to our chairman Sri. M Prabhakar Reddy GARU for fostering an excellent academic environment and labs during our project work. We sincerely thank Dr. B.D. Venkatramana Reddy M.Tech., Ph.D., and Director of our college for his suggestions during our project work. We sincerely thank Dr. V. Senthil Murugan M.E, Ph.D., and principal of our college for fostering an excellent academic environment and for his suggestions during our project work. We are grateful to Mr. R. Surya Prakash M.E, Head of the Department for his support guidance, valuable suggestions, and uninterrupted cooperation during our project work.

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