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DYNAMIC RESPONSE OF A BUILDING WITH SHEAR WALL

Vemuri Nagarjuna, SK.Bajamma
PG scholar, Department of civil, ST. Mary's Group of Institutions
Assistant professor, Department of civil, ST. Mary's Group of Institutions

ABSTRACT:
Many reinforced concrete buildings in urban regions lying in active seismic zones, may suffer moderate to severe damages during ground motions. Shear walls are extensively used for buildings to resist lateral loads induced by earthquake. Constructions made of shear walls majorly resist the seismic force, wind forces and even can be built on soils of weak bases by adopting various ground improvement techniques. Not only the quickness in construction process but the strength parameters and effectiveness to bare horizontal loads are very high. Shear walls generally used in high earth quake prone areas, as they are highly efficient in taking the loads. Not only the earthquake loads but also winds loads which are quite high in some zones can be taken by these shear walls efficiently and effectively. Though these types of constructions have their origin in western nations in early 90's, this ideology has changed rapidly and spread all over the world with in no time. The form work used in this type of construction is of a new kind in Indian construction scenario. Certain patented systems based on imported technologies such as "Mascon System" (Canada), "Mivan system" (Malaysia) have come on the Indian scene in recent years. In these systems traditional column and beam construction is eliminated and instead walls and slabs are cast in one operation at site by use of specially designed, easy to handle (with minimum laborand without use of any equipment) light weight pre-engineered aluminum forms. It is necessary to study, the actual seismic performance of the buildings with shear wall during earthquake in order to predict the distribution of forces and deformations.

The present study aims to investigate the effectiveness of reinforced concrete shear wall in the buildings subjected to seismic loads. The shear wall is an alternate structural form for resisting the earthquake forces. In this study, G+10 building seismic analysis is carried out with and without shear wall by using response spectrum method as per IS: 1893-2002 (Part I). The analysis is carried out using ETABS finite element analysis software. It is concluded that, presence of shear wall in the structure decreases percentage of reinforcement in the columns and increases the lateral stiffness of the building, thus performing effectively in resisting lateral forces induced byanearthquak.

I. INTRODUCTION

1.1 General Introduction

The walls, in a building, which resist lateral loads originating from wind or earthquakes, are known as shear walls. A large portion of the lateral load on a building, if not the whole amount, as well as the horizontal shear force resulting from the load, are often assigned to such structural elements made of RCC. These shear walls, may be added solely to resist horizontal force, or concrete walls enclosing stairways, elevated shafts, and utility cores may serve as shear walls. Shear walls not only have very large in-plane stiffness and therefore resist lateral load and control deflection very efficiently, but may also help to ensure development of all available plastic hinge locations throughout the structure prior to failure. The other way to resist such loads may be to have the rigid frame augmented by the combination of masonry walls.

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1.2 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.

1.3 Purpose of Constructing Shear Walls

Shear walls are not only designed to resist gravity / vertical loads (due to its self-weight and other living / moving loads), but they are also designed for lateral loads of earthquakes / wind. The walls are structurally integrated with roofs / floors (diaphragms) and other lateral walls running across at right angles, thereby giving the three dimensional stability for the building structures.

1.4 Comparisons of Shear Wall with Construction of Conventional Load Bearing Walls

Load bearing masonry is very brittle material. Due to different kinds of stresses such as shear, tension, torsion, etc., caused by the earthquakes, the conventional unreinforced brick masonry collapses instantly during the unpredictable and sudden earthquakes.

The RCC framed structures are slender, when compared to shear wall concept of box like three dimensional structures. Though it is possible to design the earthquake resistant RCC frame, it requires extraordinary skills at design, detailing and construction levels, which cannot be anticipated in all types of construction projects.

LITERATURE REVIEW

Mr.K.LovaRaju(**et.al**) conducted non-linear analysis of frames to identify effective position of shear wall in multi storey building. An earthquake load was applied to a eight storey structure of four models with shear wall at different location in all seismic zones using ETABS. Push over curves were developed and has been found the structure with shear wall at appropriate location is more important while considering displacement and base shear.

Syed.M.Katami et.al presented the results of time history analysis which addressed the effect of openings in shear walls near-fault ground motions. A model of ten storey building with three different types of lateral load resisting system: Complete shear walls, shear walls with square opening in the centre and shear wall with opening at right end side were considered. From the results it was observed that shear walls with openings experienced a decrease in terms of strength. The maximum lateral displacement of complete shear wall is 17% less than that of shear walls with openings at centre whose displacement is found to be 8% less than that of shear walls with openings at right end.

Dr.B.Kameshwari et.al analysed the influence of drift and inter storey drift of the structure on various configuration of shear wall panels on high rise structures. The bare frame was compared with various configurations like i) Conventional shear wall ii) Alternate arrangement of shear wall iii) Diagonal arrangement of shear wall iv) ZigZag arrangement of shear wall v) Influence of lift core shear wall. From the study it was found that ZigZag shear wall enhanced the strength and stiffness of structure compared to other types. In earthquake prone areas diagonal shear wall was found to be effective for structures.

III. METHODS OF ANALYSIS

3.1 General

Earthquake analysis of a structure can be performed either static analysis or dynamic analysis. The main parameters of the seismic analysis of structures are load carrying capacity, ductility, stiffness, damping and mass. IS 1893-2002 code is used to carry out seismic analysis of multi-storyedbuilding. In this study the buildings are modeled and analyzed using response spectrum analysis.

3.2 Earthquake analysis

Theanalysis of a structure can be performed by four different methods. They are

- Linear static analysis (Equivalent static method)
- Non-linear static analysis (Push over analysis)
- Linear dynamic analysis (Response spectrum analysis)
- Non-linear dynamic analysis (Time-history analysis)

IV.MANUAL DESIGN OF SHEAR WALLS

4.1 INTRODUCTION

The walls, in a building, which resist lateral loads originating from wind or earthquakes, are known as shear walls. A large portion of the lateral load on a building, if not the whole amount, as well as the horizontal shear force resulting from the load, are often assigned to such structural elements made of RCC. These shear walls, may be may be added solely to resist horizontal force, or concrete walls enclosing stairways, elevated shafts, and utility cores may serve as shear walls. Shear walls not only have very large in-plane stiffness and therefore resist lateral load and control deflection very efficiently, but may also help to ensure development of all available plastic hinge locations throughout the structure prior to failure. The other way to resist such loads may be to have the rigid frame augmented by the combination of masonry walls.

The use of shear walls or their equivalent becomes imperative in certain high-rise buildings, if inter- storey deflections caused by lateral loadings are to be controlled. Well-designed shear walls not only provide adequate safety, but also give a great measure of protection against costly non-structural damage during moderate seismic disturbances.

The term shear wall is actually a misnomer as far as high-rise buildings are concerned, since a slender shear wall when subjected to lateral force has predominantly moment deflections and only very insignificant shear distortions. High-rise structures have become taller and more slender, and with this trend the analysis of shear walls may emerge as a critical design element. More often than not, shear walls are pierced by numerous openings. Such shear walls are called coupled shear walls. The walls on both sides of the openings are interconnected by short, open deep, beams forming part of the wall, or floor slab, or both of these. The structural engineer is fortunate if these walls are arranged in a systematic pattern. The scope of the book limits the discussion to shear walls without any openings.

4.2 Calculation of rigidity of a Shear Wall:

Torsional rigidity of a shear wall is defined as the torque required to produce a unit rotation. If a torque T acting on a shear wall produces a rotation of _ radians, then the torsional rigidity of the wall is,

J= T/Q

The torsional rigidity of any given shape of a shear wall consists of the summation of its torsional rigidities calculated on the basis of uniform and non-uniform torsional theories, the uniform-torsion theory component for open sections only, being given by,

$$J_u = \frac{E\, t^3 \Sigma O}{6.6h}$$

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Where '0' equals the perimeter of the section of shear wall of height h and thickness 't'. It, however, works out to be negligibly small in the case of open sections such as channels, angles, tees, etc. Being a function of the cube of thickness of shear wall, which is assumed to be very small in comparison to its other dimensions.

V.MODELLING AND RESULTS

5.1 ETABS Models of Buildings:

A G+10 building is analyzed in ETABS with and without shear wall. The models of buildings are as shown in figures 5.1 and 5.2.

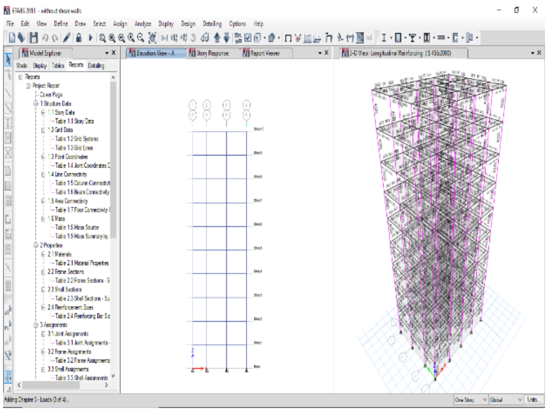

Figure 5.1: A building model without shear wall

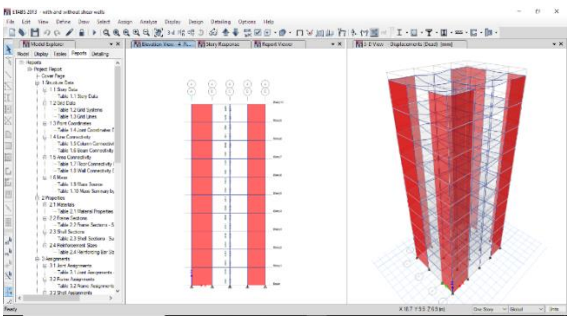

Figure 5.2: A building model with shear walls

VI.CONCLUSIONS

Conclusions

The conclusions drawn from the analysis of a G+10 building with and without shear wall are as follows

- Fundamental frequencies of structure with shear wallis increasedby 20% as compared to that in structure without shear wall, so it's about increasing of stiffness byproviding shear walls.
- The storey shears of structure with shear walls is more as compared to structure without shear walls.
- Lateral seismic load distributions in structure with shear wall are greater than in the structure without shear wall.
- The storey shears and lateral loads for EQ X and EQ Y in the structure with shear wall are equal.
- The values of storey displacements, drifts, shears, stiffness and lateral loads for EQ X of structures are greater than EQ Y values.
- Parameters like storey displacements, story drifts are found to begradually decreasing in structure with shear wall as compared to structure without shear wall.
- The rebar percentage is found to be more in the model withoutshear wall, therefore comes with the concept of economy andstability adjacently.
- Provision of shear walls may not effective in reducingpunching shear on intermediate story's but effective in top andbottom story's as shear wall attracts lateral moments fromcolumns.
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