Study of Seismic Performance Evaluation of Existing Building and Comparative Investigation of Effective With and Without Shear Wall by Using ETABS

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Abstract: Buildings are designed as per the code regulations meeting all specific requirements of the code and assuming a linear elastic behaviour of the structural members. Moreover, it is also necessary to know the behaviour of a building that were designed with older codes or which may not have been designed for earthquake forces. It is known a fact, that the globe is facing a serious threat of natural disasters from time to time. With particular record to earthquake reoccurrence, the consequences are loss of human lives and destruction of properties, which ultimately affects the natural economy. As the occurrence of an earthquake cannot be predicted and prevented, preparedness of the structures to resist earthquake forces becomes more important. Keeping the view of constant revision of the seismic zones in India, lack of proper design and detailing of structures against earthquake especial for existing building. This thesis aims to evaluate the performance of a typical selected R.C. building with respect to seismic vulnerability. For this seismic evaluation, a linear static has been performed by software ETABS considering material modification factor (Knowledge factor, K) FEMA 154. The analysis results showed the failure with respect to the concrete deterioration of the existing buildings. Based on the analysis retrofitting is done by considering shear wall at different positions of the building and the result has been compared with term of story displacement, story drift, time periods, base shear and area of steel and a number of columns failure with Knowledge factor (K), M30, M27, M24, M21, M18 and M15.

Keywords: seismic vulnerability, Knowledge factor, K, existing buildings, FEMA 154

I. INTRODUCTION

In recent past due to the rapid growth of Indian cities, there is a tremendous increase on the housing industry, especially in seismic Zone-IV & V. As most of these constructions are without earthquake resistant measures, the built environment in these zones has been found seismically vulnerable. Since Indian cities are built with varied varieties of building typologies, comprising of poorly designed and less maintained ones,

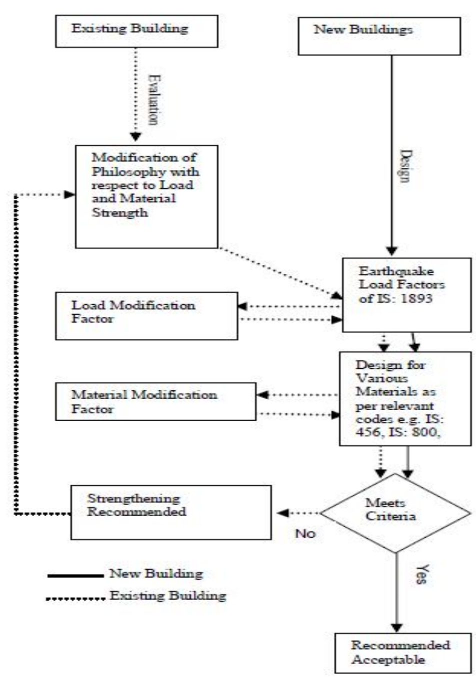

Figure 1: The relationship between the procedure for the design of new buildings and the evaluations of existing building

the seismic safety of these constructions became the most challenging tasks. Seismic vulnerability is a measure of the seismic strength or capacity of a structure, hence it is found to be the main component of seismic risk assessment. Detailed seismic vulnerability evaluation is a technically complex and expensive procedure and can only be performed on a limited number of buildings. Studies on the damage of buildings and other structures during the past earthquakes have clearly brought out the causes of severe damages which include either lack of earthquake resistant design, not following the provisions of the Bureau of Indian Standards Building Codes, faulty building practices and also poor maintenance of buildings. Lack of arrangement of proper drainage helps rain water to seepage through foundations and deteriorates it. This causes the settlement of foundation which increases the risk of developing large cracks in the building. For safety from earthquake hazards in the future, the seismic resistance of most of the existing building needs upgrading by retrofitting procedures. The vulnerability of the various existing buildings needs to be assessed for prioritizing the buildings for seismic upgrading. This compelling the structural engineers to design buildings using the building system with good resistant of lateral loads. One of the most efficient methods to improve the seismic performance of the buildings is the use of properly designed and detailed reinforced concrete shear walls.

II- SEISMIC VULNERABILITY EVALUATION

The earthquake risk at any location depends on the seismic hazard as well as the vulnerability of its structures. The seismic hazard evaluation considers the likelihood of an earthquake of a particular magnitude or intensity affecting a site, and the evaluation of seismic risk in any city will require proper consideration of the strength of likely earthquakes in the future. The seismic vulnerability, on the other hand, depends on the construction practice in the city and is related to the quality of building stock. The local construction practice has also a very strong bearing on the seismic vulnerability since the use of inherently strong building materials the result in structures showing better resistance to earthquakes.

Assessment techniques are described in the following sections:

1. RAPID VISUAL SCREENING

Rapid visual screening (RVS) was first proposed in the US in 1988, which was further modified in 2002 to incorporate latest technological advancements and lessons from earthquake disasters. These screening procedures have been widely used in many countries over the world, even though it was developed for typical constructions in the US. The most important feature of this procedure is that it permits vulnerability assessment based on walk-around of the building by a trained evaluator. The evaluation procedure and system is compatible with GIS-based database and also permits use of the collected building information for a variety of other planning and mitigation purposes. The screening method is performed without any structural analysis. The inspection, data collection and decision making occur generally on site and takes little time to complete the operation. RVS techniques can be implemented in both rural and urban areas.

2. ANALYTICAL METHODS

The methods for the assessment of the vulnerability of buildings based on score assignments are rather detailed and therefore time-consuming. More sophisticated methods, implying a more detailed analysis and more refined models, take even more time and serve therefore for the evaluation of individual buildings only, possibly as a further step after the rapid screening of potential hazardous buildings in a multi-phase procedure. They are not suitable for earthquake scenario projects where a large number of buildings have to be evaluated. Nevertheless, the concepts behind those methods can be valuable for the development of new simple methods and hence, the main analysis procedures shall be briefly outlined.

Strength capacities of existing building components should be based on the probable material strengths in the building. Probable or measured nominal strengths are the best indicator of the actual strength and can only be obtained by field or lab tests on a series of samples. This document recommends that probable strengths are either based on actual tests or the default values given in their subsequent sections of this document. These can also be assessed from the values given in the original building documents. However, they all need to be further modified for the uncertainty regarding the reliability of available information, and present condition of the component.

The probable material strengths need to be multiplied by a Knowledge Factor, K as defined in Table 1.

Knowledge factor K accounts for the confidence and reliability of the configuration and the condition of members of the lateral force-resisting system of the existing building. It can be established from a study of the original documents of the buildings or nondestructive testing of representative members. Using established field tests for materials in the building, present day strength can be estimated and used for evaluation purposes, even when it is higher than the design strength. Foundations are examples of members for which a lower K value can be adopted.

Table 1: knowledge factor, k

S. NO	Description of building	k
1	Original construction documents available, including post-construction activities, such as modification of structure or materials testing undertaken of existing structure	1.00
2	Documentation as above in (1) but no testing of materials, i.e., using originally specified values for materials	0.90
3	Documentation as above in (1) no testing of, i.e., using originally specified values for materials and minor deterioration of original condition	0.80
4	Incomplete but useable original construction documents and no testing	0.70
5	Documentation as in (4) and limited inspection, and verification of structural members, or materials test results with large variation	0.60
6	Little knowledge of details of a component	0.50

III. NEED FOR PRESENT STUDY

Many earthquake prone countries in the world have a significant amount of existing deficient buildings to be evaluated for seismic actions. Although nonlinear methods are more preferable for assessment of existing buildings, most of the practicing engineers are unfamiliar with these methods. Therefore, linear methods seem to be in use in the near future for assessment of the great number of deficient existing buildings at a reasonable time. These earthquakes showed that the large in-plane stiffness provided by shear wall, reduce lateral drifts which in turn limits the damage of both structural and nonstructural components.

This fact drew attention of academic researchers to shear wall frame buildings. Engineers need practical and easy methods to anticipate the performance of buildings before carrying out detailed analyses. The present seismic standards in India promote the construction of seismically most vulnerable constructions in highly seismic areas of the country. Better seismic standards are urgently needed in the new global economic setup and a working draft can be easily prepared by learning from ATC and FEMA documents developing the USA.

IV. AIMS AND OBJECTIVES OF THE PRESENT STUDY

The objectives of the present study were as follows:

The main objective of this study is to evaluate the seismic response of buildings of typical reinforced concrete frames when concrete starts deteriorate gradually and to make a comparative study between them.

To investigate the seismic behavior of a 14 storied RC framed building in zone 4 with Knowledge factor, K (1.0 to 0.5).

Typically a 14-storey reinforced concrete frames have been designed for seismicity according to IS 1893-2002 seismic code. Fifteen models have been created (3 models for each building) by decreasing the concrete strength gradually from M30 to M15.

To study various responses such as Roof displacement, Time period, Storey Shears, bending moment and area of steel of buildings etc.

To study the effect of shear wall with three different positions on RC framed building with Knowledge factor, K (1.0 to 0.5).

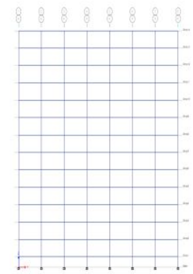

Figure 2: Elevation view of model without shear wall

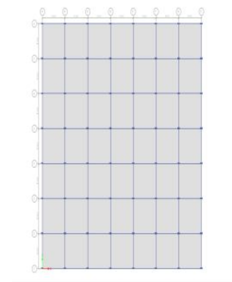

Figure 3: Plan view of model without shear wall

V. MODEL SPESIFICATION

A 14-storeyed reinforced concrete frame building with and without shear wall situated in zone IV (IS: 1893, 2002) is taken for the purpose of study. The plan area of building is 42 x 42 m with 3m as the height of each typical storey. It consists of 7 bays in X-direction and 7 bays in Y-direction. The total heights of the buildings were 40.8 m.

The column, beam dimensions are detailed in the below tables:

Table 2: Structural dimensions of 14 storey

S.No.	Specifications	Information
1	Slab Thickness	125mm
2	Beam dimensions	230x450mm
3	Column dimensions	300x630mm
4	Grade of concrete	M30 to M15
5	Grade of steel	Fe-500
6	Unit weight of concrete	25kN/m^3
7	Live loads (a) Floor load (b) Floor finishes	3kN/m^2 1kN/m^2
10	Importance factor	1.0
11	Seismic zone factor	0.24
12	Response reduction factor	5
13	Horizontal floor system	Beams & Slabs
14	Software used	ETABS 2016

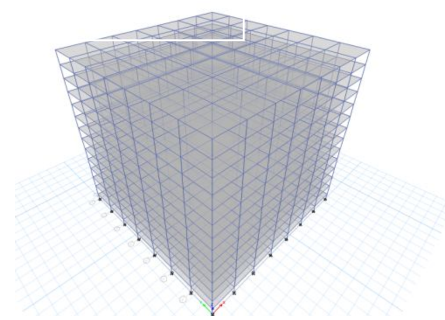

Figure 4: Isometric views of model without shear wall

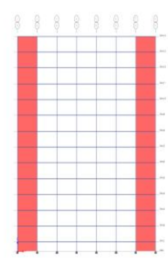

Figure 5: Elevation view with shear wall at the corner

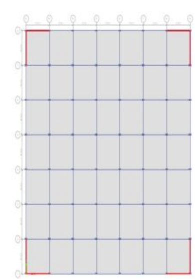

Figure 6: Plan view with shear wall at the corner

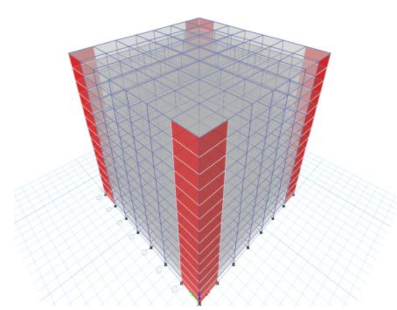

Figure 7: Isometric view with shear wall at the corner

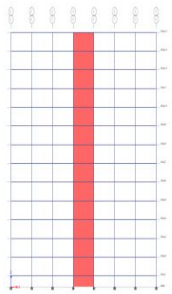

Figure 8: Elevation view with shear wall at the middle

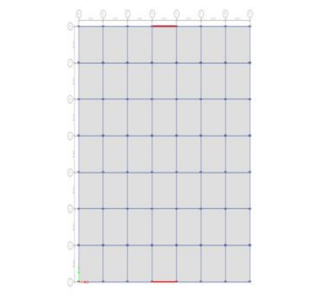

Figure 9: Plan view with shear wall at the middle

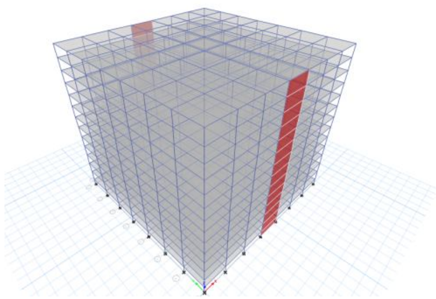

Figure 10: Isometric view with shear wall at the middle

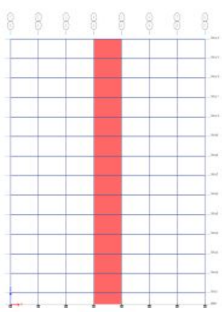

Figure 11: Elevation view with shear wall at the side

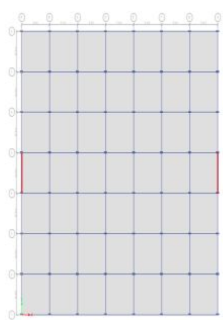

Figure 12: Plan view with shear wall at the side

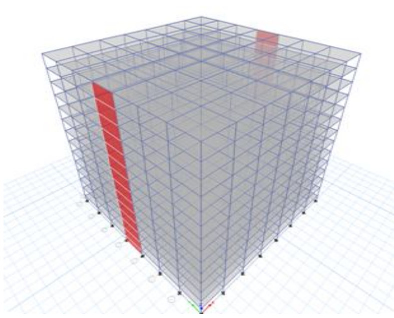

Figure 13: Isometric view with shear wall at the side

VI. RESULT AND DISCUSSION

The results obtained are of different parameters such as storey displacement, Storey drifts, Base shear, Time Periods, Base shear, AST at the corner and middle and Number of column fails. The results obtained by carrying out by linear static Analysis for fourteen Storey Buildings as listed:

Model 1: RCC building without shear wall
Model 2: RCC building with shear wall at the corners
Model 3: RCC building with shear wall at the middle
Model 4: RCC building with shear wall at the sides

Method 1: Comparison between the six models from (M30 to M15) without shear wall in six parameter:

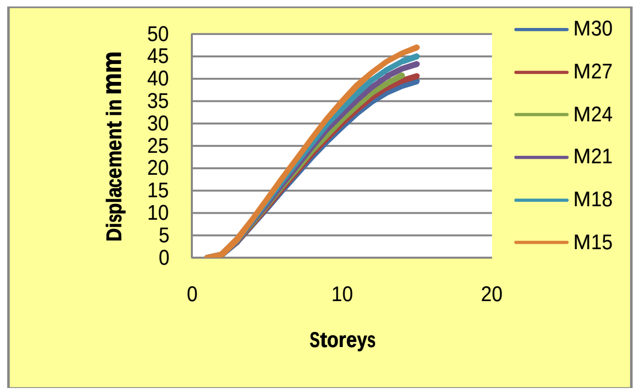

FIGURE 14: Displacements of buildings with knowledge factor (M30 to M15) without shear wall.

FIGURE 15: Drift of buildings with knowledge factors (M30 to M15) without shear wall.

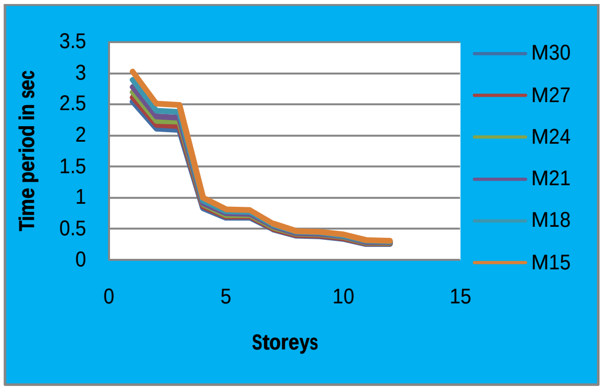

FIGURE 16: Time period with knowledge factors (M30 to M15) without shear wall.

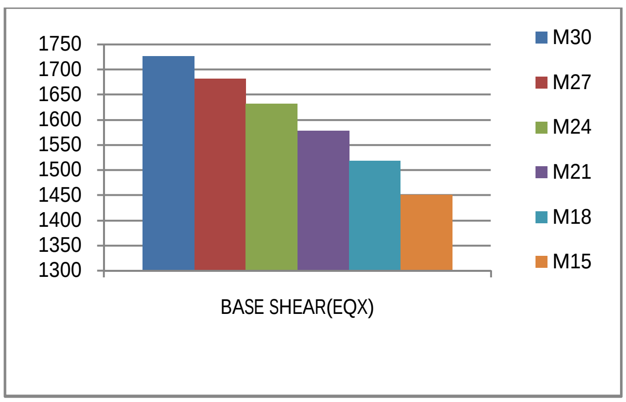

FIGURE 17: Base shear of buildings in the X direction with knowledge factors (M30 to M15) without shear wall.

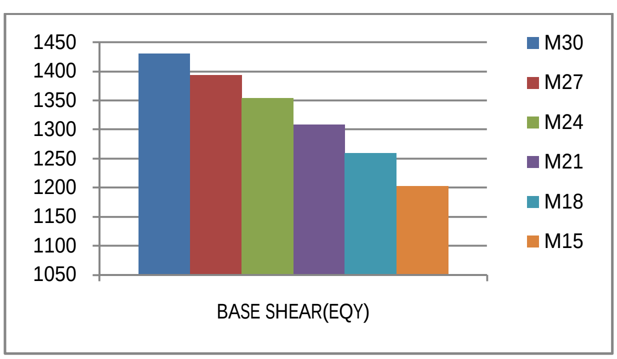

FIGURE 18: Base shear of buildings in the Y direction with knowledge factors (M30 to M15) without shear wall.

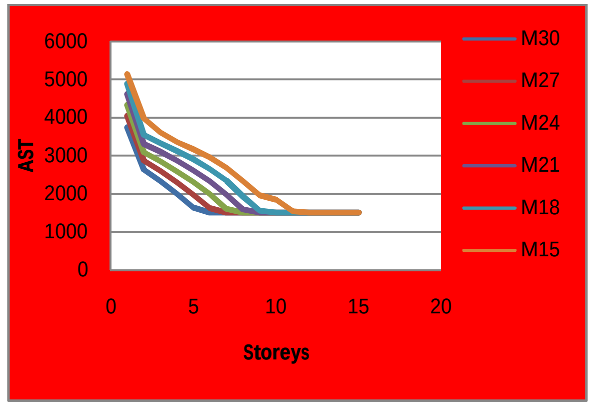

FIGURE 19: Area of steel for corner column of buildings with knowledge factors (M30 to M15) without shear wall.

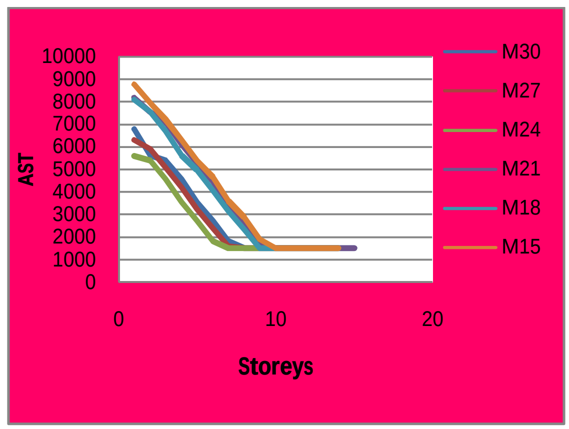

FIGURE 20: Area of steel for middle column of buildings with knowledge factors (M30 to M15) without shear wall.

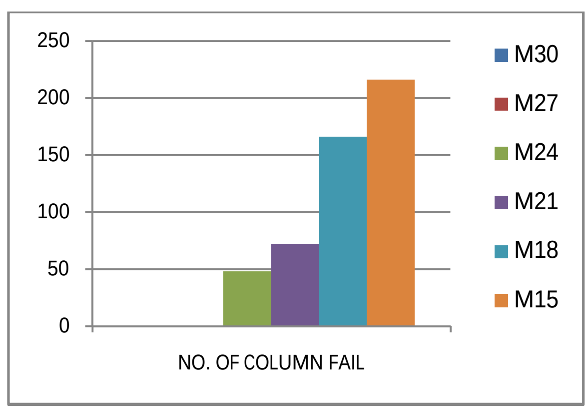

FIGURE 21: Number of columns fails of buildings with knowledge factors (M30 to M15) without shear wall.

From the above graphs show that:

1- The displacement of the buildings increases as the strength of the concrete decreases from (M30 to M15) and the M30 has the least displacement compared to other grade of concrete.

2- The drift of the buildings increases as the strength of the concrete decreases from (M30 to M15) and M30 has the least drift compared to other grade of concrete.

3- The time period is less, lesser is mass of structure and more is the stiffness so that the time period of a structure is inversely proportional to the stiffness from (M30 to M15). M30 grade of concrete structure which reflects more stiffness and lesser mass of the structure.

4- The base shear in the X and Y direction for M30 grade of concrete structure is more compared to other grade of concrete.

5- The area of steel for the corner and middle column as the concrete strength decreases the area of steel is increased from (M30 to M15). For M30 grade the required area of steel is less compared to others.

6- The number of columns fail as the concrete strength decreases is increased from (M30 to M15). For M30 grade the number of columns fails equal zero also M27 grade equal zero compared others concrete grade.

Method 2: Comparison between M30 without shear wall and M30 after putting a shear wall in three positions (corner, middle & side) in six parameter:

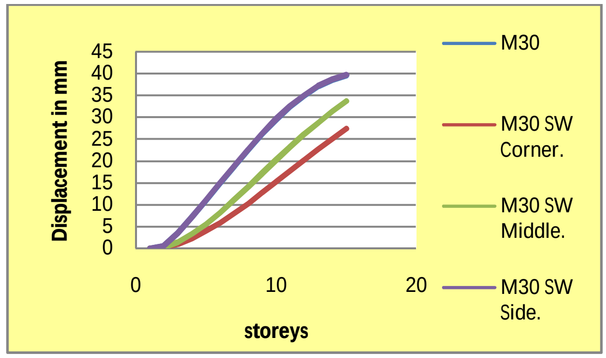

FIGURE 22: Displacements of buildings with shear wall at different positions (corner, middle & side) for M30 grade.

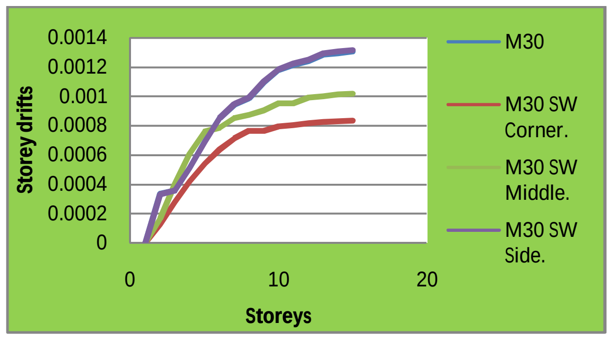

FIGURE 23: Drift of buildings with shear wall at different positions (corner, middle & side) for M30 grade of concrete.

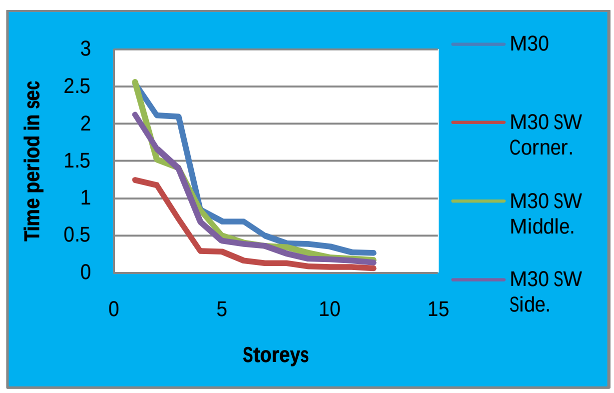

FIGURE 24: Time period of buildings with shear wall at different positions (corner, middle & side) for M30 grade of concrete.

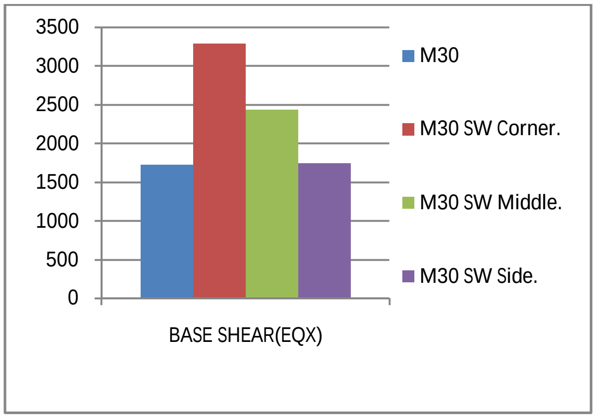

FIGURE 25: Base shears of buildings with shear wall at different positions in the X direction for M30 grade of concrete.

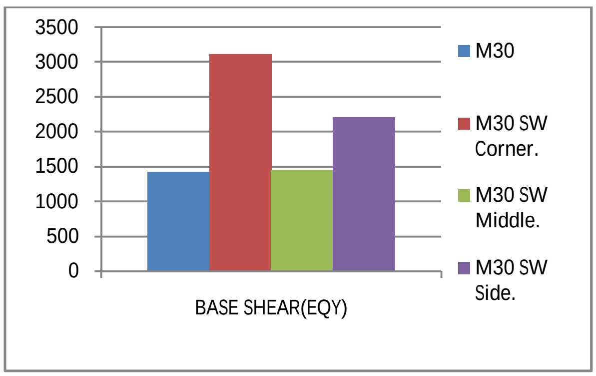

FIGURE 26: Base shears of buildings with shear wall at different positions in the Y direction for M30 grade of concrete.

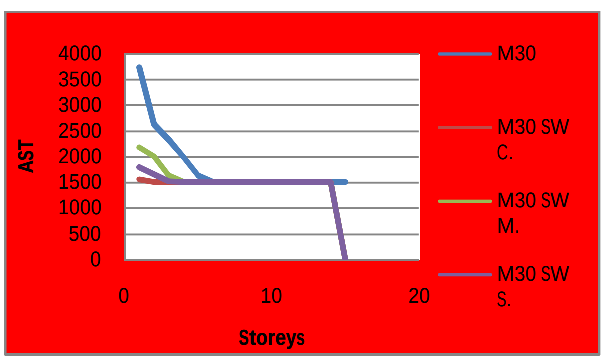

FIGURE 27: Area of steel for the corner column with shear wall at different positions (corner, middle & side) for M30 grade.

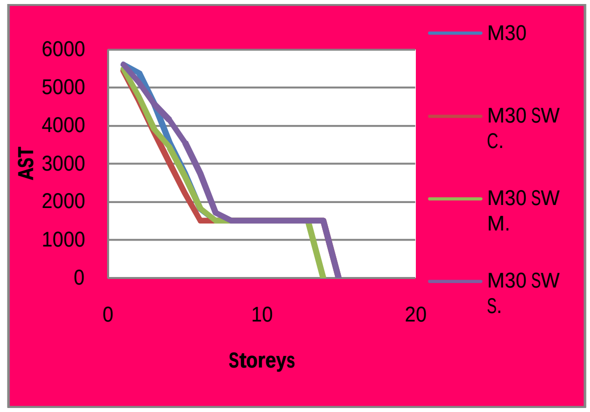

FIGURE 28: Area of steel for the middle column with shear wall at different positions (corner, middle & side) for M30 grade.

From the above graphs show that:

1- The displacement of the buildings after putting a shear wall in three positions (corner, middle &side) for M30 decreases when we compared with M30 grade of concrete without shear wall and the shear wall at the corner for M30 has the least displacement compared to other positions.

2- The drift of the buildings after putting a shear wall in three positions (corner, middle & side) for M30 decreases when we compared with M30 grade of concrete without shear wall and the shear wall at the corner for M30 has the least drift compared to other positions.

3- Time period is less, lesser is mass of structure and more is the stiffness less so that the time period of a structure is inversely proportional to the stiffness. The time period is observed less in shear wall at the corner for M30 grade of concrete structure which reflects more stiffness of the structure and lesser mass of the structure.

4- The base shear in the X and Y direction for M30 grade of concrete without shear wall structure is less compared to other structure with shear wall at the corner, middle and sides.

5- The area of steel for the corner and middle column after putting a shear wall in three positions (corner, middle & side) for M30 decreases when we compared with M30 grade of concrete without shear wall. For M30 grade with shear wall at the corner the required area of steel is less compared to other positions.

6-The number of columns fail for M30 grade equal zero compared others concrete grades.

VII.CONCLUSION

This study presents a summary of the project work, for R.C.C existing buildings with knowledge factor with and without Shear wall in different grades of concrete structure (M30, M27, M24, M21, M18, and M15). The effect of Seismic load has been studied for a building with different position of the shear wall.

On the basis of these results, conclusions have been drawn:

1- For a building that is not provided any lateral load resistance component such as bracing or shear wall, the strength is considered very weak and easy fail during earthquake.

2- M30 grade of concrete structure without shear wall is the best on all six parameters.

3- Shear wall at the corner best in all six parameters.

4- Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position.

5- It can be concluded that shear wall, placing at adequate locations is more significant in the case of base shear and displacement especial in an earthquake.

6- If the dimensions of shear wall are large then the major amount of horizontal forces is taken by shear wall.

7- Shear wall at focus and inverse sides for structures have more roof top relocation than Shear wall in corners of buildings.

8- M30 with shear wall at the corner is the best.

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