Global Retrofit Technique Applied to Restore the Stability of RC Structures

Guruprasad Y K

1Associate Professor, Department of Civil Engineering, BMS Institute of Technology and Management, Bangalore.
(Formerly Researcher and PhD Research Scholar, Department of Civil Engineering, Indian Institute of Science, Bangalore)

1guruprasad.civil.iisc@gmail.com, dr.guruprasadyk@bmsit.in

Abstract - Most of the reinforced concrete(RC) multistoried buildings house important institutions such as hospitals, educational institutions, government establishments, defence establishments, business centers, sports stadiums, commercial complexes and nuclear power plants. Usually a high cost is incurred to construct such multistoried RC structures. Such structures need to be maintained and restored based on their functionality and importance, using suitable repair or retrofit strategies when these structures undergo damage within repairable limits instead of demolishing them. RC structures undergo damage due to earthquakes, fire, corrosion of steel reinforcement and due to ageing. This work looks at the structural behavior of a nine storey RC framed structure in terms of the storey drifts, the structure undergoes when subjected to an earthquake, to study the stability of the structure by performing an analysis in ETABS. A global retrofit technique is applied in reducing the storey drifts to restore the overall stability of the structure when subjected to an earthquake by introducing shear walls in the RC structure to improve the overall stiffness of the structure. Analysis is carried out to study the effect of introducing shearwalls separately in various locations in the RC structure that influences the variation in the storey drifts, and the overall stability of the RC structure when subjected to an earthquake. A typical buckling analysis of vertical members present in the RC structure is also carried out in Abaqus to study the stability behavior of vertical members.

Key words: Reinforced concrete (RC) structure, Retrofit, RC Shear wall, earthquake , stability

1. INTRODUCTION

Many of the multistorey RC buildings in cities and towns tend to have different important occupational utilities such as hospitals, educational institutions, government and defence establishments, business centres, stadiums, commercial complexes and nuclear power plants. The construction of such multistoried RC structures would be expensive. Such RC structures need to be well maintained. When such RC structures undergo damage due to earthquakes, fire, corrosion of reinforcing steel due to environmental exposure due to spalling of cover concrete or due to ageing, such structures need to be restored using repair or retrofit techniques. Before application of the repair or retrofit, quantification of amount of damage taken place in the structural members present in the structure should be assessed using non-destructive testing (NDT) techniques [1 – 3]. Based on the results of non-destructive testing, one would be able to assess if a structure or a structural member is within repairable limits or not based on the degree of damage taken place. There are two types of retrofitting methods that can be applied to a structure, namely, a global retrofit method and a local retrofitting method. In a global retrofit method, the retrofitting is applied by introducing structural members such as shearwalls, bracing in the already existing structure at various locations in the structure, so that the overall stiffness and load carrying capacity of the structure is increased. Local retrofit method is applied when strengthening of individual structural members present in a structure is carried out using wrapping techniques using fibre reinforced polymers(FRP) or by using of RC jacketing technique [4,5]. In this work, behaviour of a retrofitted nine storey RC framed structure in terms of storey drifts when the structure is subjected to an earthquake in one direction, is studied by introducing RC shearwalls [6 – 15] in different locations as a global retrofit measure.
2. ANALYTICAL STUDY

2.1 BEHAVIOR OF A NINE STOREY RC STRUCTURE SUBJECTED TO EARTHQUAKE RETROFITTED BY INTRODUCING SHEARWALLS AS A GLOBAL RETROFIT MEASURE

In this work a nine storey RC framed structure is modelled in ETABS with and without shearwalls as a global retrofit measure subjected to an earthquake in one direction (Y direction) in plan. The details of the RC structure modelled in ETABS are: total number of storeys : 9, bay to bay distance : 6m, Storey height : 3.6m, Column cross section : 0.23m x 0.6m, Cross section dimensions of beams parallel to X axis : 0.23m x 0.45m, cross section dimensions of Beams parallel to Y axis : 0.23m x 0.6m, slab thickness : 0.15m,thickness of shearwall : 0.15m. Load applied are : dead load of 2kN/m² and live load of 4 kN/m² applied on the slab on each floor. An earthquake load is applied in Y direction in plan for zone V based on IS1893(2002) for soil of type II, importance factor considered as 1 and response reduction factor equal to 3. First the analysis of the RC framed structure without shearwalls (as shown in figure 1a) is carried out in ETABS, when the structure is subjected to an earthquake in Y direction in plan and the storey drifts are computed. Following this analysis, shearwalls are introduced in the RC framed structure parallel to Y axis in plan on two parallel sides, parallel to X axis in plan on two parallel sides, parallel to X and Y axis in plan on four sides and in the central core portion of the framed structure separately (as shown in figures 1b, 1c, 1d and 1e respectively) when subjected to an earthquake in Y direction in plan and the storey drifts are computed separately for each of the cases respectively.

2.2 BUCKLING BEHAVIOUR OF RC SHEARWALL AND RC COLUMN

A buckling analysis is carried out on an RC shearwall and an RC column separately in the finite element(FE) package Abaqus to separately understand the buckling modes of failure of the shear wall and the column. The RC shearwall is modeled as a 3D planar shell element, with boundary conditions as fixed on the sides and bottom, and vertical displacement allowed on the loaded edge.

The dimension of the shearwall considered in the buckling analysis is 6mx6mx0.15m. An RC column having the dimensions 0.23m x0.45mx6m is modeled as a 2D beam element with boundary conditions as fixed at the base and vertical displacement allowed on the loaded end.

The Young’s modulus and Poisson’s ratio of concrete having 25MPa cube compressive strength was given as the materials property to the framed RC model in ETABS and in Abaqus. Density of concrete considered was 2500Kg/m³.

Figure 2a and 2b show the finite element model and the meshed model of the RC shearwall in Abaqus. Figure3 shows the finite element model of the RC column with mesh in Abaqus.

Figure 1: Details of RC Framed Structure (a) RC Framed Structure without shear wall, (b) Shearwall introduced in the framed structure parallel to Y axis in plan, (c) Shearwall introduced in the framed structure parallel to X axis in plan , (d) Shearwall introduced in the framed structure parallel to X and Y axis in plan , (e) Shearwall introduced in the framed structure in the core portion

Figure 2 (a) Finite element model of RC shearwall, (b) meshed finite element model of RC shearwall
3. RESULTS AND DISCUSSIONS

This section presents the results and discussions of the analysis performed in ETABS and Abaqus. Figure 4 shows the storey drifts of the RC framed structure without the shearwall. Figure 5, 6, 7 and 8 show the storey drifts of the framed RC structure with shearwall parallel to Y axis in plan on two sides, shearwall parallel to X axis in plan on two sides, shearwall parallel to X and Y axis in plan on all sides of the structure and shearwall in the core portion of the structure respectively. Storey drifts shown in the figures 4 to 8 are in meters. Figure 9 shows the model 1 and mode 2 buckling modes of the shearwall in Abaqus. Figure 10 shows six modes of buckling of an RC column in Abaqus.
Figure 9: Mode 1 and mode 2 buckling modes of the shearwall in Abaqus.

Figure 10: Six modes of buckling of an RC column in Abaqus.
It is observed from the results shown in figures 4 to 8, for the earthquake load acting in the Y direction, the RC framed structure without shearwall has a maximum value of storey drift at the 9th floor equal to 31mm. Whereas, the RC framed building having shearwall parallel to Y axis (on both sides as shown in figure 1b), RC framed building having shearwall parallel to X axis (on both sides as shown in figure 1c), RC framed building having shearwall parallel to X and Y axis (on all sides as shown in figure 1d) and RC framed building having shearwall in the central core portion (as shown in figure 1e) have 19.5mm, 32mm, 21.3mm and 24.8mm as the following maximum storey drifts at the 9th floor respectively.

It is understood from the values of the maximum storey drifts, the shearwalls provided parallel to the Y axis on in the RC framed structure tend to provide a larger resistance to the earthquake acting along the Y axis. The reason being the shearwall placed parallel to the direction of the earthquake motion provides a large in plane shear resistance. Whereas, shearwalls placed parallel to X and Y axis and shearwalls provided in the central core provide reasonably good resistance to the earthquake when compared to the shearwalls placed parallel to the Y axis. The shearwalls placed parallel to X and Y axis and in the central core have provided reasonably good resistance to earthquake, is due to the reason of symmetrical location of the shearwall in plan. Shearwalls placed parallel to X axis actually didn’t improve the earthquake resistance of the framed structure at all. It is known from this case that shearwalls placed in buildings perpendicular to the direction of earthquakes tend to provide minimal resistance.

It is also learnt from the results of the buckling analysis of the RC shearwall and the RC column (shown in figures 9 and 10), the shearwall is a stiffer structural element when compared to the RC column. Therefore, when one has to carry out retrofitting on a global scale, it would be more preferable to introduce new shearwalls in RC structure instead of introducing many new RC columns.

4. CONCLUSION

- To ensure structural safety and stability of a damaged RC structure or RC components in a structure, identification of the type, extent of damage and evaluation should be made correctly using nondestructive testing and semi nondestructive techniques.
- A global retrofit technique by introducing a shearwall in a damaged RC structure tends to increase the stiffness, strength, stability and lateral load resisting capacity of such a structure.
- Placing shearwalls unsymmetric in plan due to improper planning does not improve the lateral load resisting capacity of the structure.
- Provision of shearwalls symmetric in plan increases the overall stiffness and also the lateral load resisting capacity of the structure.
- Comparatively it is preferable to introduce shearwalls as a global retrofit measure in a damaged RC structure, as it tends to provide increased stiffness and lateral load resisting capacity to the structure when compared to introduction of new RC columns as a retrofit measure.

References

[8] Kalpana P., Prasad R.D., Kranthi Kumar B. 2016. Analysis of building with and with out shear wall at various heights and


