Performance of Different Retrofitting Techniques on Existing RCC structures

Milind V. Mohod

Abstract: Most of earthquake in India shows that engineered as well as non-engineered structures are heavily doubted during moderate earthquake. India has a great population due to urbanization and that creates a challenge on structural designers to make use of acute space effectively. Constructing new structures is not always a choice especially in compact areas of city. Hence, utilizing reserved strength of existing structure will help to achieve economy as well as heritage. Most of the old structures need a retrofitting (up gradation of strength) due to many reasons like changing environmental condition, revision of codal provisions, revision of zones of India and improper supervision of structures. To depict the potential of retrofitting technique over existing structures, an attempt is made to upgrade the existing structure in the vicinity of Amravati region (M.S.). Existing structure was constructed with open ground storey without consideration of infill wall during analysis (Prior to this study). This paper presents consequences of providing open ground storey and remedial measures of retrofitting among different methods of retrofitting techniques.

Keywords: Retrofitting techniques, Equivalent Static Analysis, Response Spectrum Method.

I. INTRODUCTION

Earthquake has potential to disturb all marvels created by human being. As we all know that earthquake forces are unpredictable and preparedness is important. Indian standard IS 1893-2002 is revised in the year 2002. The number of buildings those which are designed as per the previous code may not comply with the present code. The number of world's greatest earthquakes occurs in India from last decades. From all earthquakes some earthquakes were very huge and destructive for reinforced concrete building. Most of the structural designers are not aware about this destruction and hence they design poor type of design and implement it. The structure in high seismic areas may be susceptible to the severe damage along with gravity load structure has to withstand to lateral load which can develop high stresses. For measuring the efficiency of earthquake whole country is divided in some zones called as seismic zones. These zones will be revised after some time when required. The structural safety and stability can be predicted after knowing the actual feasible condition of structure, i.e whether the structure is in position of its intended use or not, the various retrofitting strategies may be suggested.

Revised Manuscript Received on 30 July 2019.

***** Correspondence Author

Dr M. V. Mohod*, Civil Engineering Department, Prof. Ram Meghe Institute of Technology & Research, Badnera, Amravati, Maharashtra, India.

It is a known fact that the globe is facing a threat of natural disasters from time to time. With particular records based on earthquake occurrence, the consequences are loss of human lives and destruction of properties, which ultimately affects the natural economy. The occurrence of an earthquake cannot be predicted and prevented but the preparedness of the structures to resist earthquake forces become more important. A large number of existing building in India are severely deficient against earthquake forces and the number of such buildings are growing very rapidly. This has been highlighted in the past earthquake. Seismic behaviour, vulnerability assessment and design of strengthening intervention for seismic retrofit of the existing RC structures are one of the most challenging topics for the structural engineer in the twenty-first century, especially in that region where social and economic development has occurred in the last decades, after the Second World War.

A. Different Retrofitting Techniques

There are two techniques of retrofitting listed below

a. Structural Level Approach (Global Approach)

Structural level approach is a global approach or method which is applied on complete structure using many techniques like adding shear wall, infill wall, bracing, base isolation etc. It is a qualitative approach of retrofitting.

b. Member Level Approach (Local Approach)

There are the various types of techniques which are generally adopted for strengthening of structural elements like jacketing of beam column, FRP wrapping etc. This approach may also be classified as quantative approach of structural analysis.

II. LITRATURE REVIEW

From the literature survey done on research work on various retrofitting methods by number of researchers, it can be observed that a particular method of retrofitting can be effective as per the problems associated with the structure under consideration. Depending on the severity of the hazard that can be expected to occur on to the structure various permutation and combinations of the different methods of retrofitting shall be adopted. Literature cited discretized as per different retrofitting techniques shows that many researchers have gone for different retrofitting techniques and application of one of those technique on their chosen system. But none of the literature referred above have shown comparison of different retrofitting techniques on a same structure. Hence, taking an inspiration from the work contributed to the research field by various researchers working in the area of retrofitting, present dissertation work is carried out to find out the most feasible and practically possible solution to safeguard the structure vulnerable to the event of earthquake.

III. SYSTEM DEVELPOMENT

System development presents methodology for static and dynamic analysis of structure. A detailed description of equivalent static analysis and response spectrum analysis is presented in this research paper. ETABS version 9.7.4 computer program is used for the analysis purpose.

A. Computational Models

With the help of this methods of analysis of structures we have analysed an existing structure (open ground structure) situated in region of Amravati by using different techniques of retrofitting and the most suitable retrofitting method is suggested. Various models adopted to show the applicability of different methods of retrofitting are listed below,

Bare Frame – Reinforced cement concrete frame building

Infill wall - Reinforced cement concrete frame building considering infill effect

Retro jacketing - Retrofitting of building by using jacketing

Retro Infill Wall - Retrofitting of building by using infill wall

Retro Shear Wall - Retrofitting of building by using shear wall

Retro Bracing System - Retrofitting of building by using bracing system

These six models are basic models which highlight different retrofitting techniques that can be adopted to achieve the desired level of safety under the event of earthquake. The existing residential building, which is to be analysed is of G+ 4 storeys and situated in seismic zone III (Amravati region). An existing building has a rectangular plan of dimension 18 x 8 m having four bays in X-direction and two bays in Y-direction. The model ideally represents the mass distribution, strength, stiffness and deformability. Material properties and modelling details of the structural elements used in the present study is discussed below.

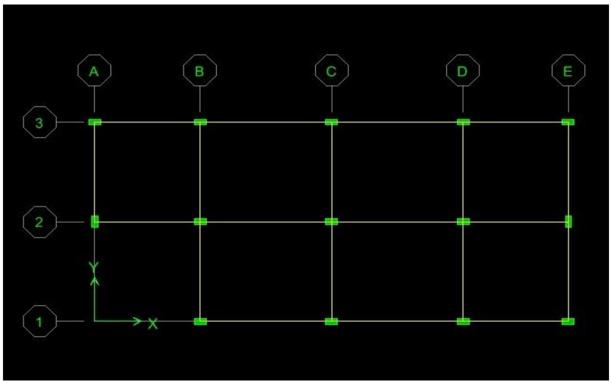

Fig 1: Plan of Existing Building

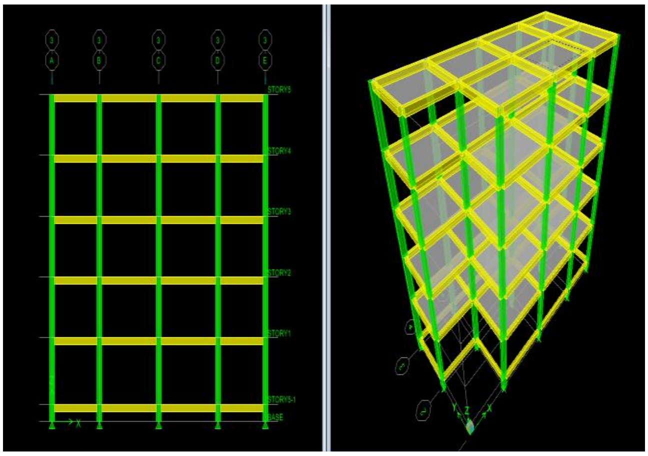

Fig. 2: Elevation of Existing Building

B. Material Property

M-20 grade of concrete and Fe-415 grade of reinforcing steel are used for all the frame models used in this study as per the available data of existing structure. Elastic material properties of these materials are taken as per Indian Standard IS 456:2000. The short-term modulus of elasticity (E_c) of concrete is taken as

$$E_C = 5000\sqrt{f_{ck}}$$

f_{ck} is the characteristic compressive strength of concrete cube in MPa at 28 day (20 MPa in this case). For the steel rebar, yield stress (f_y) and modulus of elasticity (*E*s) is taken as per IS 456 (2000).

C. Structural Element Sizes

1. For G+4 building bare model (Existing Building)

   Column size - 230 x 450 mm.

   Beam size - 230 x 380 mm.

Thickness of slab - 120 mm.

Thickness of outer wall provided is 230 mm and for interior wall is 115 mm.

2. For G+4 building (Retrofitting using jacketing)

Column size - 380 x 600 mm.

Beam size:
B1– 380 x 530 mm.
B2 – 530 x 680 mm.

3. For G+4 building (Retrofitting using bracing)
   Channel section- ISMC 75

4. For G+4 building (Retrofitting using Shear wall)

   Thickness of shear wall - 150 mm.

Remaining structural details are same for all models.

5. Dimension of strut provided for infill wall effect by equivalent strut method to provide stiffness.we calculated width of strut and depth of strut is as similar as thickness of wall.

TABLE I. DIMENSION OF STRUT FOR INFILL WALL.

Sr. No.	*Thickness of Wall*	*Stiffness* λ	*Width* w_e
1	230 mm (for 4m block)	0.572	0.703
2	115 mm (for 4m block)	0.481	0.754
3	230 mm (for 5m block)	0.562	0.82
4	115 mm (for 5m block)	0.473	0.879

IV. COMPARISIONS OF DIFFERENT RETROFITTING TECHNIUQES

In this research work we have studied both the approaches Viz, structural level approach and member level approach (Global & Local approach) to existing structure and compared all the results of different retrofitting techniques in the form of various parameters like point displacement, storey drift , storey shear etc. On the basis of obtained results of various retrofitted models following comparative results are plotted.

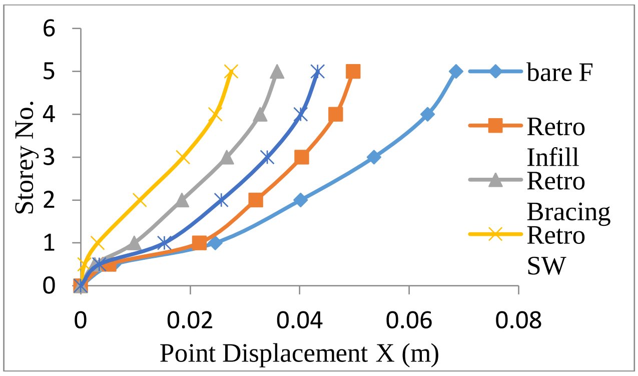

Fig.3: Point Displacement in X Direction

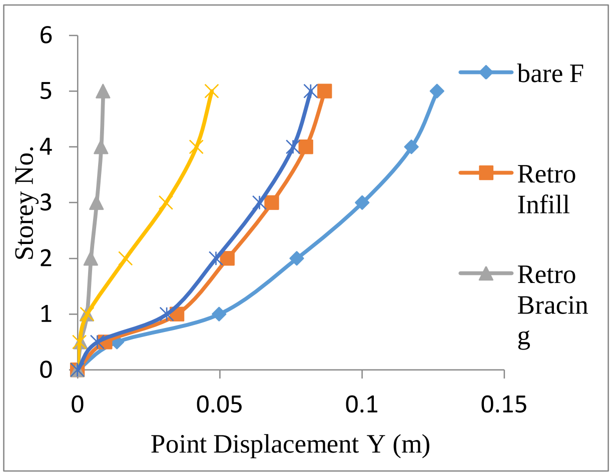

Fig. 4: Point Displacement in Y Direction

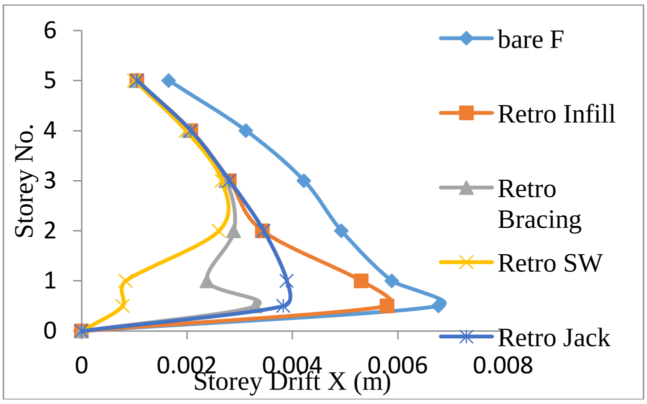

Fig.5: Storey Drift in X Direction

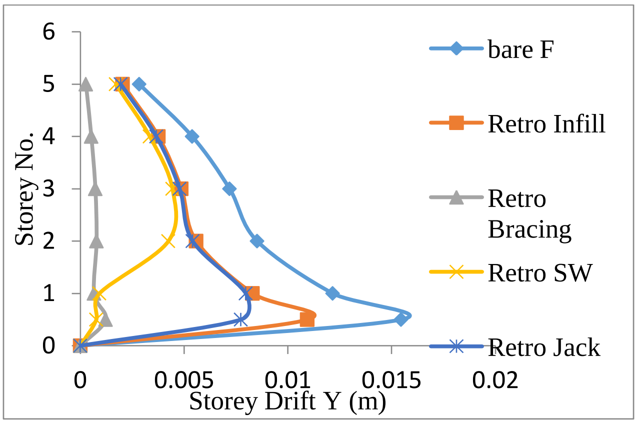

Fig. 6: Storey Drift in Y Direction

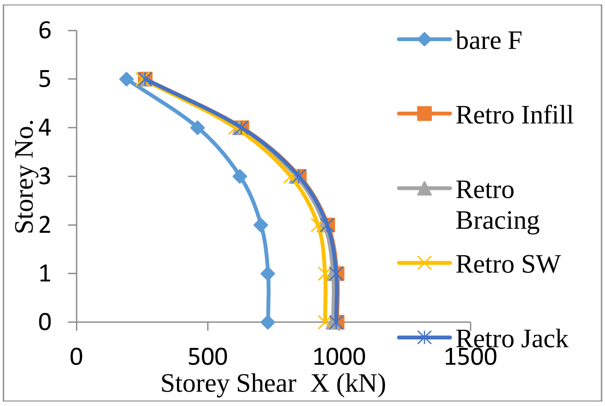

Fig. 7: Storey Shear in X Direction

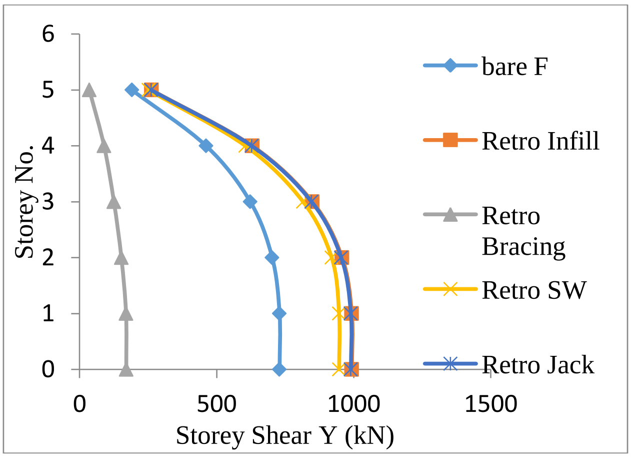

Fig.8: Storey Shear in Y Direction

V. RESULT AND DISCUSSION

From the obtained results of equivalent static analysis and response spectrum analysis, following discussion is made,

1. In existing G+4 storey bare frame model, the maximum Point displacement occurs in Y direction but nodal displacement in X direction also exceeds the permissible criteria. As per the criteria specified in IS 1893: 2002 regarding maximum permissible storey displacement developed in existing bare frame model fails to satisfy. Hence, obtained results urgently necessitate the need of retrofitting.
2. Due to the ignorance in considering effect of infill while analyzing the structure led to weaker understanding of structure during the event of earthquake. Available results clearly depict the increase in stiffness and shear carrying capacity of the structure. Hence, revision in analysis done by not considering infill stiffness necessitates retrofitting.

2 In G+4 storey existing building retrofitted by using different techniques, the minimum point displacement occurred by using shear wall as compared to other techniques (Jacketing, Infill wall, Bracing) in X direction. When we compared the results of point displacement in Y direction we have found that the minimum point displacement was observed in bracing system.

3 In G+4 storey existing building retrofitted by using different techniques, the minimum storey drift occurred in model retrofitted by using shear wall as compared to other techniques(Jacketing, Infill wall, Bracing) in X direction. When we compared the results of storey drift in Y direction we have found that the minimum storey drift was observed in bracing system.

4 In G+4 storey existing building retrofitted by using different techniques, the maximum storey shear was observed in models retrofitted by using infill wall as compared to other techniques(Jacketing, shear wall, Bracing) in X direction. When we compared the results of storey shear in Y direction then we had found that the maximum storey shear is taken by Infill wall. Storey shear in shear wall, jacketing and infill wall are more or less same in x direction but bracing system attract very lesser storey shear in Y direction compared to other.

From above discussion, It is observed that bracing system and shear wall both techniques are effective for the chosen existing structure but when we studied the results in brief then we have found that point displacement, storey drift are near about same in X and Y direction but storey shear is less attracted by bracing system as in comparison to shear wall. Which clearly shows that shear wall is the most feasible, practically possible and economical solution for the existing residential building.

VI. CONCLUSIONS

Seismic up gradation of existing structure is a need of time and assessing the proper retrofitting technique is a challenging job as it has to cater both the feasibility and economic criteria. In the present study an existing G+4 residential building was chosen to provide a optimized/ feasible retrofitting technique (Global+ Local). To perform this mammoth task model of various retrofitting techniques namely infill walls, steel bracing and shear wall as reported in the literature were modeled in ETABS software. As per the obtained results discussed in performance analysis chapter conclusion are drafted,

Following are the salient conclusions from the present study,

1) Stiffness of infill wall must be considered in design and analysis of new or existing structure. A bare frame is much less stiff than a fully infilled frame; it resists the applied lateral load through frame action and shows well-distributed plastic hinges at failure. When this frame is fully infilled, truss action is introduced. A fully infilled frame shows less inter-storey drift, although it attracts higher base shear (due to increased stiffness).
2) IS 1893: 2002 has suggested a criteria regarding permissible value of inter storey drift requirement for a RCC structure. Retrofitting models developed for shear wall and steel bracing have effectively satisfied the laid criteria as in comparison to other retrofitting methods.
3) Parametric study done on all models have shown that among all the chosen models used for retrofitting shear wall yields lesser point displacement, storey drift and attracts more shear in both X and Y direction.
4) Shear wall have come out to be a feasible and practically possible solution for an existing RC structure.

REFERENCES

1. Giuseppe Olveto and Massimo Marletta, “Seismic Retrofitting of RC Buildings Using Traditional and Innovative techniques,” ISET Journal of Earthquake Technology, vol-42, pp 21-46, 2005.
2. Amlan K. Sengupta, CHEMURU Srinivasulu Reddy , Badari Narayanan V T and Asokan A, “Seismic Analysis and Retrofit of Existing Multistoreyed Buildings in India – An Overview With a Case Study,” 13th World Conference on Earthquake Engineering Vancouver, 2004.
3. William t holmes, “Risk Assessment And Retrofit Of Existing Buildings,”12 WECCE, 2000.
4. Peyman Amini Motlagh andAli Pak, “Comparision of Seismic Rerofitting Methods For Existing Foundation in Seismological Active Regions,” World Academy of Science, Engineering and Technology International Journal of Civil, Environmental, Structural Construction and Architectural Engineering, Vol- 8, No:5, 2014.
5. F U lin ZHOU, “Advanced Passive Control Techniques for retrofit of existing Building in Seismic Zone,” 12 WCEE 2000.
6. S D V S N Rao, J Vikranth, “Promotion of Seismic Retrofitting For Existing Low Earthquake Resistant Structures,”Int. Journal of Engineering Research and Applications, Vol. 3, Issue 6, pp- 1850-1855, 2013.
7. D. D. Ayala and A. W. Charleson, “Review of Seismic Strengthening Guidelines For R. C. Buildings In Developing Countries,” Published by Elsevier Science Ltd. All Rights Reserved 12th European Conference on Earthquake Engineering.
8. Ciro FAELLA, Enzo MARTINELLI, “Seismic Assessment And Retrofitting Of R.C. Existing Buildings,” 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada, 2004.
9. Vijayakumar. A, Venkatesh Babu. D.L., “A Survey of Methods and Techniques Used For Seismic Retrofitting of RC Buildings,” International Journal of Civil and Structural Engineering, Vol- 2, No 1, 2011.
10. K. Galal and H. El-Sokkary “Recent Advancements in Retrofit of RC Shear Walls,” The 14th World Conference on Earthquake Engineering, Beijing, China, 2008.
11. Author Reza Amiraslanzadeh Toshikazu Ikemoto &MasakatsuMiyajim, “A Comparative Study on Seismic Retrofitting Methods for Unreinforced Masonry Brick Walls,” 12WCEE 2007.
12. Diptesh Das and C.V.R. Murty, “Brick Infill Masanory in Seismic Design of RC Frame Buildings: Part1 Cost Implications,” The Indian Concrete Journal, 2004.
13. S Krishnan,“ Modeling Steel Moment Frame and Braced Frame Buildings in Three Dimensions Using Frame 3D,” The 14th World conference earthquake engineering Beijing China, October 12-17, 2008.

14. Akihiro Kunisue,Norihide Koshika "Retrofitting Method of Existing Reinforced Concrete Building Using Elasto-Plastic Steel Dampers, "12 WCEE, 2000.
15. FEMA 356, 2000, Prestandard and Commentary for the Seismic Rehabilitation of Buildings, Federal Emergency Management Agency, Washington DC.

.

Retrieval Number: B1878078219/19©BEIESP
DOI: 10.35940/ijrte.B1878.078219
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication