RESEARCH ARTICLE | SEPTEMBER 05 2023

Pushover analysis of retrofitted RC building

Amruthakala Gugulothu; Atulkumar Manchalwar; Srikanth Koniki; K. Vamsi Krishna

AIP Conference Proceedings 2754, 040006 (2023)
https://doi.org/10.1063/5.0167124

Pushover Analysis of Retrofitted RC Building

Amruthakala Gugulothu[1,a)], Atulkumar Manchalwar[1],
Srikanth Koniki[1]and Vamsi Krishna K[2,b)]

[1] *Department of Civil Engineering, GRIET, Hyderabad, Telangana,500090, India*
[2] *Department of Civil Engineering, Malla Reddy Engineering College, Hyderabad, Telangana, India.*

[b)] Corresponding author: kandevamsi4u@gmail.com
[a)]amruthag1998080408@gmail.com

Abstract. Because of the infrastructure's growing degradation, which is usually accompanied with the necessity for structural upgrading due to the structure's change in functioning, Retrofitting is becoming more and more important and receives today considerable emphasis throughout the worlds. Retrofitting is an action that improves future performance by adjusting the structure or design of a structure or its components. Retrofitting is required to make structure earthquake-resistant. Retrofitting is preferred over destruction and reconstruction since it is often less expensive. In this paper, base shear capacities and displacements of RC building with and without retrofitting is analysed and compared in ETAB software.Two types of retrofitting techniques were used i.e., Steel Jacketing and RC Jacketing, to strengthen the structural members. Non- linear static analysis was carried out and the result shows that there is an increment in the Base shear capacity and the maximum displacement where failure takes place.
Keywords. Non-Linear Static Analysis; Reinforced Concrete; Retrofitting, Jacketing; ETABS

INTRODUCTION

Many existing RC structures across the world, built before earthquake-resistant design techniques, are unable to provide appropriate seismic ductility. Columns with insufficient reinforcement in the transverse direction, in particular, may get damage owing to a low capacity of deformation, causing the structure to collapse. Retrofitting this sort of column with an extra jacket layer of steel may provide the requisite reinforcement in the transverse direction while also improving seismic behaviour by increasing ductility and lowering the demand for seismic effects. The behavior of the building typically explored by using non-linear pushover analysis with and with out completely steel and CFRP jackets retrofitted to its columns in this study. A. Rahimi et al. (2020) [1] Pushover analysis was performed on three RC frames with varied stories of 4, 8, and 12 that were retrofitted with X-braces and compared to inelastic Dynamic analysis to determine the structure's performance. The results demonstrate that as the storey height rises, so does the need for base shear after retrofitting. There is also a drop in maximum lateral displacement, ductility requirement, shear capacity, and shear demand in all frames, but the effectiveness declines. However, due to the introduction of X-Bracing systems in RC frames, the placement of the plastic hinge has shifted; this movement may cause complications and requires close inspection and appropriate reinforcement. Djamal Yahmi et al. (2017) [4] A non-linear static pushover study on a steel moment resisting frame with various stories and bays using SAP2000 software, taking into account specific parameters to see how they impact the behaviour factor (BF) and its components was studied. The results demonstrate that when the capacity factor grows, structural lateral capacity enhances, and the performance extent of structure is determined by number of stages. The strength factor is reserved by unaffected by the no. of floors, the number of bays, or the horizontal force pattern. Unaffected by number of bays and storeys, all of the structures exhibit equal redundancy, with a value exceeding those suggested by Euro Code 8. Low-rise frames have the highest ductility factor and behaviour factor values. Mohmmad T. N.S. Hadi (2017) [5] This paper study of circularised and axial compression force on Fiber Reinforced Polymer wrapped hollow concrete specimens.

The conclusions of the test indicate that circularising hollow specimens is similarly to the circularising solid specimens in that it reduced the and around corners, there may be a concentration of stress and enhances ductility and ultimate load-carrying capacity. provides significantly higher eventual axial stress than corner in both hollow and solid concrete specimens. To assess the axial stress on a square of Carbon Fiber Reinforced Polymer and circularized both solid and hollow, analytical design was created by an axial load. Mohmmad R. Irshidat (2017) [6] The effects of this study examine the effects of carbon nanotubes on the flexural strength recovery of heat-damaged RC beams made up of carbon fibre reinforced polymer (CFRP) composites. The casted sample were, heated to 5000–6000°F, and instead repaired. break patterns, mode of failures, and SEM investigations being used to analyse data. By use of epoxy resin enhanced with CNTs improved the strength of beams that have been harmed by the heat. The results indicate that CFRP confinement improves the ultimate load bearing capabilities and stiffness by 111%, 81%, and 56%, accordingly, over the unheated beam values. Pranay Ranjan and Poonam Dhiman (2016) [7] The author developed Reinforced Concrete, FRP, and jacketing for faulty columns in an old structures & studied the effectiveness retrofitting techniques. This article includes a comparison of all methods. The dimensions of the sections in RC jacketing were increased, resultant in less free available workable region and a substantial increase in dead mass. Jacketing with RC plates, and other old columns by drilling holes, slabs and beams is inflicting more harm to the structure. Confinement via FRP Jackets reduced the performance of concrete columns. Number of advantages does have by Fiber reinforced polymer Jacketing. Fakharifaret al. (2015) [8] They presented a quicker strengthening methodology for damaged beyond repair RC columns which also utilises lightweight prestressed steel jackets to order to defuse to column structure, mass, and stiffness. A thin steel sheet prestressed restrain fiber, it is subsequently wrapped around the column in a jacket-like way in less than 12 hours using greater although the sheet by steel prohibits from intruding into cracked concrete. The research findings indicate that the retrofitted columns' ultimate strength and ductility being restored to 115 and 140 percent of their original strength and ductility, according, using the strengthening method, as well as respectively. The initial stiffness, on either hand, was recovered by eighty percentage rigidity of the column as build. Turgey et al. (2014) [9] consequences and These reinforcement bars

International Conference on Materials, Processing & Characterization
AIP Conf. Proc. 2754, 040006-1–040006-4; https://doi.org/10.1063/5.0167124
Published by AIP Publishing. 978-0-7354-4634-2/$30.00

of large-scale square or rectangular fibre reinforced polymer columns are being analyzed (FRP). The experimental research programme investigated the performance of large- scale square RC columns coated in carbon fibre reinforced polymer (CFRP) sheets. Further, the research was particularly concerned towards evaluating the appropriate impact of longitudinal and the impacts of longitudinal land lateral reinforcement, as well as on the behaviour Under axial load, 20 large- scale RC columns were developed and fabricated to fail. Unwrapped, totally wrapped, and partially wrapped columns were also the critical factors. Unwrapped (Column no 1), partially wrapped (Column no 2), entirely wrapped (Column no 3), partially wrapped with two layers (Column no 4), and thoroughly wrapped with two fourteen layers (Column number 5) were the five distinct test series carried out. Consequence and damaged mechanism of rectangular columns covered by all of FRP are being investigated and prosecuted (FRP). In the Study programme, the large-scale square performance of RC columns encased in carbon fibre reinforced polymer (CFRP) sheets was researched. Furthermore, they work has concerned with determining a appropriate role of longitudinal and actually Considering the real-world impact of transverse reinforcement and FRP jackets on concentrically driven columns the behaviour of it. In the structural laboratory, were designed by twenty large scale RC columns & built to fail under applied loads. Unwrapped, thoroughly wrapped, and partially wrapped columns were also significant. Unwrapped (Column number 1), partially wrapped (Column number 2), fully wrapped (Column number 3), partially wrapped with two layers (Column number 4), and thoroughly wrapped with two layers (Column number5) were the five-test series used (Column number 5).

CFRP Retrofit Technique

Confining the concrete part with CFRP is another interesting retrofit approach. For retrofitting old columns, this material has been employed as an appealing and constructive process. Specifically, columns built prior to this have proven sensitivity to nonlinear conditions and can break suddenly and without caution during a severe earthquake. Fabric sheets that have been assembled are made up of synthetic fibres and a resinous matrix that may be applied to any concrete portion. This approach has several advantages. Because CFRP is lightweight, it may be installed rapidly with fewer labour costs and less disturbance to the building's operations. This material is also resistant to corrosion in chloride conditions, which might result in lower maintenance costs. Retrofitting susceptible reinforced concrete columns utilising CFRP can significantly boost ductility and energy dissipation capabilities, as well as vastly improve total resistance to earthquakes. The confinement offered by jacketing by using CFRP can compensate for the shortcomings of inadequate steel reinforcement while also increasing capacities of moment and shear as jacketing alters the response of the column from brittle to ductile. As compared to previously damaged columns, the CFRP retrofit technology significantly improves ductility and seismic behaviour, with the extent of improvement being entirely connected to the severity of the compensation. More CFRP layers are necessary as the extent of defectiveness increases to obtain performance comparable to that of undamaged columns that have been retrofitted. CFRP jacketing will mostly be used for columns to preserve the discontinuities between footings and column or column and beam joints. This strengthens the columns and moves the hinge made of plastic region from boundary to away section having low capabilities for stiffness, like beams [2].

Steel Jacketing

It covers the reinforced column with metal jacket is the efficient approaches for improving earthquake resistant capability. Steel jacking provides a number of benefits over ties of reinforcing bars wrapped around the column. The presence of a large quantity of transversal steel, that gives additional confinement to the concrete that is incompression, is one of the main reasons for installing steel jacketing. Also, avoiding concrete from buckling, that might be a major cause of rebar corrosion and longitudinal bar buckling in a column. Steel jacketing is disruptive, time taking, and expensive, but it also results in the least amount of space lost. Steel jacketing is made out of angles of steel at the ends of columns and straps of steel at some points along the length to create monolithic behaviour at the span of steel-concrete [2].

PUSHOVER ANALYSIS

It covers the reinforced column with metal jacket is the efficient approaches for improving earthquake resistant capability. Steel jacking provides a number of benefits over ties of reinforcing bars wrapped around the column. The presence of a large quantity of transversal steel, that gives additional confinement to the concrete that is incompression, is one of the main reasons for installing steel jacketing. Also, avoiding concrete from buckling, that might be a major cause of rebar corrosion and longitudinal bar buckling in a column. Steel jacketing is disruptive, time taking, and expensive, but it also results in the least amount of space lost. Steel jacketing is made out of angles of steel at the ends of columns and straps of steel at some points along the length to create monolithic behaviour at the span of steel-concrete [2].

DETAILS OF THE STRUCTURE

A building model with dimensions of 20 m x 21.5 m is developed. It is symmetrical, both the X and Y directions by four bays, each measuring 5m length. The height of building has a soft ground floor was 5.5 mt & further level with heights of 4 mts. The primary beams are 450 mm x 300 mm. Columns, on the other hand, come in two varieties: Columns on the first and second levels are 750 mm x 750 mm in size. Columns on the following higher levels are 600 mm × 600 mm in size. Every floor has a slab that is 120mm thick. Table 1 shows the dimensions of a structure, and Table 2 shows the material properties considered for construction. The building plan view and elevation view are represented in the figure below.

Table 1. Beam and Column Dimensions

Stories	Beam(mm)	Column(mm)
4 story	B=450×300	C1=750×750; C2=600×600

Table 2. Building Parameters.

Concrete	M30
Steel	HYSD415
Supports	Fixed

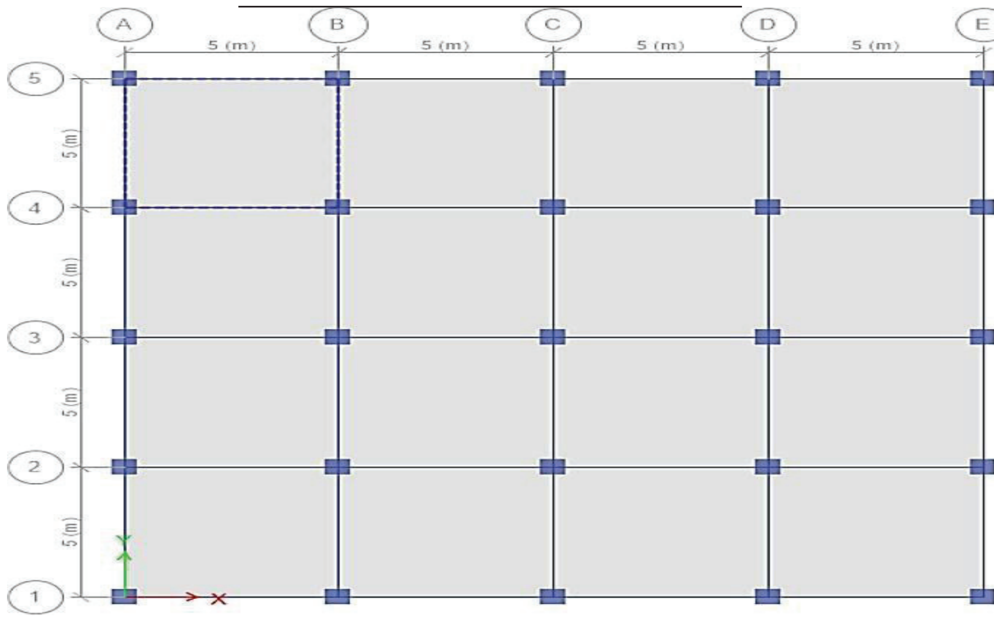

Fig 1. Plan for 4 Storey Building.

MODELLING DETAILS

A building model with specifications of 20 m x 21.5 m is created. It is symmetrical, having four bays in both the direction of X & Y, each measuring 5m length. The structure has a ground storey with a elevation of 5.5m as well as further storeys with heights of 4 m. The model is designed in the manner represented in Figure 2 and is analysed using the ETAB programme. The support conditions are determined by the qualities of the building materials, as Mix30 is the concrete grade and Fe415 is the grade of steel considered. The modelled building was subjected to linear dynamic analysis and was designed for a critical load combination in accordance with Indian standard code (IS 456-2000).

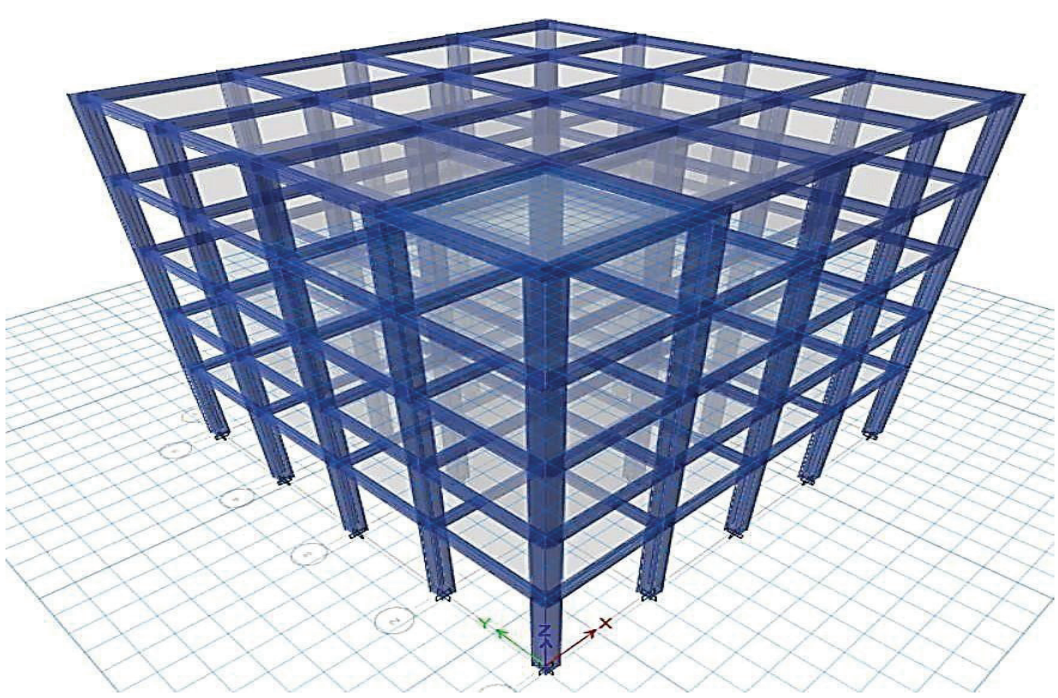

Figure 2. 3D Building model in ETABS

CONCLUSION

- From the extensive literature survey conducted it can be concluded that retrofitting can be effectively used to make the structure earthquake-resistant and to overall improve the capacity of the building.
- There are various methods of retrofitting techniques throughout the literature, each having advantages and certain limitations. Pushover analysis is a reliable technique to determine the capacity of the structure.so, i am trying to assess using ETAB and compare with their results.
- The ductility of the structure was increased using both retrofitting procedures. In the instance of CFRP jacketing, in addition to a large increase in ductility, the involvement of CFRP jacketing resulted in a modest gain in flexural strength.

- The overall structural performance of steel jacketed columns was enhanced by lateral force and ductility, with strength being more important due to enlarged additional longitudinal reinforcements and cross-sections
- As a conclusion, if lateral movements must be minimized, steel jacketing may be preferable. Which in turn, limits damage.

REFERENCES

1. Rahimi and Mahmoud Maheri (2020), "The effects of steel X-brace retrofitting of RC frames on theseismic performance of frames and their elements." *Engineering Structures* Volume.206, Issue 5, page. 110-149.
2. Nahavandi and Hamidreza (2020), "Pushover Analysis of Retrofitted Reinforced Concrete Buildings", *Civil and Environmental Engineering Master's Project Reports* Volume.21, Issue 2, page. 204-215.
3. Jalilkhani, Maysam,, and Masood Danesh (2020)"A multi- mode adaptive pushover analysis procedure for estimating the seismic demands of RC moment-resisting frames." *Engineering Structures* Volume.213, Issue 5, page. 540-552.
4. S. Dhanush, and U. Pasha, (2018), "Retrofitting of Existing RC Columns by Reinforced Concrete Jacketing Using ANSYS and ETABS," volume.7, Issue 6, page. 572–578.
5. Yahmi, Djamal, et al. (2017) "Evaluation of behaviour factors of steel moment-resisting frames usingstandard pushover method." "*Procedia Engineering*" Volume.199, Issue 6, page.397- 403.
6. Mohmmad and Mohmmad Hadi (2017), "Behaviour of circularized and FRP wrapped hollow concrete specimens under Axial compression load" Volume.171 , Issue3, page.538-548.
7. R. Irshidat, Mohmmad Al-Saleh (2017), "Flexural strength recovery of Heat – damaged RC beams usingcarbon nanotubes modified by CFRP", Volume.145, Issue 6, page. 474-482.
8. Panay Ranjan and Dhiman (2016), "Retrofitting of columns of an existing building by RC, FRP andSFRC techniques", Volume. 234, Issue 2278-1684, page.232-334.
9. Fakharifar, and Dalvand, (2016), "A. Rapid repair of earthquake-damaged RC columns with prestressed steel jackets", *"J.Bridge eng,"* Volume.21, Issue 4.
10. Srinivas. T, Abhignya. G and Ramana Rao. N.V, A Review on Geopolymer RCC Beams made with Recycled Coarse Aggregate, E3S Web of Conferences, ICMED, 10-12 July 2020, India (2020).
11. Jagannadha Kumar, M.V., Jagannadha Rao, K., Dean Kumar, B., Srinivasa Reddy, V., Int. J. of Civil Eng. and Tech., 9(7), pp. 1133-1141 (2018)
12. T.Srinivas and G. Sukesh Reddy, "Mechanical Properties of Geopolymer Concrete Made With Partial Replacement of Coarse Aggregate by Recycled Aggregate", International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249 – 8958, Volume-9 Issue-1 (October-2019), PP 2301-2304.
13. Ganta, J.K., Seshagiri Rao, M.V., Mousavi, S.S., Srinivasa Reddy, V., Bhojaraju, C., Structures 28, pp. 956-972 (2020)
14. T.Srinivas and R. N. Koushik, "Sulphate attack Resistance of Geo-polymer Concrete made with Partial Replacement of Coarse Aggregate by Recycled Coarse Aggregate", International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-8 Issue-12 (October-2019), PP 112-117.
15. Naidu, K.S.S.T., Rao, M.V.S., Reddy, V.S., Int. J. of Innov. Tech. and Explor. Eng.g (IJITEE), 8(9 Special Issue 2), pp. 641-642 (2019)
16. K. Sai Gopi, Dr. T. Srinivas and S. P. Raju V, "Feasibility Study of Recycled Plastic Waste as Fine Aggregate in Concrete", E3S Web of Conferences ICMED 184, 01084(2020), GRIET, 28-29 February, https://doi.org/10.1051/e3sconf/2020184011084.
17. Chandana Priya, C., Seshagiri Rao, M.V., Srinivasa Reddy, V., Int. J. of Civil Eng. and Tech., 9(11), pp. 2218-2225 (2018)
18. T.srinivas and P. Manoj Anand, "Permeation Properties of Geopolymer Concrete Made with Partial Replacement of Recycled Coarse Aggregates", International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-8 Issue-12 (October-2019), PP 2987-2990.
19. Satya Sai Trimurty Naidu, K., Seshagiri Rao, M.V., Srinivasa Reddy, V., Int. J. of Civil Eng. and Tech., 9(11), pp. 2383-2393 (2018)
20. Supriya, Y., Srinivasa Reddy, V., Seshagiri Rao, M.V., Shrihari, S., Int. J. of Rec. Tech. and Engi., 8(3), pp. 5381- 5385 (2019)
21. Kotkunde, N., Krishna, G., Shenoy, S.K., Gupta, A.K., Singh, S.K. International Journal of Material Forming, 10 (2), pp. 255-266 (2017)
22. Kotkunde, N., Krishna, G., Shenoy, S.K., Gupta, A.K., Singh, S.K. Experimental and theoretical investigation of forming limit diagram for Ti-6Al-4 V alloy at warm Condition (2017) International Journal of Material Forming, 10 (2), pp. 255-266.