iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** V **Month of publication:** May 2019

DOI: https://doi.org/10.22214/ijraset.2019.5648

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

A Comparative Study on Retrofitting of Reinforced Concrete Column by Concrete, Steel and FRP Jacketing using ETABS and ANSYS

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Abstract: Construction of a new facility after an earthquake is not economical, also it takes more time. Retrofitting technique is used to increase the strength and ductility of building also helps in up gradation of lateral strength. Doing so will mean that the building will be less costly to operate, will increase in value, last longer, and contribute to a better, healthier, more comfortable environment for people in which to live and work. Jacketing is the most popular method for strengthening of building columns. Types of Jacketing are; Steel jacket, Reinforced Concrete jacket, Fibre Reinforced Polymer Composite (FRPC) jacket. The Purpose for jacketing is to increase concrete confinement, to increase shear strength, and to increase flexural strength. In this paper G+10 storied RC moment resisting frame building with plan dimension of 35 m x 22 m is considered. Response spectrum analysis is carried out in ETABS software. After analysis and design, deign load of a failed column is selected. That failed column is drawn in ANSYS 18.1 workbench software for retrofitting. Linear static analysis is taken in ANSYS software. Deformation of column without jacketing is found out. Then Concrete, Steel CFRP and GFRP jacketing are done to reduce the deformation of the column. After comparing the results of columns with jacketing and it is found that concrete jacketing is effective in reducing the deformation of failed column.

Keywords: Retrofitting, Jacketing, ETABS, ANSYS Software, Strengthening

I. INTRODUCTION

Earthquake is a dreaded natural calamity man has been trying for centuries to combat this catastrophic act of nature. Despite being able to construct steel and concrete sky scraper buildings, providing 100% guarantee of stability of these buildings against a major earthquake has still been a challenge. Earthquake engineering is an interdisciplinary branch of engineering that designs and analyses structures, such as buildings and bridges, with earthquakes in mind. Its overall goal is to make such structures more resistant to earthquakes. An earthquake engineer aims to construct structures that will not be damaged in minor shaking and will avoid serious damage or collapse in a major earthquake. Earthquake engineering is the scientific field concerned with protecting society, the natural environment, and the man-made environment from earthquakes by limiting the seismic risk to socio-economically acceptable levels. There are two main types of constructions commonly seen in buildings, load bearing wall structure and framed structure. In load bearing walls structure, the building is constructed with continuous vertical walls to support the floor slabs at different levels. However, if it is functionally inconvenient to have continuous vertical partitions, then the framed structure is implemented wherein isolated vertical posts are connected with horizontal bands to support the structure. Both these structures play the role of withstanding the load of the objects stored on them, similar to the structure of shelves. The effect of an earthquake is very similar to this horizontal push. Fortunately, present day technology can precisely determine the forces and stresses that a building can undergo. Knowing the strength of the material of which the member is made of helps in achieving economy of materials hence economy of cost of construction. The whole process is called structural analysis and design.

A. Retrofitting of buildings

Retrofitting an existing building can oftentimes be more cost-effective than building a new facility. Since buildings consume a significant amount of energy, particularly for heating and cooling, and because existing buildings comprise the largest segment of the built environment, it is important to initiate energy conservation retrofits to reduce energy consumption and the cost of heating, cooling, and lighting buildings. But conserving energy is not the only reason for retrofitting existing buildings. The goal should be to create a high-performance building by applying the integrated, whole-building design process, to the project during the planning phase that ensures all key design objectives are met. For example, the integrated project team may discover a single design strategy that will meet multiple design objectives. Doing so will mean that the building will be less costly to operate, will increase in value, last longer, and contribute to a better, healthier, more comfortable environment for people in which to live and work. Improving indoor environmental quality, decreasing moisture penetration, and reducing mold all will result in improved occupant health and productivity.

Further, when deciding on a retrofit, consider upgrading for accessibility, safety and security at the same time. The unique aspects for retrofit of historic buildings must be given special consideration. Designing major renovations and retrofits for existing buildings to include sustainability initiatives will reduce operation costs and environmental impacts, and can increase building adaptability, durability, and resiliency. Basic Concept of Retrofitting aims at up gradation of lateral strength of the structure, Increase in the ductility of the structure and to increase in strength and ductility.

B. Methods of Retrofitting

Effectiveness of each Retrofitting method varies a lot depending upon parameters like type of structures, material condition, amount of damage etc.

1) *Adding New Shear Walls:* It is frequently used for retrofitting of non-ductile reinforced concrete frame buildings. The added elements can be either cast in place or precast concrete elements. New elements preferably placed at the exterior of the building. Not preferred in the interior of the structure to avoid interior mouldings.
2) *Adding Steel Bracings:* It is an effective solution when large openings are required. Potential advantages due to higher strength and stiffness, opening for natural light can be provided, amount of work is less since foundation cost may be minimized and adds much less weight to the existing structure.
3) *Base Isolation (Seismic Isolation):* Isolation of superstructure from the foundation is known as base isolation. It is the most powerful tool for passive structural vibration control technique.
4) *Mass Reduction Technique of Retrofitting:* This may be achieved, for instance, by removal of one or more storey's as shown in Figure. In this case it is evident that the removal of the mass will lead to a decrease in the period, which will lead to an increase in the required strength.
5) *Wall Thickening Technique of Retrofitting:* The existing walls of a building are added certain thickness by adding bricks, concrete and steel aligned at certain places as reinforcement, such that the weight of wall increases and it can bear more vertical and horizontal loads, and also its designed under special conditions that the transverse loads does not cause sudden failure of the wall.
6) *Jacketing:* This is the most popular method for strengthening of building columns. Types of Jacketing are; Steel jacket, Reinforced Concrete jacket, Fibre Reinforced Polymer Composite (FRPC) jacket. The Purpose for jacketing is to increase concrete confinement, to increase shear strength, and to increase flexural strength

II. NEED FOR THE STUDY

Important buildings must be strengthened whose services are assumed to be essential just after an earthquake like hospitals. Retrofitting helps to reduce earthquake damages, hence it is worth much more than its cost. At the stage of selecting the retrofitting method, the current status of the existing structure and its performance are known, and the performance required for the structure after retrofitting and the conditions for retrofitting work are given. Factors that should be considered in selecting the method include the effectiveness of the various retrofitting methods with respect to the required performance improvements, the viability of execution of the retrofitting work, the impact of the retrofitting work on the surrounding environment, the ease of maintenance after retrofitting, economy and other factors. In this study three methods of Jacketing Retrofitting technique are taken and conducting a comparative study.

III. SCOPE AND OBJECTIVES

The scope of this study is to analyze the performance of steel and FRP jacketing on equivalent static analysis of RC building under gravity loads and seismic loads using ETABS software. The objectives are;

A. To analyze the seismic response of RC building using steel Jacketing.
B. To analyze the seismic response of RC building using FRP (CFRP and GFRP) Jacketing.
C. Comparative study on both analyses to choose the best retrofitting technique.

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IV. METHODOLOGY

In this study G+10 storied RC moment resisting frame building with plan dimension of 35 m x 22 m (7-bay at 5m c/c along X axis and 4-bay at 5.5m c/c along Y axis) is considered. The plan and 3D view of the model are shown in Fig. 1 and Fig.2 respectively. Height of each story is 3.0 m. All floor slabs, beams and columns are modelled and analyzed as shell element, beam element and column element respectively in ETABS. Details of building designed are given in Table1.

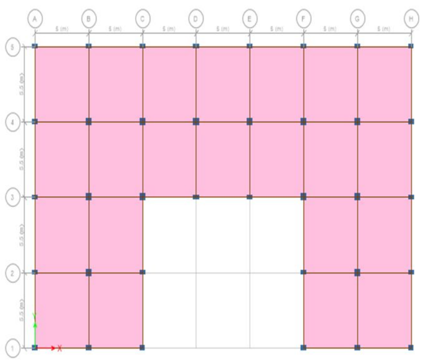

Fig.1 Plan of the building model

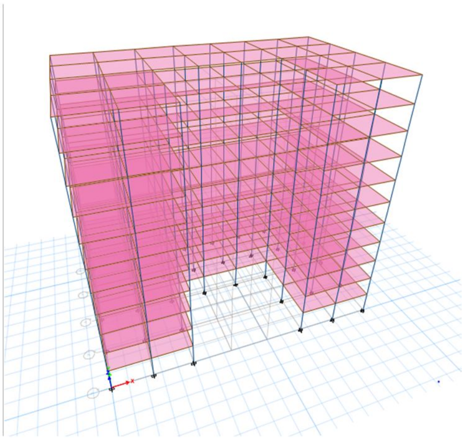

Fig.2 3D Rendered view of the building model

Table 1 Data of building designed

Plan area	35m X 22m
Storey height	3m
Beam size	300mm X 450mm
Column size	C1(corner) 350 x 500 C2(edge) 350 x 550 C3(middle)550 x 550
Slab thickness	150mm
Grade of concrete	M 25, M 30
Grade of steel	Fe 415
Density of concrete	25 kN/m^3
Earthquake zone	III
Soil type	Medium soil
Damping ratio	5%
Importance factor	1.5
Response reduction factor	5

After completing the model, analysis is done. Here Response spectrum analysis is taken. And finally deigning is carried out. Loading is taken as per IS 875 and Load combinations are default. After analysis and design, a failed column is selected and the CAD modelling of column is carried out using finite element software i.e., ANSYS 18.1 work bench, which shows in Fig 3. The type of analysis carried out in ANSYS is linear static analysis. Column is analyzed with and without jackets.

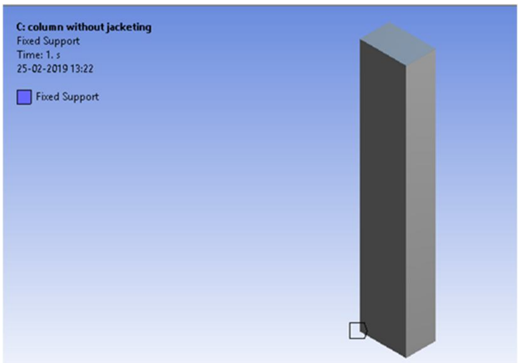

Fig.3 Geometry of column with fixed support

V. RESULTS AND DISCUSSION

Analysis and design of the building are carried out in ETABS. Plan of storey 4 and elevation are given below in Fig 4 and Fig 5. The result shows some failures in elements. A failed column of size 350x550 is selected. The design load Pu acting on the column is considered for further analysis in ANSYS

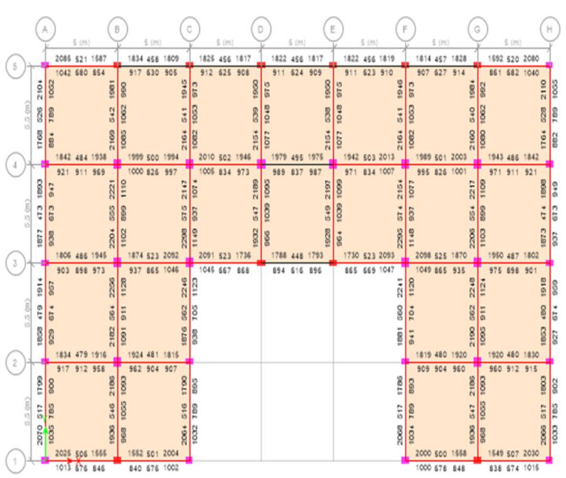

Fig.4 Plan of Storey-4

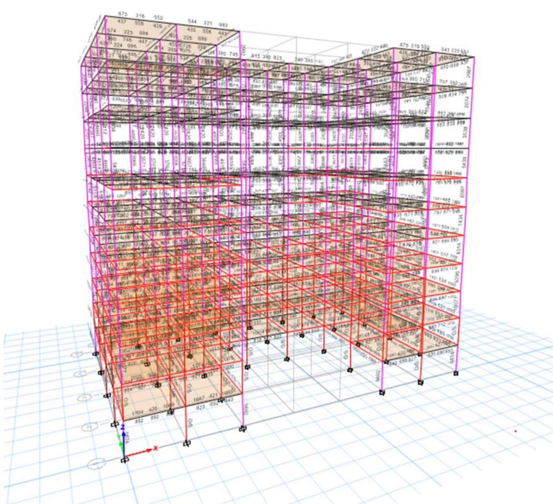

Fig.5 3D Rendered view of structure after design

Analysis and design are carried out in ETABS software. After Design the following results were obtained. Column number 22 of storey4 is failed. The P_u value of column 22 obtained from analysis is 3707.325 kN.

A. Column without Jacketing

A failed column of size 350x550 is taken from ETABS design. The cad modelling of column is carried out using finite element software i.e., ANSYS 18.1 work bench. The type of analysis carried out in ANSYS is linear static analysis. First we have to model a concrete control column specimen and with this we can generate the model of jacketed column. The sizes of column used for modelling are 350X550X3000mm. Fig 4.9 shows the geometry of column without jacketing. The support given to the column is fixed.

B. Column with Steel Jacketing

To reduce the deformation of column, steel plate of 40mm wide, 8mm thick is provided as jacketing. Fig 4.13 shows the geometry of column with steel jacketing. Design load of 3707.325Kn is applied on the steel jacketed column.

C. Column with CFRP Jacketing

To reduce the deformation of column, CFRP plate of 40mm wide, 8mm thick is provided as jacketing. Fig 4.16 shows the geometry of column with CFRP jacketing.

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D. Column with GFRP Jacketing

To reduce the deformation of column, GFRP plate of 40mm wide, 8mm thick is provided as jacketing. Fig 4.17 shows the geometry of column with GFRP jacketing.

E. Column with RC Jacketing

To reduce the deformation of column, RC is provided as jacketing. A new sized column is designed using IS 15988:2013. Fig 4.18 shows the geometry of column with RC jacketing.

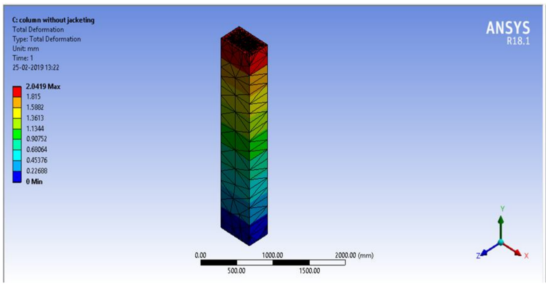

Fig.6 Column without Jacketing

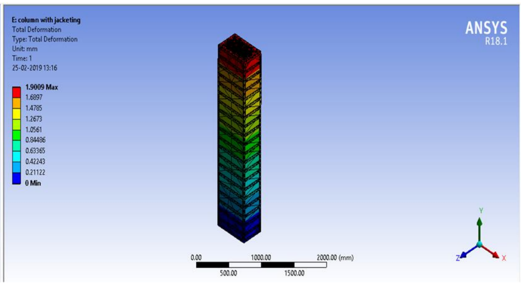

Fig.7 Column with Steel Jacketing

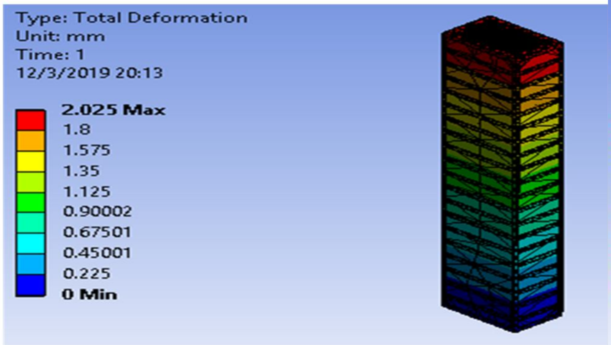

Fig.8 Column with CFRP Jacketing

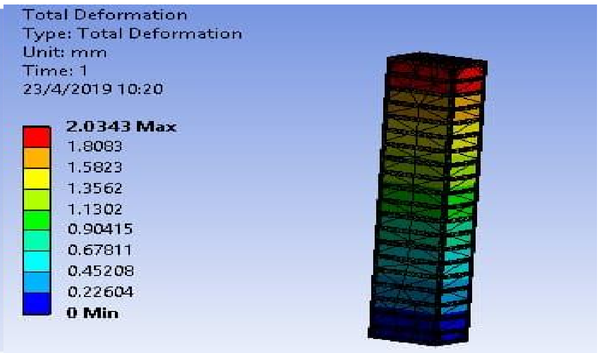

Fig.9 Column with GFRP Jacketing

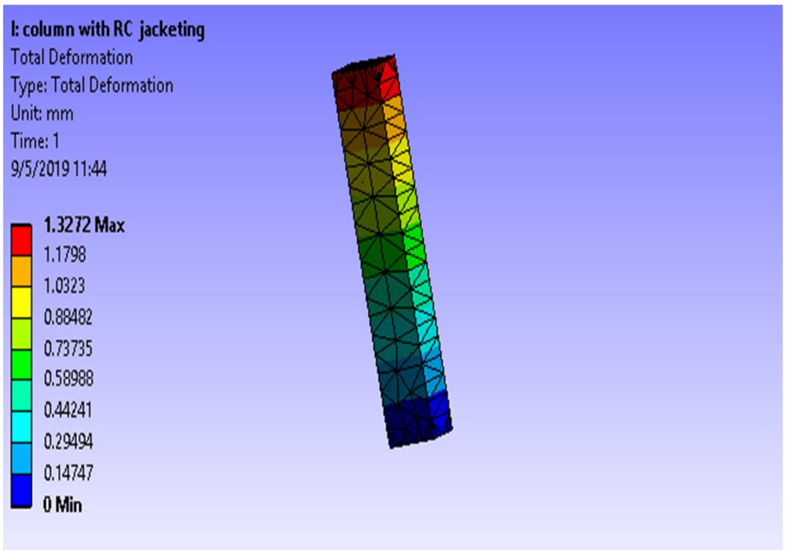

Fig.10 Maximum deformation of column with RC Jacketing

Columns are analysed in ANSYS, they are simple column without jacketing, with steel jacketing, with RC jacketing, with CFRP and GFRP jacketing. Maximum deformation in these three columns are compared in Fig 12

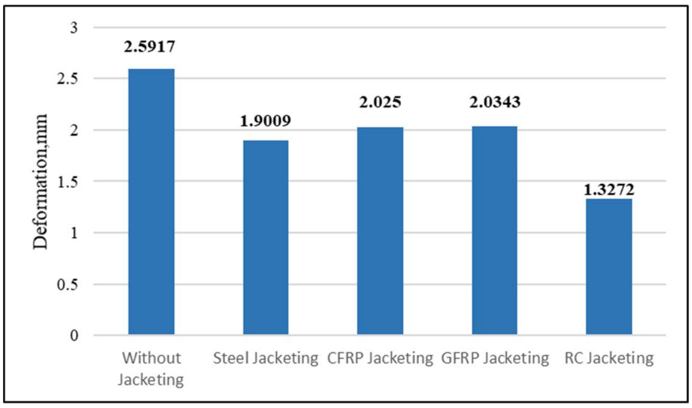

Fig 20 Comparison of maximum deformation of columns

VI. CONCLUSIONS

A failed column from a structure designed in ETABS is drawn in ANSYS software to reduce the deformation due to design load. Following are the conclusions after linear analysis in ANSYS software.

A. Maximum deformation of a column without jacketing is 2.5917mm. To reduce the deformation Jacketing methods are adopted.

B. Values obtained after analysis of Steel, CFRP, GFRP and R C jackets are 1.9009, 2.025,2.0343 and 1.3272 respectively.

C. From the results, R C Jacketing is better to reduce maximum deformation of a column when compared with other Jacketing techniques i.e. it reduces 48.79% deformation of column without Jacketing.

D. While comparing the materials i.e. steel, CFRP, GFRP and R C; the best material for jacketing technique is Reinforced Concrete.

VII. ACKNOWLEDGEMENT

We are really thankful to all the teaching and non-teaching staff of Sri Vellapally Natesan College of Engineering for supporting us throughout this work.

REFERENCES

[1] Senthilkumar, E, Murugesan, A, and Thirugnanam, G.S (2010), Experimental study on behaviour of Retrofitted with FRP wrapped RC Beam Column Exterior Joints Subjected to cyclic loading, International Journal of Civil and Structural Engineering, 01, 0976 – 4399.

[2] Pandey, G.R, Mutsuyoshi, H and Aravinthan, T(2007), Retrofitting Reinforced Concrete Bridge Frames Using Externally Bonded FRP Sheets, Asia-Pacific Conference on FRP in Structures (APFIS 2007), S.T. Smith (ed) © 2007 International Institute for FRP in Construction.

[3] Kevadkar, M.D, and Kodag, P.B (2013), Lateral Load Analysis of R.C.C. Building, International Journal of Modern Engineering Research (IJMER), 03, 1428-1434.

[4] Antonio Nanni and Bradford, N.M (1995), FRP Jacketed concrete under uniaxial compression, Construction and Building Materials, 09,115-124.

[5] AbediniMehrmashhadi,J, Mussa,M.H, Ansari,M and Tohidmomeni (2017),Evaluation of concrete Structures Reinforced with FRP bars: A Review, Journal of Asian Scientific Research,07, 165-175.

[6] Abdullah and Takiguchi (2003), An Investigation into behaviour and strength of RC columns strengthened with ferrocement jackets, Cement and Concrete Composites, 25,233-242.

[7] Tiwary, A.K, and Mani Mohan (2015), Strengthening Of Exterior Beam Column Joint With Modified Reinforcement Technique, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 32-37.

[8] Campione, G, Miraglia, N and Papia, M(2004), Strength and strain enhancements of concrete columns confined with FRP sheets, Structural Engineering and Mechanics,18, 118-126.

[9] Sawant, R.M, Junaid Khan, Jabeen Khan, and Waykar, S (2015), Behavior Of High Strength Fiber Reinforced Concrete Under Shear, International Journal of Civil Engineering and Technology (IJCIET), 06, 46-54.

[10] Cosenza, E, Manfredi, G and Realfonzo, R, (1997), Behaviour and Modelling of FRP Rebars to Concrete, Journal of composites for construction,1,312-318.

[11] Jodawat, A, Parekh, A, Marathe, B, Ketan Pawar , Sunny Patwa , YashSahu and Indrajeet Jain (2016), Retrofitting Of Reinforced Concrete Column by Steel Jacketing, Int. Journal of Engineering Research and Application,06,01-05.

[12] Colotti, V and Spadea, G (2001), Shear strength of RC beams strengthened with bonded steel or FRP plates, Journal of structural Engineering, 4,127-135.

[13] Ashok kumar, G and Harish Nayak, B (2016) Seismic retrofit of RC building using jacketing – a review and case study, International Journal for Research in Applied Science and Engineering Technology, 5, 18064-18071.

[14] Belal, M, Mohamed, H.M and Morad, S (2015) Behavior of reinforced concrete columns strengthened by steel jacket, HBRC Journal,11,201-212.

[15] Elsamny, M.K, Hussein, A.A, Nafie, A.M and Abd-Elhamed, M.K (2013),Experimental Study of Eccentrically Loaded Columns Strengthened Using a Steel Jacketing Technique, International Scholarly and Scientific Research & Innovation,7,12-19.

[16] Tarabia, A.M, and Albakry, H.F (2014) Strengthening of RC columns by steel angles and strips,Alexandria Engineering Journal,53, 615-626.
[17] Nagaprasad, P, RanjanSahoo, D and Durgeshrai, C (2009),Seismic strengthening of RC columns using external steel cage, International journal for earthquake engineering,38,1563-1586.
[18] Montuori, R and Piluso, V (2009) Reinforced concrete columns strengthened with angles and battens subjected to eccentric load, InternatinalJornl Of Engg Trends And Technology, 31,539-550.
[19] Raval, S and Dave, U.V (2013), Effectiveness of Various Methods of Jacketing for RC Beams, Procedia Engineering, 51, 230-239.
[20] Chavan, R and M,Rukesh, P (2017), Retrofitting Techniques For Existing Multistoried Building, International Journal of Advanced Scientific Technologies in Engineering aSnd Management Sciences ,03,245-356.
[21] Lakade, D and Pise, C.P (2015) Performance of RC Building Under Dynamic Forces and Suitability of Strengthening By FRP Jacketing, International Journal of Civil Engineering and Technology, 06,147-159.
[22] Dhanush, S.S, Ummer Farooq Pasha, and Kumar, N.S (2017), Retrofitting of Existing RC Columns by Reinforced Concrete Jacketing Using ANSYS and ETABS, International Journal of Science and Research, 07, 114-121.
[23] Robert Sonnenscheina, Katarina Gajdosova, and Ivan Holly (2016) FRP Composites and Their Using in the Construction of Bridges, Procedia Engineering 161, 477 – 482.
[24] Nikita Gupta, Poonam Dhiman, and Anil Dhiman (2015) Design and Detailing of RC Jacketing for Concrete Columns, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 54-58.
[25] Jayshree Chandrakar, and Ajay Kumar Singh (2017) Retrofitting of RCC Structral Members Using Concrete Jacketing, International Journal of Recent Development in Civil & Environmental Engineering , 2, 30-37.
[26] Sirigineedi Naga Lakshmi and Dumpa Venkateswarlu (2018) Seismic retrofit of reinforced concrete buildings using jacketing, International Journal of Research, 5, 4789-4796.
[27] Indian standard criteria for earthquake resistant design of structures, IS 1893 (Part 1) 2002, General provisions and buildings (fifth revision) Bureau of Indian standards, New Delhi, India.
[28] Indian standard code of practice for design loads (other than earthquake) for buildings and structures, part-2 Live loads, IS 875 (part2): 1987 (second revision), Bureau of Indian standards, New Delhi, India
[29] Indian Standard code of practice for design loads (other than earthquake) for buildings and structures, part-2 Dead load loads, IS 875 (part2): 1987 (second revision), Bureau of Indian standards, New Delhi, India.
[30] Indian Standard code of Seismic Evaluation and Strengthening of Existing Reinforced Concrete Buildings Guidelines, IS 15988:2013 Bureau of Indian Standards, New Delhi, India.