SEISMIC RESISTIVITY AND RETROFITTING OF RC FRAME BUILDING

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ABSTRACT: Tall structures are necessary in big cities owing to the high cost of land, the shortage of open space and the scarcity of available land. In general, tall structures are quite sensitive to lateral stresses induced by earthquakes. Because it is expensive to construct structures to endure these lateral pressures on occasion, it is not always desirable. Retrofit procedures are the exact methods utilised to carry out the retrofit plan in its entirety. Numerous retrofit strategies are possible for a particular refit scheme. Many structural failures during earthquakes are a result of insufficient shear strength and inappropriate confinement spacing in concrete columns. Thus, to enhance the cross section of the column, column strengthening operations such as jacketing the column are performed. Nonetheless, concrete jacketing of concrete columns has been shown to be quite successful at increasing strength and ductility and transforming strong-beam weak-column structures into strong-column weak-beam structures.

Keywords: RCC Buildings, Static analysis, Retrofitting of column, ETABS

1. Introduction

For structural design, it is extremely important to predict the structure's response to a particular load type. Basic information on the type of load and intensity for different types and site conditions is contained in the codes and previous reports. The method of analysis that is to be adopted depends entirely on the choice of the engineers according to the exactness of the work. The nonlinear analytics of time history can be considered as the most accurate seismic demand forecasting method and structure performance assessment. This method, however, requires the selection of a suitable set of ground movements, the detailed site conditions, and also a digital tool for the analysis of data. In many cases, the analysis is still computationally costly. In the past, seismic design codes focused only on ensuring an adequate degree of life safety to justify that earthquake are generally unpredictable and rare when compared to other side loads like winds. In this context, the main objective was to limit damages. Recent observations of actual building behavior during certain strong seismic events have shown that these philosophies have certain serious weaknesses where the damage inflicted has resulted in enormous economic loss, high repair costs, as Well as indirect costs of business interruptions in Many structure that satisfied the requirement that there should be no collapse.

2. Literature Review

Birendra karaiya (2019): Under seismic stress, open ground level reinforced concrete (RC) constructions designed primarily for gravity loads are more prone to severe damage or complete collapse. Inadequate shear and flexural strengths of ground storey columns are seen as the primary reason of these structures collapsing. Carbon fibre reinforced polymer (CFRP) jacketing is often used to enhance the axial and lateral load resistance of RC components. The purpose of this research was to determine the efficacy of CFRP jacketing in improving the overall seismic performance of a damaged Rc structure. The test specimen was a two-story half-scale RC frame with severely damaged columns in the bottom level and masonry infill walls in the top storey. Micro-concreting was used to fix these damaged columns, followed by a CFRP jacketing method. The rehabilitee test frame was subjected to slow-cycle testing by applying progressively increasing lateral cyclic displacements at both storey levels. Latitudinal strength, hysteretic response, and ductility response were the primary parameters evaluated. The test results showed that the suggested rehabilitation approach significantly improved the test frame's lateral strength and drift capabilities.

Hamid Farrokh Ghatte(2019):During earthquakes, brittle inferior columns are a common cause of structure failure. Since capacity design concepts and ductile detailing ideas were not sufficiently employed during construction of the bulk of existing buildings, seismic retrofitting is required for many of them. A prevalent problem, although not the only one, is a lack of ductility. Only a few experiments have looked at the behaviour of full-scale substandard columns in rectangular cross sections. The seismic response of filled inadequate columns with larger rectangular cross sections is examined in this work via experiment and theory. Once carbon fiber-reinforced polymer (CFRP) has been applied to the columns, they are tested.

Geetha M (2021): A few years ago, individuals were building buildings without a long-term vision and without adhering to the applicable building rules. In the modern world, individuals are increasingly looking for ways to expand their homes without having to destroy their old buildings, for both residential and commercial purposes. In India, urban sprawl is a major issue. This is a description of how the urban population is growing. It's becoming more difficult to buy property in metropolitan regions like Bangalore, Hyderabad, Mumbai or Chennai since the cost of land in these cities has risen so much in recent years. As a result, rather of acquiring new land, a floor is added to an existing structure to provide more living or working space. The goal of this project was to test a refurbishment plan for residential buildings. Developing a cost-effective and time-efficient strategy for remodelling, extending, and adding floors to existing apartment buildings was the project's goal. Studying alternative retrofitting approaches for any structure that has to be retrofitted is the subject of this current research, which examines soil structure interaction and the effects of seismic loads. Story drift, displacement, and shear were all measured for several retrofitting structures in various soil conditions and compared across the different structures. The linear static approach was used to analyse the G+5 storey structure. Steel jacketing, column jacketing, and steel bracing are some of the retrofitting methods used in this research. ETABS is the analytic programme of choice.

3. Module And Building Configuration

A reinforced concrete frame building with a located in zone II is studied in the first model. The building's plan area is 13 x 19 m, with each typical storey being 3m tall. It has 8 bays in the X direction and 10 bays in the Y direction.

The Plan configuration consists of

Model 1: R.C.C. Regular building G+5 design for gravity loads

Model 2: R.C.C. Regular building G+5 design for seismic loads

Model 3: R.C.C. Regular building G+5 design for seismic loads with retro fitting of column and beams

Columns- 230 mm x 300 mm

230 mm x 380 mm

230 mm x 450 mm

Beams- 230 mm x 300 mm

230 mm x 380 mm

230 mm x 450 mm

Slab thickness- 125 mm

Concrete grade- M25

Grade of steel - HYSD500

Building design code- IS 456-2000

The seismic data used for modelling are as below:

a. Seismic zone- II

b. Soil type- II

c. Response reduction factor- 3

d. Importance factor- 1

The load combinations considered are as given below.

a. 1.5(DL +LL)

b. 1.5(DL-EQX)

c. 1.2(DL+LL+EQX)

d. 1.2(DL+LL-EQX)

The plan and 3D view of the building used for the modelling is as below:

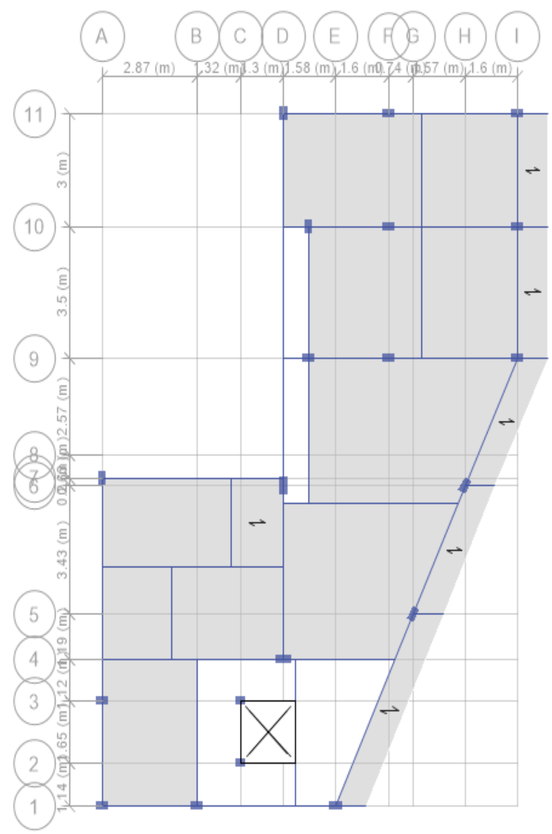


Figure 1: Plan view of G+5 storey building

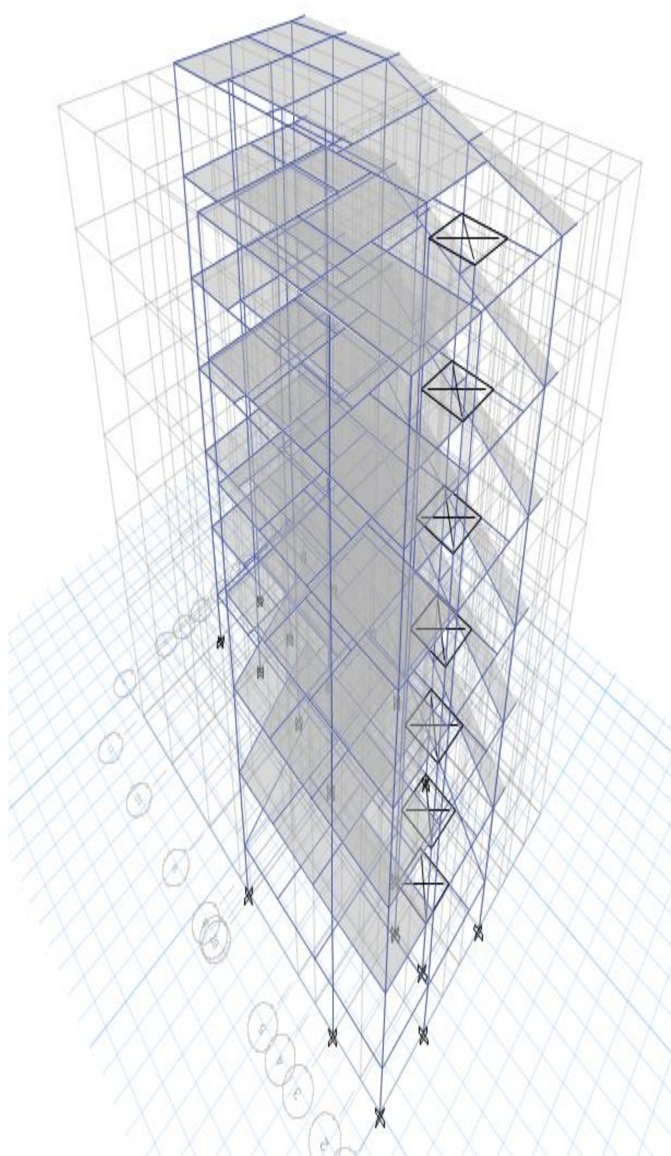


Figure 2: Isometric view of G+5 building

4. Methodology

The methodology adopted to conduct the study is as under.

a. A G+5 storey building is modelled and analyzed in ETABS software by linear static analysis.

b. The seismic loads in terms of axial load and moment are obtained from the analysis results. The concrete jacket is designed as per IS 15988:2013.

c. The concrete jacket section designed is modelled in ETABS using section designer for further study.

5. Results For Models

PERCENTAGE OF STEEL IN COLUMNS DUE TO GRAVITY LOAD 1.5 (DL+LL)

PERCENTAGE OF STEEL IN COLUMN FOR GRAVITY LOADS							
GRID	Story 6	Story 5	Story 4	Story 3	Story 2	Story 1	Base
1A	0.8	0.8	0.8	0.8	0.8	0.8	0.84
3A	1.11	1.21	1.51	0.8	0.84	0.84	1.4
5A	2.03	2.13	2.37	1.48	1.32	1.13	1.6
6A	1.86	2.01	2.16	1.68	1.55	1.38	1.68
B1	2.3	2.09	1.64	1.14	0.8	0.8	1.23
2C	0.8	0.8	0.8	0.8	0.8	0.8	0.82
3C	0.8	0.8	0.8	0.8	0.8	0.8	0.8
4D	2.74	2.49	1.89	1.29	0.8	0.8	0.99
6D	3.27	2.93	2.2	1.29	0.8	0.8	0.8
11D	0.8	0.8	0.8	0.8	0.8	0.8	0.8
1E	1.95	1.71	1.41	0.95	0.8	0.8	1.66
9F	1.98	1.32	0.8	0.8	0.8	0.8	0.8
10F	0.95	0.8	0.8	0.8	0.8	0.8	0.8
11F	0.8	0.8	0.8	0.8	0.8	0.8	0.8
5G	2.47	2.3	1.45	0.8	0.8	0.8	0.8
6H	1.57	1.43	0.94	0.8	0.8	0.8	0.8
9I	1.1	0.95	0.8	0.8	0.8	0.8	0.8
10I	0.99	0.8	0.8	0.8	0.8	0.8	0.8
11I	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Table 2: Percentage of steel for column with gravity load

PERCENTAGE OF STEEL IN COLUMN FOR LATERAL LOADS							
GRID	Story 6	Story 5	Story 4	Story 3	Story 2	Story 1	Base
1A	0.8	0.8	0.8	0.81	0.81	0.96	1.53
3A	2.84	3.07	3.42	2.44	2.37	2.16	2.69
5A	4.41	o/s	o/s	o/s	o/s	o/s	3.05
6A	4.07	4.25	4.41	3.73	3.33	2.94	3.03
B1	4.57	4.33	3.73	2.92	2.38	1.62	2.38
2C	1.8	1.66	1.08	0.97	0.89	0.8	1.67
3C	1.48	1.46	1	0.88	0.8	0.8	1.62
4D	5.28	4.75	4.06	3.12	2.39	1.69	2.29
6D	5.98	5.59	4.38	3.02	1.77	0.8	0.8
11D	0.8	0.8	0.8	0.8	0.8	0.8	0.8
1E	4.14	3.98	3.64	2.86	1.99	1.6	3.07
9F	3.35	3.04	2.16	1.33	0.8	0.8	0.8
10F	2.64	2.4	1.66	0.86	0.8	0.8	0.8
11F	1.95	1.6	0.93	0.8	0.8	0.8	0.8
5G	4.83	4.61	3.33	2.92	1.3	0.8	0.8
6H	3.47	3.27	2.69	1.82	1.35	0.82	1.46
9I	2.79	2.7	2.34	1.64	1.16	0.8	0.89
10I	2.67	2.49	2.07	1.32	0.8	0.8	0.85
11I	1.38	1.27	0.98	0.8	0.8	0.8	1.29

Table 3: Percentage of steel for column due to lateral load (1.5DL-1.5EQX)

PERCENTAGE OF STEEL IN RETROFIT COLUMN FOR LATERAL LOADS							
GRID	Story 6	Story 5	Story 4	Story 3	Story 2	Story 1	Base
1A	0.8	0.8	0.8	0.8	0.8	0.8	1.28
3A	1.84	2.02	2.26	1.53	1.25	0.85	1.74
5A	1.05	2.42	2.97	3.37	3.33	3.5	2.4
6A	0.96	1.18	2.19	2.66	3.04	2.56	2.75
B1	1.78	1.62	3.46	3.06	2.38	1.58	2.34
2C	1.5	1.3	0.8	0.8	0.8	0.8	1.54
3C	1	0.92	0.8	0.8	0.8	0.8	1.41
4D	2.29	1.97	1.93	2.59	2.06	1.37	1.9
6D	2.72	2.43	1.69	3.1	1.81	0.8	0.8
11D	0.8	0.8	0.8	0.8	0.8	0.8	1.8
1E	1.45	3.53	3.52	2.75	1.9	1.56	2.92
9F	3.3	2.99	2.11	1.28	0.8	0.8	0.8
10F	2.65	2.41	1.62	0.84	0.8	0.8	0.8
11F	1.96	1.6	0.93	0.8	0.8	0.8	0.8
5G	1.69	1.6	3.22	2.37	1.25	0.8	0.83
6H	3.29	3.06	2.46	1.59	1.07	0.8	1.08
9I	2.82	2.74	2.41	1.66	1.19	0.8	0.86
10I	2.69	2.13	1.34	0.8	0.8	0.8	0.83
11I	1.39	1.31	1.07	0.8	0.8	0.8	1.27

Table 4: Percentage of steel for Retro fitting column due to lateral load (1.5DL-1.5EQX)

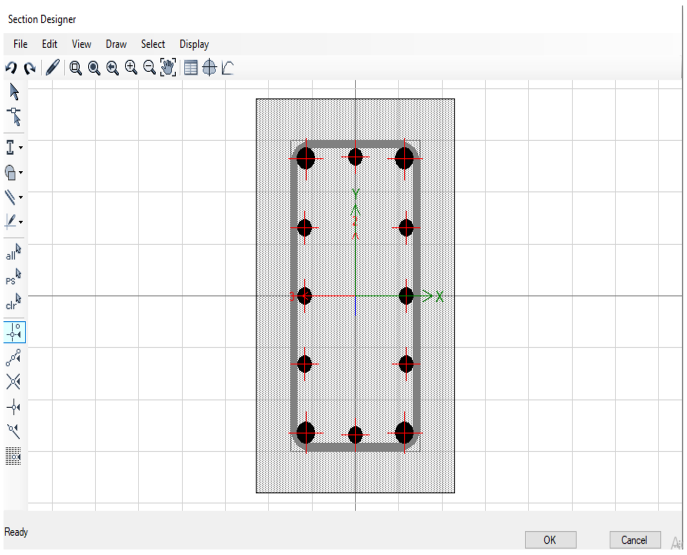


Figure 3: column (230 mmx300 mm) before retrofitting

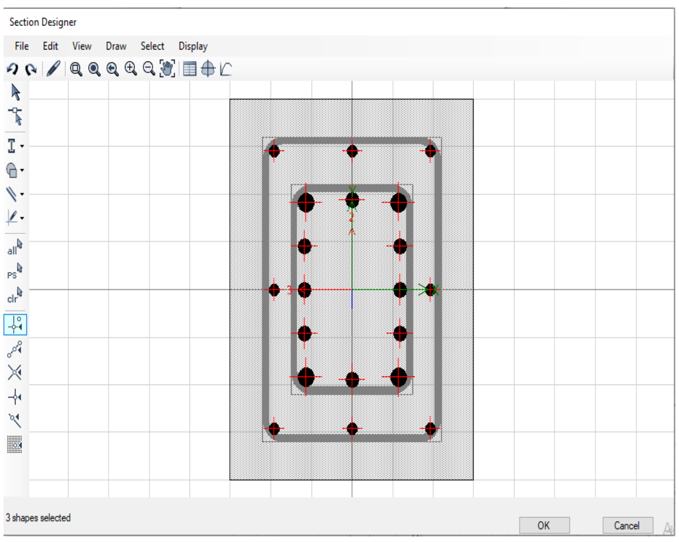
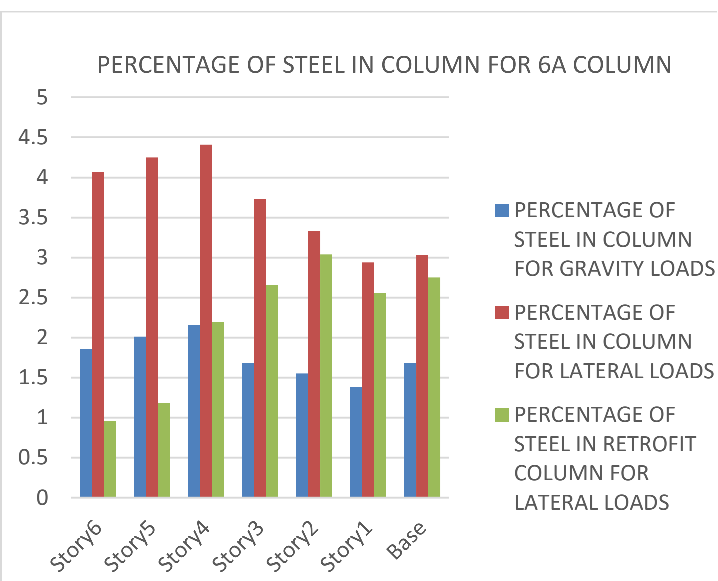
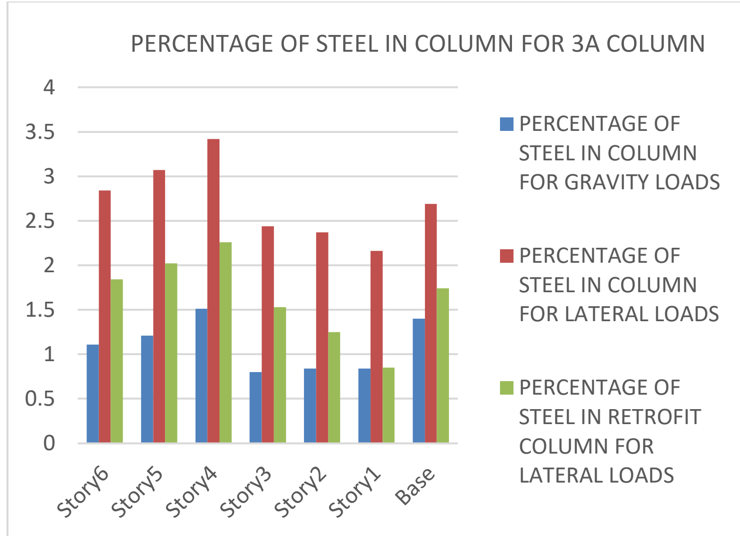
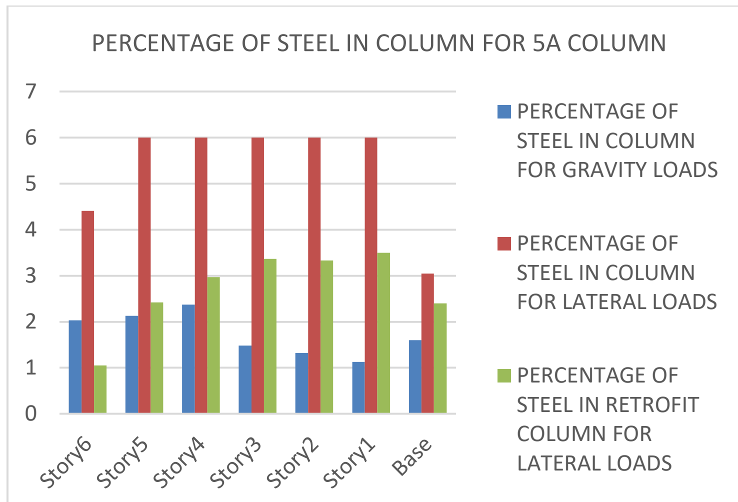


Figure 4: column (350 mmx450 mm) after retrofitting







6. Conclusions

• In India, the majority of existing and new RC frame structures were and are being planned without taking earthquake pressures into account. Building behaviour and failure mechanisms alter as a result of lateral stresses. This raises severe concerns regarding building earthquake safety.

• Redesigning beams and columns for seismic forces by jacketing them provides high ductility and increases strength carrying capacity and initial stiffness by up to three times when compared to building designs for gravity loads.

• Structural breakdowns in concrete columns owing to insufficient shear strength and inappropriate confinement spacing. As a result, column strengthening operations, such as column jacketing, are used to enhance column cross section.

• Nonetheless, concrete jacketing of concrete columns has been found to be quite efficient in enhancing strength and ductility, as well as transforming strong-beam weak-column buildings to strong-column weak-beam structures.

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