17th World Conference on Earthquake Engineering, 17WCEE
Sendai, Japan - September 13th to 18th 2020

SEISMIC PERFORMANCE COMPARISION OF COMMERCIAL BUILDING STRENGTHENED USING RC COLUMN JACKETING ON 2 AND 4 FACES

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Abstract

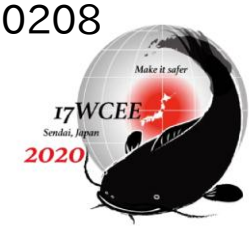
In India due to rapid economic development and establishment of new companies, many existing buildings were given permissions to raise the number of floors. This addition of new floors to the existing building will increase the loads on the columns which may not be designed for the additional load. Therefore, such columns need to be strengthened to carry the additional loads. RC jacketing is the most preferred strengthening technique to increase the load carrying capacity of the existing building.

In this paper, comparison of two RC buildings i.e., One with columns strengthened only on 2 faces and another with columns strengthened on all four sides with RC jacketing is presented. In 2-face RC jacketing, U shape stirrups are used and for 4-face jacketing closed stirrups are used.

Behavior of columns strengthened on all four sides using RC jacketing is more satisfactory in the case of immediate occupancy.

In case of high seismic zones under cyclic loading, the seismic performance of RC jacketed columns on 2 sides is not desirable for immediate occupancy.

Keywords: RC Jacketing; Closed stirrup; Immediate occupancy;



1. Introduction

To meet the infrastructural needs due to growing population in cities and major towns, the owners of the existing buildings are seeking permission to raise extra stories. The columns, beams of these buildings are to be strengthened for additional loads using concrete jacketing, steel jacketing or by using CFRP jacketing. Concrete jacketing is the most economical solution of the above-mentioned jacketing techniques.

A study is done to check the seismic performance of five floor commercial building when three additional floors are increased. Nonlinear static Pushover analysis is performed in SAP2000. The columns are failing when additional three floors are added to the existing five floor building. Two strengthening methods using concrete jacketing are proposed. The first method is to strengthen the rectangular columns on two sides using U stirrups and the other is to jacket the column on all the four sides.

The performance of the structure with two side concrete jacketed columns is compared with the performance of the structure with four side concrete jacketed columns in Indian seismic zones III, IV and V. Two sides jacketing for columns is mostly preferred due to cost and space constraint.

Our aim is to compare the seismic behavior of the building strengthened with columns jacketed on two sides and building strengthened with columns jacketed on four sides for immediate occupancy. The time required for the repair of structures after an earthquake for occupancy is compared.

2. Structural system and modeling

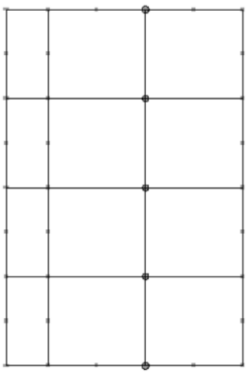


Fig. 1 – Plan of Building

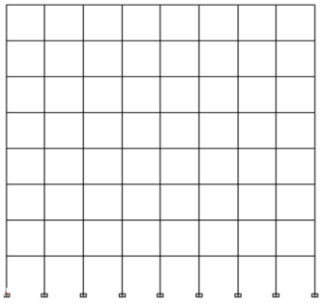


Fig. 2 – Elevation of Building

An existing five story RC moment resisting frame commercial building is considered for the present study. The building plan dimensions are 17mx25.7m. The height of each story is 3m and the total height of the 15m. The thickness of slab is 120mm and 16mm diameter bars are used as longitudinal reinforcement and 8mm bars are used for stirrups. HYSD reinforcement of grade Fe415 confirming to IS: 1786 is used in the building. The concrete compressive strength is 30MPa.

Rectangular columns of 250mmx300mm and circular columns of diameter 400mm are present in the existing building. Type II, Medium soil as per IS 1893(Part1): 2016. The walls are 230mm thick brick masonry walls. 4kN/m^2 is considered as live load. Importance factor I is taken as 1.5 and Response reduction factor R as 5.

Additional three floors are added to the existing building for the purpose of nonlinear static pushover analysis in SAP2000. For the study we are comparing two buildings, Building A with two side column jacketing and Building B with four side column jacketing in seismic zone III, IV and V. Linear analysis is run and 9 elements are failing. Three rectangular columns in ground and first floor are failing, three circular columns in ground floor are failing.

Building A rectangular columns of size 250mmx300mm are strengthened with 100mm concrete jacket on north and south side for ground and first floors. The total column dimension after strengthening is 450mmx300mm. U-stirrups are used to hold the additional longitudinal reinforcement and are drilled to the existing column for a depth of 75mm. The size of the new rectangular column is 450mmx500mm in Building B. Closed stirrups are used. Minimum number of bars in RC jacket according to clause 8.5.1.2b of IS 15988:2013 is 4 bars. Total 8 bars of 16mm diameter and 4 bars of 20mm are present in the new columns after strengthening.

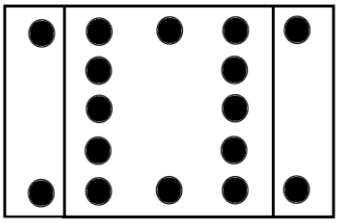


Fig. 3 – Two side jacketing

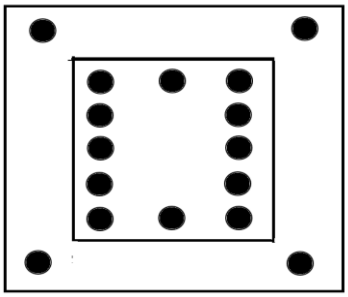


Fig. 4 – Four side jacketing

Table 1 – SAP2000 analysis values from Pushover Curve –P_y

Step	2 Sides			4 Sides		
	Displacement m	Base force kN	B to IO	Displacement m	Base force kN	B to IO
1	0.001007	425	26	0.000623	372	17
2	0.006196	664	199	0.000905	405	56
3	0.007466	713	253	0.003085	524	245
4	0.008079	751	275	0.003287	553	269
5	0.008165	784	295	0.003297	585	287
6	0.008399	801	303	0.003425	599	285

3. Example:

Percentage of steel = 2.4%

Area of steel = 3240mm^2

P_u = 2047 kN

M_u = 111 kN-m

V_2 = 52 kN

Table 2 – Manual calculations

Number of column sides jacketed	$\frac{P_u}{f_{ck}\,bD}$	$\frac{M_u}{f_{ck}\,bD^2}$	M_{u2} kN-m	$M_{u2,1}$ kN-m	M_{u3} kN-m	$M_{u3,1}$ kN-m	P_{uz} kN	α_n
Two	0.505	0.06	111	93	41	109	2757	1.9
Four	0.303	0.032	111	168	41	151	3439	1.65

The column interaction equation for two side jacketed column in Building A is more than 1.

The column interaction equation for four side jacketed column in Building B is less than 1.

This proves that Building A with 2 side column jacketing is not providing satisfactory seismic performance.

$$\left[\frac{M_{u2}}{M_{u2,1}}\right]^{\propto n} + \left[\frac{M_{u3}}{M_{u3,1}}\right]^{\propto n} = \left[\frac{111}{93}\right]^{1.9} + \left[\frac{41}{109}\right]^{1.9}$$

$$= 1.64 > 1$$

The column interaction equation for two side jacketed column in Building A is more than 1.

For Four Side Jacketing the interaction equation is

$$\left[\frac{M_{u2}}{M_{u2,1}}\right]^{\propto^n} + \left[\frac{M_{u3}}{M_{u3,1}}\right]^{\propto^n} = \left[\frac{111}{168}\right]^{1.65} + \left[\frac{41}{151}\right]^{1.65}$$

$$= 0.68 < 1$$

The column interaction equation for four side jacketed column in Building B is less than 1.

This proves that Building A with 2 side column jacketing is not providing satisfactory seismic performance.

4. Conclusion

The roof displacement of Building B with four sides jacketed columns is 0.0654 m and Building A with two sides jacketed columns is 0.0928m for Zone V. The column interaction equation for two side jacketed column in Building A is more than 1 and for four side jacketed column in Building B is less than 1. This proves that Building A with 2 side column jacketing is not providing satisfactory seismic performance. The seismic performance of Building B with 4 sides column jackets has good confinement effect and is more satisfactory in Seismic Zones III, IV and V.

5. References

References must be cited in the text in square brackets [1, 2], numbered according to the order in which they appear in the text, and listed at the end of the manuscript in a section called References, in the following format:

[1] IS 456:2000 Indian Standard Plain and reinforced concrete. Bureau of Indian Standards, New Delhi, India.

[2] IS 15988:2013 Indian Standard Seismic evaluation and strengthening of existing reinforced concrete building. Bureau of Indian Standards, New Delhi, India.

[3] IS 13920: 2016 Indian Standard Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces – Code of Practice (First Revision). Bureau of Indian Standards, New Delhi, India.

[4] IS 1893 (Part 1:2002): Indian standard Criteria for earthquake resistant design of structures. Bureau of Indian Standards, New Delhi, India.

[5] Hazem M.F. Elbakry, Ahmed M. Tarabia CA: Factors affecting bond strength of RC column jackets. *Alexandria Engineering Journal (2016) 55*.

[6] Nikita Gupta, Poonam Dhiman, Anil Dhiman: Design and Detailing of RC Jacketing for Concrete Columns

