SIESMIC RESPONSE OF R.C MULTISTOREYED BUILDING STRENGTHENED BY DUAL COLUMN FRAME SYSTEM

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Abstract - *Any Structure which is subjected to a seismic force should have sufficient strength to sustain against impending loads. Structures must prevent damages to the structural and also non-structural elements during excitation. In this work dual column frame system, to study under response of Linked Column Frame (LCF) system is used for Reinforced Concrete (RC) multistoried building. An LCF consists of links are connected between columns with link beam, the frame with hinged beam to column connection and rigid beam to column connection. The building with LCF system is analyzed using time history method of analysis. The links are connected to normal frame of the building to show that the inter storey drift, base shear and peak displacement are effectively reduced*

Keywords: Linked column frame, base shear, storey drift lateral loading, and seismic response.

1. INTRODUCTION

An earthquake is the vibration of surface of the earth, resultant from the rapid release of energy in earth's lithosphere that creates seismic wave (body waves and surface waves). Consequently, structures founded in ground vibrate, inducing inertial forces on them. The ground shaking may cause landslide, mudslides and also damages building and hurt people.

Shear walls have been successively to improve the seismic performance of R.C structure. But shear wall have some disadvantages like higher floor displacements, required more reinforcement, lateral load resistance strong only on few walls rather than on large number of column, etc. To overcome from this disadvantages the introduce on the use researchers presented their research on utilization of steel braces for concrete structures. The steel bracing system have disadvantages it not have a ability to give strength ,stiffness. It suffers from shortcoming as considered return to occupancy.

In 2007 Dusika and Iwai [1] was initially introduced the linked column frame system which consist of easily replaceable link beams between two columns closely. In 2012 M.Malakoutian et al [1] studied the behavior of 2D steel frame strengthened by LCF under seismic loading. The author also investigated LCF system and component behavior experimentally. In 2013 Alstair fussell [3] studied about design of LCF system with New Zealand application and modeled using E-tabs and analysis is done as pushover analysis. In 2014 Nabib Raj C and S Elavenil [2] studied on hybrid dual column frame structure under seismic loading by analytically, the dual column frame structure consist of dual column with steel bracing. In Waseem Khan et all [4] non linear analysis is done for tall structure b providing damper under seismic loading and concluded that by providing damper performance of tall building under seismic loading can be improved. In 2016 joel Shelton J et al [5,6] investigated on dual column frame system for seismic resistance of R.C frames experimentally using SAP2000 and concluded the R.C building can strengthened by providing LCF system. In 2017 Chiniju C Mathew, Anoop pp [8] studied the behavior of linked column frame by providing on both sides of the building with infill wall for multistoried R.C building.

In this study the behavior of R.C multistoried building strengthened by linked column frame system under seismic loading is analyzed as non-linear analysis by using E-tabs.

1.1 Linked column frame (LCF)

In linked column frame system (LCF), two columns are connected with replaceable links used in eccentrically braced frames with removable bolts in steel structure.

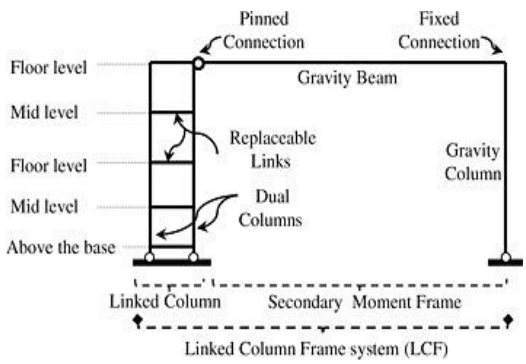


Figure 1: elevation of single bay two storey building with LCF [7]

In Concrete structure the concrete is used as link elements to resist shear and connected to columns to transfer the shear. LCF system components are gravity beam, replaceable links, gravity column, dual columns, Secondary moment frame, and Linked column.

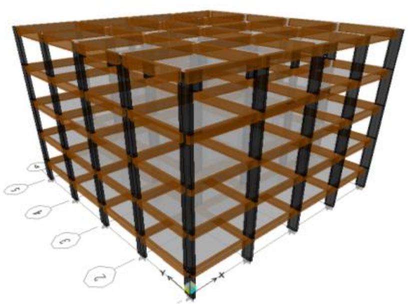
In the above LCF system gravity beam is connected to gravity column and linked dual columns. It doesn't takes any load expect dead load on it. The dual system means the new column is connected with other column of the structure with providing gravity beam on the floor heights with links between the columns with mid height of the of floor. The linked beams are designed as R.C members to resist shear.

2. METHODOLOGY

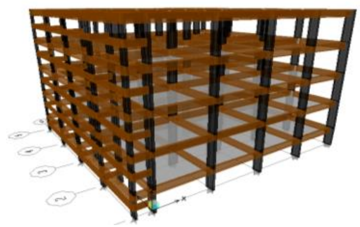
Lcf building with dual column spacing of 1.1m, 1.4, 0.85m and the lcf system is provided on both side of building and compared with their results obtained .The non-linear time history analysis done for all different types of models are done. The results are compared with both LCF and non LCF model for 4, 7, 10 story's. Procedure adopted is as follows.

1. Selection of building plain
2. Creating of building 2D and 3D centerline frame.
3. Material property to be defined.
4. Define section property of beam and column.
5. Slab section should be defined.
6. Static load cases should be assigned.
7. Load pattern as dead load to be assigned.
8. Earthquake load cases should be assigned.
9. Load pattern as dead load to be assigned.
10. Analysis is done.
11. Analysis results such as absolute displacement, base shear and peak acceleration should be compared.

The modeling of the building models are shown in figure1 to figure4.

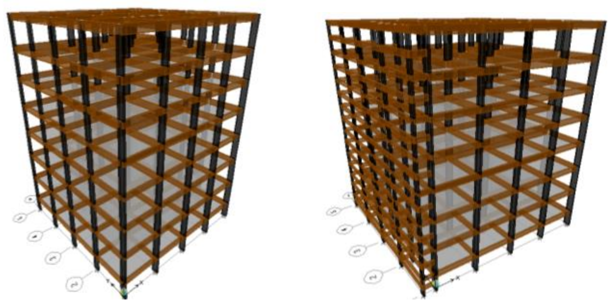


(a)



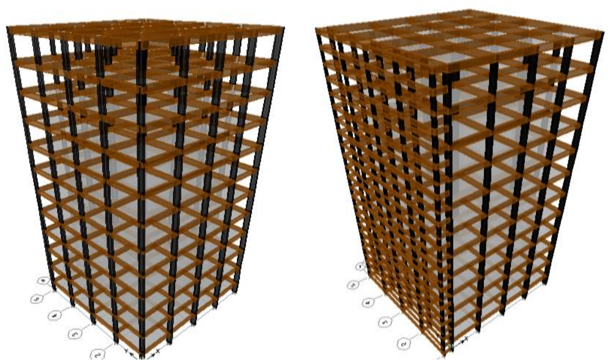
(b)

Figure 2. 3D view of 4 storey building. (**a)** normal frame. **(b).** link column frame.



(a) (b)

Figure 3. 3D view of 7storeyed building. (**a)** normal frame. **(b)** linked column frame.



(a) (b)

Figure4 . 3D view of 11 storeyed building. (**a)** normal frame. **(b)** linked column frame.

The details of the buildings are given below.

- In x, direction bay length : 4m.
- In y, direction bay length : 4m.
- In z direction bay length : 3m.
- Size of beam : 0.2m x 0.4m.
- Size of column: 0.2m x 0.4m.

- Depth of slab : 0.12m.
- Size of linked beam : 0.15m x 0.3m.
- Size of linked column : 0.15m x 0.3m.
- Linked column spacing in LCF : 1.1m.

3. RESULTS AND DISCUSSION

In this study the seismic response of the LCF in reinforced concrete building has been accomplished by non linear time history analysis is done R.C structures. Time history is carryout as per IS 1893 (part1) 2002 and on the basics of real EQ values before happen, in this the earthquake values are obtained as per every minute seconds that happen and damages in building for that EQ on that time. The results are tabulated in the form of peak displacement, base shear and maximum top story drift for both LCF building and for also NON-LCF building.

3.1 Peak displacement

The maximum value of the peak displacement at top story of model-1 to model-15, normal frame and linked column frame building with link 1.1m,1.4m, 0.85m and linked column frame on both sides of the building with link spacing 1.1m for earthquake valley load is given in below table(1). From the above obtained results it can be observed that for earthquake load case the peak displacement are effectively reduces by 43% compared to normal frame when linked column frame with link spacing 1.1m is provided for 4-storey, for 7-storey linked column frame with link spacing 1.1m the peak displacement are reduces by 34.8%, for 11 storey linked column frame with spacing 1.1m the peak displacement are reduced by 38.6% when linked column frame are provided compared to normal frame.

Table -1: peak displacement

Storey	Displacement for normal frame (mm)	Displacement for Link column frame (mm)	% of reduction
G+4	5.860	2.5198	43%
G+7	3.5602	1.2461	34.8%
G+11	2.550	0.960	38.6%

Figure 5 shows comparison of link column frame with normal frame with respect to peak displacement for four, seven and eleven storey buildings.

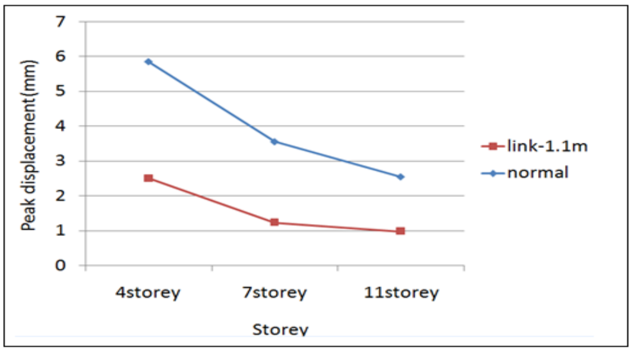


Figure 5: Storey v/s displacement for normal frame and LCF (7).

3.2 Peak accelerations

The maximum values of acceleration for 4storey, 7storey, 11storey, with and without link column frame are tabulated below in table (2). It is observed that by providing link column frame with link spacing 1.1m for 4-storey reduces peak acceleration by 48.5% compare to normal frame, and for 7-storey increases by 1.4% compare to normal frame, and for 11-storey reduces by 38.3%compared to normal frame.

Table -2: peak accelerations

Storey	Acceleration for normal frame (mm/s^2)	Acceleration for link column frame (mm/s^2)	% of Increment and reduction
G+4	672.3	332.71	48.5%
G+7	728.7	731.46	⇧ 1.4%
G+11	624.5	374.12	38.3%

Figure 6 shows comparison of link column frame with normal frame with respect to peak acceleration for four, seven and eleven storey buildings.

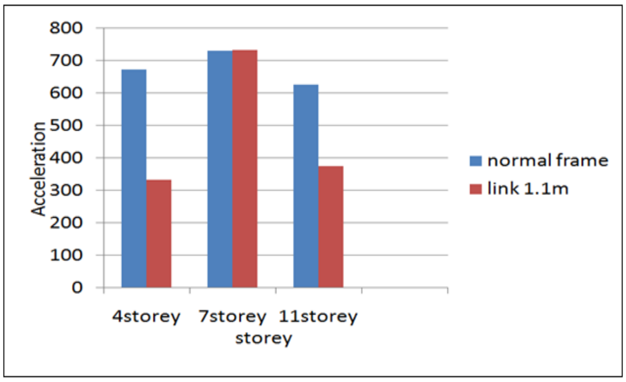


Figure 6: Bar chart for normal frame and link column frame

3.3 Storey drifts

In graph shows the maximum story drift for normal and dual linked column frame building values are obtained. In graph the compare linked column frame with normal frame with respect to story drift for 3, 7, and 11 storey building. The story drift are successfully reduced when link column frame are provided for the same building.

Table -3: Storey drift

Storey	Storey drift for normal frame	Storey drift for link column frame
G+4	0.0006728	0.0004852
G+7	0.0004261	0.0003150
G+11	0.0003730	0.0001370

Figure 7 shows comparison of link column frame with normal frame with respect to peak acceleration for four, seven and eleven storey buildings

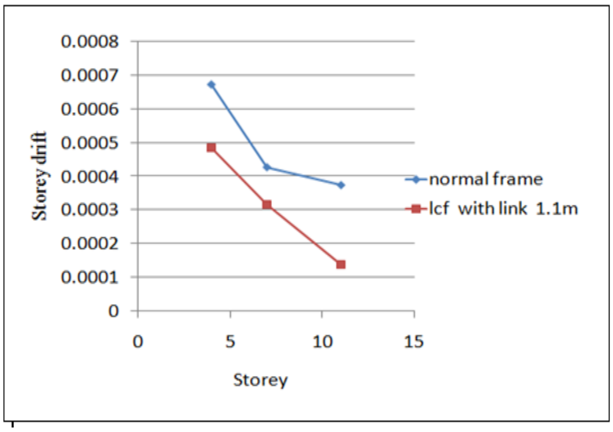


Figure 7: Storey v/s drift for normal frame and link column frame

3.4 Base shear

The maximum value of the base shear for 4storey, 7storey, 11storey, with and without linked column frame are tabulated below in table and the charts are plotted for obtained base shear values for all storeys of the same building. It can be observed that base shear is effectively reduces by 43.87% for 4storey by providing link column frame with link spacing 1.1m compared to normal frame. Base shear for 7storey link column frame building with link 1.1m is reduces by 7.32% compared to normal frame and for 11storey link column frame building with link 1.1m is reduces by 38.3% compared to normal frame building.

Table -4: Base shear

Storey	Base shear for normal frame (KN)	Base shear for linked column frame (KN)	% of reduction
G+4	422.49	239.84	43.87%
G+7	422.49	423.52	7.32%
G+11	673.20	415.36	38.3%

Figure 8 shows comparison of link column frame with normal frame with respect to peak acceleration for four, seven and eleven storey buildings

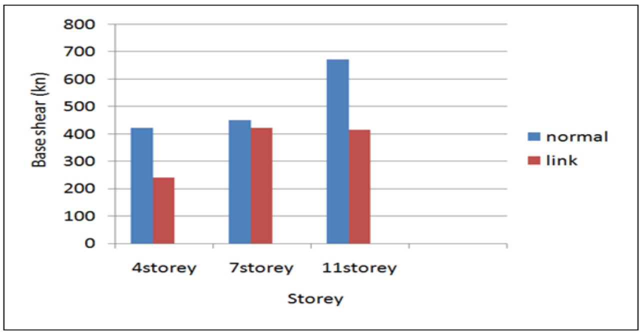


Figure 8: Bar chart for normal frame and link column frame

4. CONCLUSIONS

The investigation carried on dual column frame system with link for seismic resistance of R.C multi-storeyed building the following conclusions is drawn.

- Seismic performance of the reinforced concrete building can be improved by providing LCF.
- Peak displacement for 4-storey 43% are effectively reduced , for 7-storey 34.8% are reduced and for 11-storey 38.6% are reduced for seismic loading by provided linked column frame with linked column spacing 1.1m for RC building.
- Base shear are also reduced by LCF compared to normal frame building.
- Storey drift are be reduces by providing LCF for building.
- This method can be effectively used as rehabilitation of existing structures that are not designed to resist seismic forces.
- Peak acceleration for 4-storey 48.5% are reduced, for 11-storey 32.4% are reduced by providing lcf with linked column spacing 1.1m.

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Codes and guidelines

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[10] IS: 875 (part 1-part 5) 1987: imposed load, dead load, wind load, special loads and load combinations.

[11] IS: 456 2000: Design of plan and reinforced concrete structures.