Progressive Collapse of RCC Structure Due to Earthquake and Wind Load

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Abstract - *This paper discuss the progressive collapse analysis of RC frame building by removing different column one at a time as per the GSA guidelines. Building consists of 3 X 3 bays of 5 m in both direction and designed by Indian code as a special moment resistant frame. Structural model of building has been created in ETABS and loads are applied as per GSA guidelines, for evaluation of progressive collapse linear static method of analysis and nonlinear static method of analysis have been used. As per GSA guidelines, removal of three columns one at a time is studied, for Corner column, Exterior column and interior column at ground floor. For all three cases both linear and nonlinear analysis have done and DCR ratios are evaluated. Member having DCR ratio greater than 2 fails for corresponding column removal case. It is observed that shear in beam is not critical in any case, Columns are also not critical in Progressive collapse. But by Linear static analysis and nonlinear static it is observed that beams are going to fail in flexure.*

Key Words: GSA, collapse, wind, earthquake, RCC, DCR

1. INTRODUCTION

Rapid urbanization and unavailability of space across world is resulting in increasing of construction of multi-story buildings. Multi-story buildings are susceptible to damage due to sudden impact, earthquake, explosions, fire, blasts, design or construction error, overload due occupant misuses, vehicular collision etc, unless they are adequately considered in design and analysis. Moreover, such building undergoes progressive collapse leading to the failure of whole structure. Progressive collapse refers to the failure of one or a group structure load carrying members that gives rise to a more widespread failure of the surrounding members and partial or complete structure collapse. The perimeter columns of the ground floor of a RC frame are generally more vulnerable to accidents, which could lead to an initial local failure. Such a failure may spread throughout the entire structure and result in disproportionate or overall structural failure.

Many accidental and intentional events, such as false construction order, local failure due to accidental overload, damage of a critical component by earthquake and explosion could induce the progressive collapse of structure. Because of the high peak, short duration and negative phase of blast load, the progressive collapse induced by an explosion is very different from that by earthquake ground excitation. Progressive collapse is a complicated dynamic process where collapsing system redistributes the loads in order to prevent the loss of critical structural members, beam, column, and frame connections must be designed in a way to handlev the potential redistributes of large loads. Many practicing engineers and academic researcher have engaged in the prevention of progressive collapse since the progressive collapse of Ronan point apartment building in 1968. The progressive collapse of Alfred P.Murrah Federal Building and world Trade centre, researchers are more focused than ever on constructing building safer from progressive collapse..

1.1 CAUSES OF PROGRESSIVE COLLAPSE-

A number of potential abnormal load hazards, which could trigger progressive collapse, are
given below:

1. Gas Explosions
2. Bomb explosion (Blast load)
3. Design or Construction error
4. Fire
5. Overload due to occupant misuse
6. Vehicular collision
7. Aircraft Impact
8. Transportation and storage of hazardous materials

1.2 PROBLEM STATEMENT

The important guideline general service administrative (GSA) criteria for analysis for progressive collapse are studied. The codal provisions for earthquake point of view is IS 1893(Part1):2002 and wind point of view is IS 875(Part-III):1987 are here study. This research aims to study the disproportionate collapse of RC building by removing ground storey columns at different location and to find out critical column location vulnerable to progressive collapse. The problem statement is drafted as below: - removal of columns at different location and compare the development of forces and displacements due to earthquake and wind loading and identified the critical column location in building which are most vulnerable to progressive collapse.

1.3 Model Data

Table No 3.1 Model Data

Types of Structure	OMRF
No. Of stories	G+7
Storey Height	
-Ground floor	4 m
-Upper floors	3.5 m
Material property	

-Grade of concrete	M25
-Grade of Steel	Fe 415
Member Properties	
-Thickness of slab	0.150 m
Beam Size	0.23 x 0.45 m
Column Size	0.3 x 0.3 m
Height of building	28.5 m
Dead load	3.75 KN/M2
Live load	3 KN/M2
Seismic Zone	II
Location	Bangalore
Seismic Zone	III
Location	Nagpur
Seismic Zone	IV
Location	Darbhanga

1.4 MODELLING

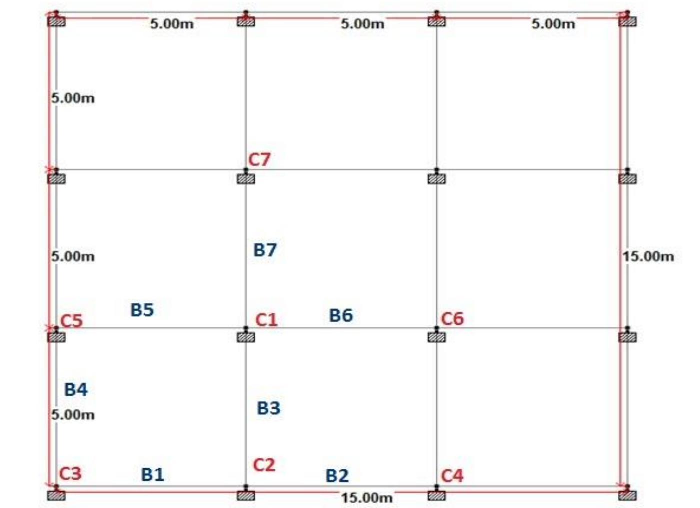
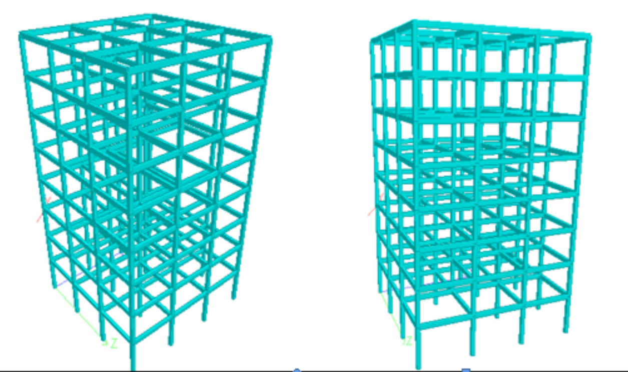


Fig -1: Name of the figure

1.5Load Combination (used in etab)

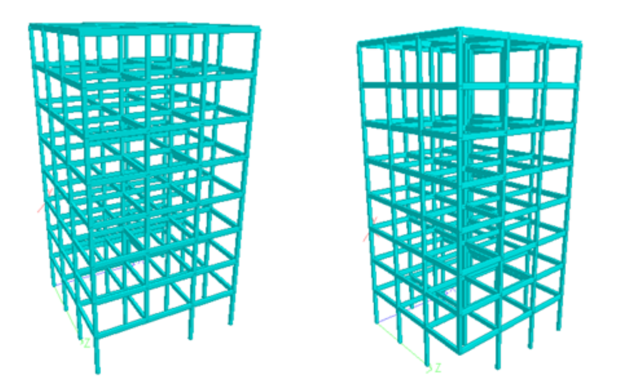
1) DL
2) LL
3) WIND-X
4) WIND-Z
5) SEISMIC-X
6) SEISMIC-Z
7) 1.5 (DL+LL)
8) 1.2(DL+LL+WIND-X)
9) 1.2(DL+LL+WIND-Z)
10) 1.2(DL+LL-WIND-X)
11) 1.2(DL+LL-WIND-Z)
12) 1.2(DL+LL+SEISMIC-X)
13) 1.2(DL+LL+SEISMIC-Z)
14) 1.2(DL+LL-SEISMIC-X)
15) 1.2(DL+LL-SEISMIC-Z)
16) 1.5(DL+WIND-X)
17) 1.5(DL+WIND-Z)
18) 1.5(DL-WIND-X)
19) 1.5(DL-WIND-Z)
20) 1.5(DL+SEISMIC-X)
21) 1.5(DL+SEISMIC-Z)
22) 1.5(DL-SEISMIC-X)
23) 1.5(DL-SEISMIC-Z)
24) 0.9(DL)+1.5(SEISMIC-X)
25) 0.9(DL)+1.5(SEISMIC-Z)
26) 0.9(DL)-1.5(SEISMIC-X)
27)0.9(DL)-1.5(SEISMIC-Z)

Column removing location



Model without column removal

Model with internal column removal



Model with side column removal

Model with corner column removal

Procedure

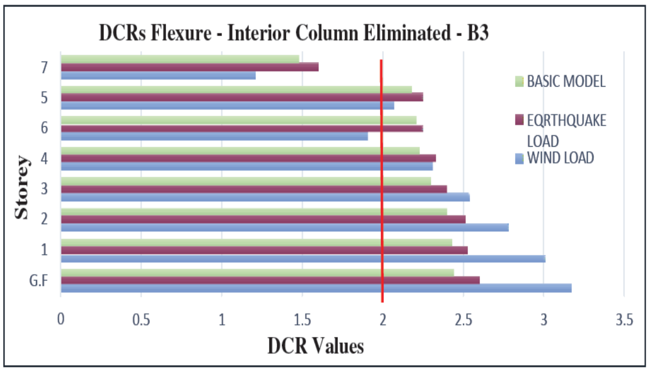
All the selected building models with different configuration are analysed using ETAB software. This chapter presents the analysis results and relevant discussions. According to the objectives of the present study, the results presented here are focused on DCR values, Displacements, axial forces, Moments and finding the critical column location for different types of building models. The details of the all models are discussed and Modal analysis procedure is explained in General Service Administrative (GSA) Analysis of G+7 storied RC frame for twenty-eight models by removing column at different location is done using ETAB software, from the analysis results obtained and comparison has been made for different models in different earthquake zone and different wind load cases considering various parameter like DCR ratio, storey displacement, moment and axial force. Columns at ground storey are removed by considering guideline provided by General Service Administrative (GSA) criteria for progressive analysis. Earthquake forces are applied using IS 1893 (PART-1): 2002 code and Wind forces are calculated using code IS-875 (PART-3).For calculation of forces, moments and displacement, load case is used which gives maximum value among all load cases given in codes.

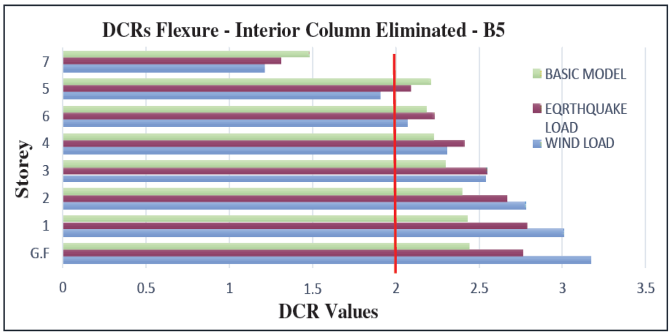
RESULT AND DISCUSSION

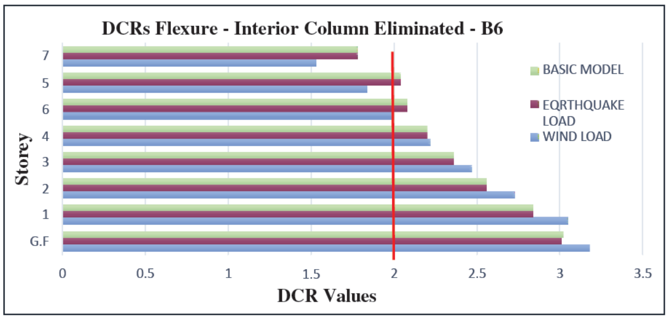
Result obtain from analysis are shown in table form and from result graph has been plotted by considering various parameter.
Description of models:
Model 1: represent G+7 RC building and analysis is done without removal of column.
Model 2: represent G+7 RC building and analysis is done by removing internal column.
Model 3: represent G+7 RC building and analysis is done by removing side column.
Model 4: represent G+7 RC building and analysis is done by removing corner column. Basic model: represent RC frame with Dead load and Live load without applying any lateral forces.

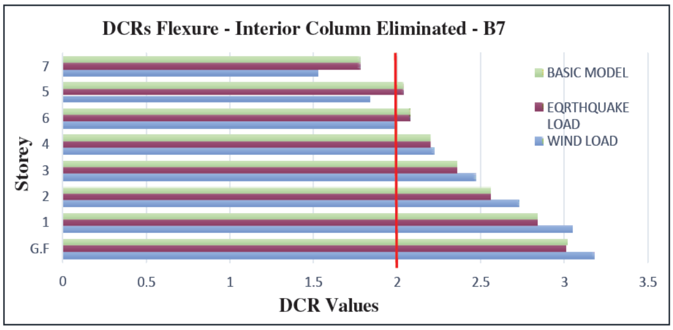
DCR VALUE (MOST AFFECTED COLOUMN)

INTERNAL COLOUMN

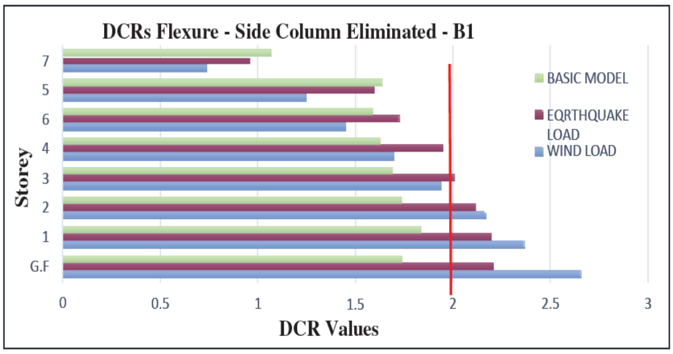


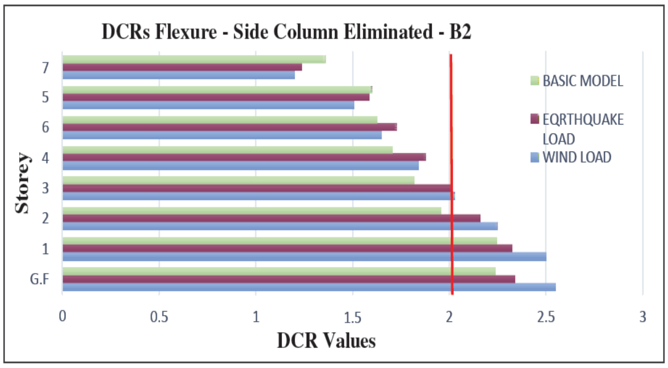


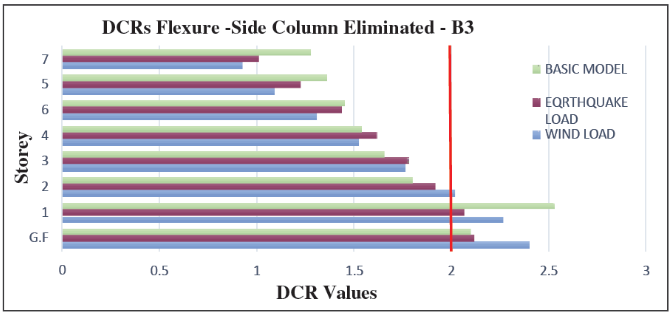




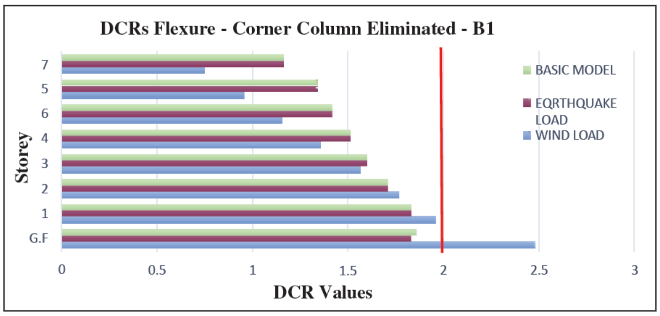
SIDE COLOUMN

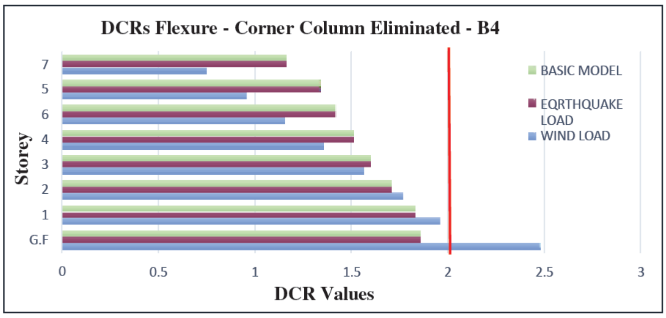






CORNER COLUMN





CONCLUSIONS

From results, it is cleared that ground storey internal column are more vulnerable to progressive collapse as compare to side column and corner column. Shear walls can be used as a primary vertical load carrying element. In comparison Earthquake load case is less predominant than wind load case. Twenty-eight models are analyzed using standard ETAB software. The analysis outputs were noted in terms of axial forces, displacements, DCR value and moment. Based on the work carried out following point-wise conclusions are made:

1. Ground storey columns are more vulnerable to progressive collapse.

2. DCR values are more for Wind load case as compare to Earthquake load and Basic model

3. DCR value for beams when internal column eliminated are much higher as compare to side column and corner column removal.

4. The Absolute displacement is the maximum in case of corner column removal i.e. in model 4 among all the other three models in both Earthquake and Wind load cases.

5. The Absolute displacement in Wind load case is more when compared to earthquake load.

6. Axial force, shear force and bending moment values are maximum in case of removal of interior column C1 in different Earthquake zone and for different Wind speed.

7. Axial force and bending moment are the maximum for Wind load case as compare to Earthquake load and Basic model.

8. Maximum value of Bending Moment after removal of interior column C1 exceed 23% and 20% when compared to C2 and C3 respectively in Earthquake load case.

9. Maximum value of Bending Moment after removal of interior column C1 exceed 34% and 60% when compared to C2 and C3 respectively in wind load case.

10. Internal column C1 is found to be more critical than side column C2 and corner column C3.

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