IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X
PP 67-70
www.iosrjournals.org

Progressive Collapse Potential of Irregular Concrete Building

B. Gururaja[1], R. Sridhar[2]
[1]*CivilDepartment, East West Institute of Technology, Karnataka, India*
[2]*Civil Department, Alva's Institute of Engg. & Technology, Karnataka, India*

ABSTRACT: *The progressive collapse of building structures is initiated when one or more vertical load carrying members are removed. Once a column is removed due to a vehicle impact, fire, earthquake or any other man-made or natural hazards, the weight of the building transfers to neighboring columns in the structure. The present study investigates the vulnerability to progressive collapse of mid-rise RC framed buildings of complex structural configuration. Following the GSA (2003) Guidelines the potential for progressive collapse of structures is assessed using the linear static analysis procedure in the so called "missing column" scenarios. The Linear static analysis is carried out using software ETABS V9.6 for building which is designed for ductile standards to resist earthquake in seismic Zone II.*

Keywords: *Ductile, linear static analysis, progressive collapse, potential, Structural configuration.*

I. INTRODUCTION

Progressive collapse mechanisms have two different modes. The first mode demonstrated by releasing support that leads to spreading failure to the above members. The second mode is demonstrated by failure at high levels that cause debris loads which trigger dominion mechanism[1]. On the other hand, investigations on buildings collapsed under the effect of earthquake have different failure mechanisms. The earthquake failure mechanisms involve lateral sway of the buildings and then the building could collapse under its gravity loads. The spreading of failure as in first mode depends on the geometry and beam spans which has been evident in the present study results.

GSA Guidelines

The General Service Administration (GSA) analysis includes removal of one column at a time from the storey 1 above the ground floor. GSA provides criteria for column removal for static analysis case. According to that a column is removed as mentioned below for typical structures.
Exterior Column in the middle of longer side of building
Exterior column in the middle of shorter side of the building
Corner column
But in the present study the building considered is atypical structure and has an irregular/asymmetric plan and bay size. Hence GSA suggests, an engineering judgment is to be done along with the above mentioned column removal cases and additional critical locations for removing column for analysis are to be decided[3].

Acceptance criteria

DCR = Qud / Q_{CE}
where, DCR = Demand Capacity Ratio, Q_{UD} = Acting force (demand) determined in component or connection/joint (moment, axial force, shear, and possible combined forces)
Q_{CE} = Expected ultimate, un-factored capacity of the component and/or connection/joint (moment, axial force, shear and possible combined forces). The allowable DCR value for primary and secondary structural elements is < 1.5 for atypical structural configurations, members exceeding this value are considered to be failed.

II. DESIGN OF STRUCTURES

The 12-story building considered consists of irregular geometry with atypical structural configuration have the same 3D configuration, as illustrated in Fig. 2.1. L shaped block – consists of 12 storey with total height 43.6 m and rectangular minor block (Portion C) – consists of 7 storey with total height 25.6 m. Floor height ground floor 4 m and typical floors 3.6 m. Plan of building in Y – Direction (south- north) 75 m length (portion A), X – Direction, (east- west) 57 m lengths (portion B). Widths of the portion A of building is 24 m along X direction and width of portion B of building is 21 m along Y direction.

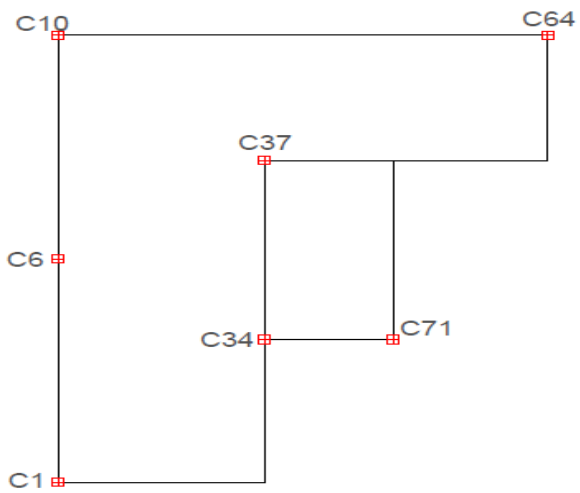

Figure 1.1: Top view of building showing columns removed for progressive collapse analysis one at a time.

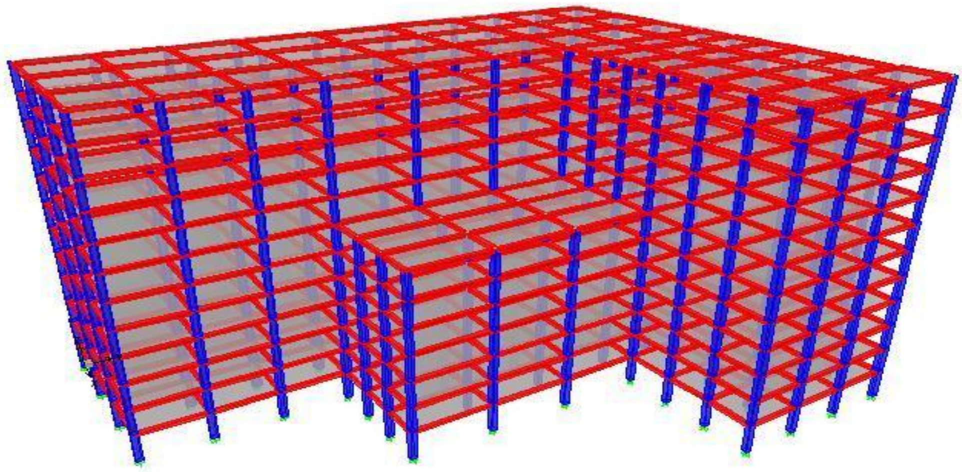

Figure 2.1. Geometry of structures

The minor rectangle (portion C) is 30 m X 15 m in plan consists of 10 m bays in Y direction and 5 m bays in X direction with 3 bays each. In both the direction building contains varying bay distances between column as 10 m,7 m, 8 m, 6 m, 5 m. Beams are maintained uniform in size (500 x 400 mm), column sections are reduced towards top storey as per design from 1m X 1m sections to 0.7m x 0.5m.

The design of structure is made in order to include the ideal geometric irregularity[7]. The Special Combination and the Fundamental Combinations of loads, taken into account in design is 2DL + 2SDL+ 0.5LL + 1EQX and for analysis 2(DL + 0.25LL), where DL is dead load. SDL is super dead load (imposed uniform load on beams), LL is live loads and EQX is earthquake loads[6]. Material properties are reinforced concrete of M25 grade[4], reinforcing steel Fe415 grade, concrete modulus of elasticity = 5000√fck and poisons ratio = 0.2. Loads on beams are taken from brick masonry wall considered as 17 KN/m and on roof 7 KN/m and slab loads are 4 KN/m^2 and floor finishes of 1.5 KN/m^2

III. PROGRESSIVE COLLAPSE ANALYSIS

The DCR values for flexure and axial forces are determined at column faces and axis at minimum eccentricity respectively. The progressive collapse analysis is performed for all the seven damage analysis cases (C1, C6, C10, C34, C37, C64 and C71). Only the results of the case C64 (causing max damage) - are detailed in this paper. Other cases showed similar results.

IV. RESULTS

Flexural DCR values for column show that beams having 10 mtr spans fail in all damage cases. Table 5.1 shows the total number of beams failing in progressive analysis and figure 5.1 shows the intensity of collapse spread in each storey

Table 5.1

No. of beams failing for C64 column removed	
STOREY	DUCTILE FRAME
1	70
2	100
3	93
4	93
5	81
6	33
7	26
8	23
9	36
10	12
11	11
12	18
Total	596/1422

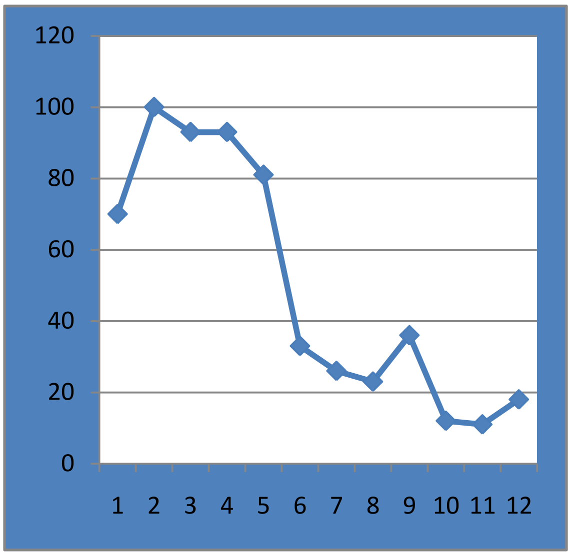

Figure 5.1: No. of Beams Failing in each storey

In the analysis column DCR values calculated showed columns failing only when columns C1, C10 and C64 were removed for remaining damage analysis case all columns DCR values were below allowable value and safe. It is observed from results of axial DCR's in ductile frame that columns are failing only in top storey (11th and 12th storey) where the cross section of column decreases. For C64 and C10 columns removal a total of 34 columns fail in all storey, for C1 damage analysis columns C2, C3, C4 and C5 shows failure.

V. CONCLUSION

Building analyzed is highly susceptible to collapse and have very high potential to progressive collapse. 39 % of beams fail under flexure and spread of failure is concentrated towards long span beams in all storeys. DCR values obtained show random response of damage for all seven column damage analysis considered. Columns are failing only in top storey where there cross section is reduced and can be overcome by revising the design. Spread of damage in beams is random in the buildings having irregular geometry.

REFERENCES

A.Marchis, M. Botez & A.M. Ioani. "Vulnerability to Progressive Collapse of Seismically Designed Reinforced Concrete Framed Structures in Romania". 15 WCEE LISBOA 2012.

General Service Administration. "Progressive Collapse Analysis and Design Guidelines for New Federal Office Buildings and Major Modernization Projects", June 2003.

G.Sukanya1, Dr.C.Natarajan2, Dr.A.Rajaraman. "Progressive Collapse Analysis of RC Beams". IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE e-ISSN: 2278-1684 Volume 5, Issue 4 (Jan. - Feb. 2013), PP 55-67.

IS 456:2000, "Code of practice for plain and reinforced concrete"(Fourth Revision).

IS: 875 (Part 1) – 1987. "Code of practice for design loads (other than earthquake) for buildings and structures" part I & part II (Second Revision) (Incorporating IS: 1911-1967), (Reaffirmed 1997) Edition 3.1, (1997-12) Indian Standard.

IS 1893:1987. "Criteria for earthquake resistant design of structures". Part1 general provisions and buildings - (Fifth Revision) Indian Standard.

Miss. Preeti K. Morey, Prof S.R.Satone. "Progressive Collapse analysis of building" /International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 4, June-July 2012, pp.742-745 742 Page.