PROGRESSIVE COLLAPSE ANALYSIS OF RCC FRAMED STRUCTURE SUBJECTED TO COLUMN FAILURE.

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Abstract: *This paper presents the progressive collapse analysis on the framed building structures. Progressive collapse failure starts with a local damage which extends up to the whole structure. The static linear method and (pushover analysis) non-linear static method is used to carry out progressive collapse analysis. In the static linear analysis, Demand Capacity Ratios (DCR) for the various floor levels are calculated considering the column removal scenarios according to the GSA guidelines. Following to which, Pushover analysis is carried out for the three column removal scenarios. The hinges formation at various displacement levels are studied and compared with the DCR values.*

Keywords: Progressive collapse, local damage, static linear analysis, pushover analysis, DCR.

I. INTRODUCTION

The collapse of one or more structural elements may lead to Progressive Collapse of a part or the whole structure. According to General Service Administration (GSA) 2013 guidelines, Progressive Collapse is defined as an extent of damage or collapse that is disproportionate to the magnitude of the initiating event. The progressive collapse initiates, when one or more load carrying members are removed. It is a chain reaction of failures that disseminates either throughout the entire structure or a portion of the structure which is disproportionate to the original local failure. The collapsing structure seeks for an alternative load path continuously, in order to survive.

Progressive Collapse has an important characteristics that the final damage is disproportionate to the initial local damage. However, the traditional designs do not take into account the extreme loading conditions that may provoke progressive collapse. The progressive collapse grabed attention of the structural engineers after the accidental collapse of the Ronan Point tower in Canning Town, UK on May 1968. The collapse caused due to gas explosion that knocked out the precast concrete panels near the 18th floor leading to the collapse of floors above.

II. OBJECTIVE OF THE WORK

In this project, the following aspects are attempted to study.

1) To design a RCC framed structure.

2) To analyze the structure by Linear static method and Non-linear static method.

3) To perform analysis of structure with removal of critical elements.

4) To determine the potential for progressive collapse.

5) To compare the results obtained.

III. MODEL DESCRIPTION

The building for the study is five story asymmetrical R.C. building. Typical floor-to-floor height is 3m. Wall having 150 mm thickness is considered on all the beams. Slab thickness considered is 125 mm. Beam size is taken as 230 × 450 mm. Column size of 230 × 450 mm is considered for C1 to C6 and C13 to C18. Column size of 230 × 600 mm is considered for C7 to C12.

Loading considered on the building for the study are as follows.

- Dead load

Self-weight of the structural elements

Floor finish = 1.5 kN/m^2 and Wall load on all beams is 7.65 kN/m

- Live load

On roof 2 kN/m^2, and on floors 3.0 kN/m^2

- Seismic loading as per IS:1893

Zone III,

Soil type II

Importance factor 1

The characteristic compressive strength of concrete (fck) is 20 N/mm^2 and yield strength of reinforcing steel (fy) is 415 N/mm^2. Analysis and design of building for the loading is performed in ETAB. One five story building is designed for seismic loading in ETAB according to the IS 456:2000. Based on the reinforcement, Demand capacity ratio is calculated

3.1 Model Details G+5

The space frame building is modeled in ETAB.

Beam Size: 230 X 450 mm

Column Size: 230 X 450 mm

230 X 600 mm

Slab Thickness: 125 mm

Storey Height: 3m

Grade of concrete: M20

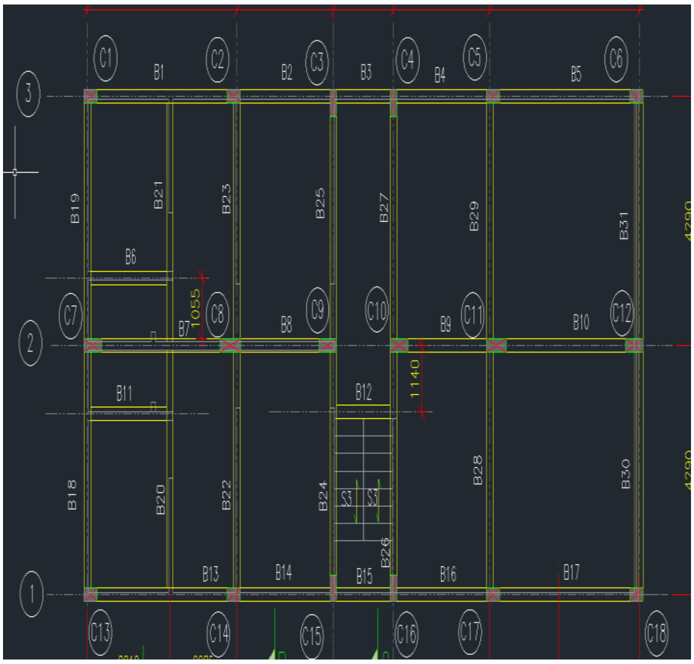

Fig.3.1 Model in AutoCAD

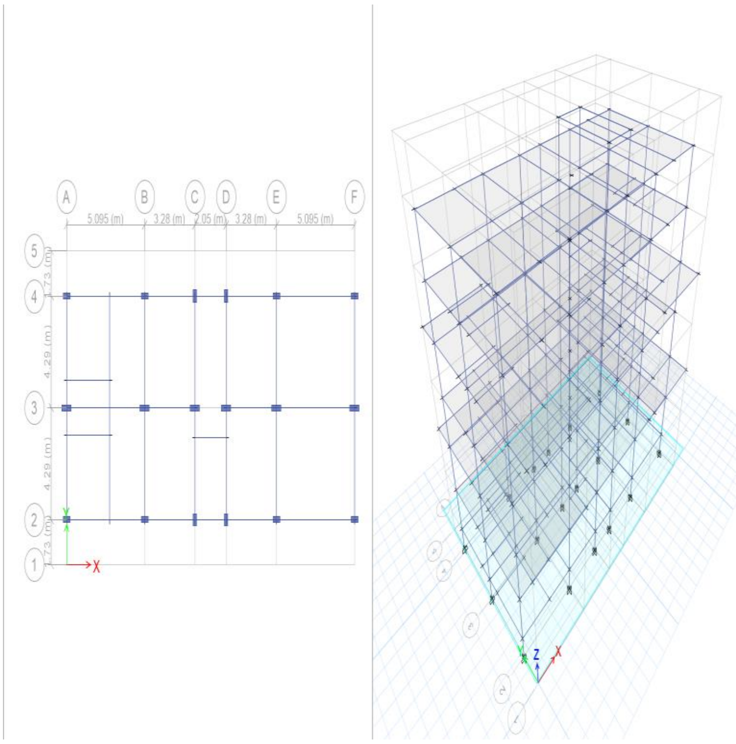

Fig.3.2 Intact building model in ETAB

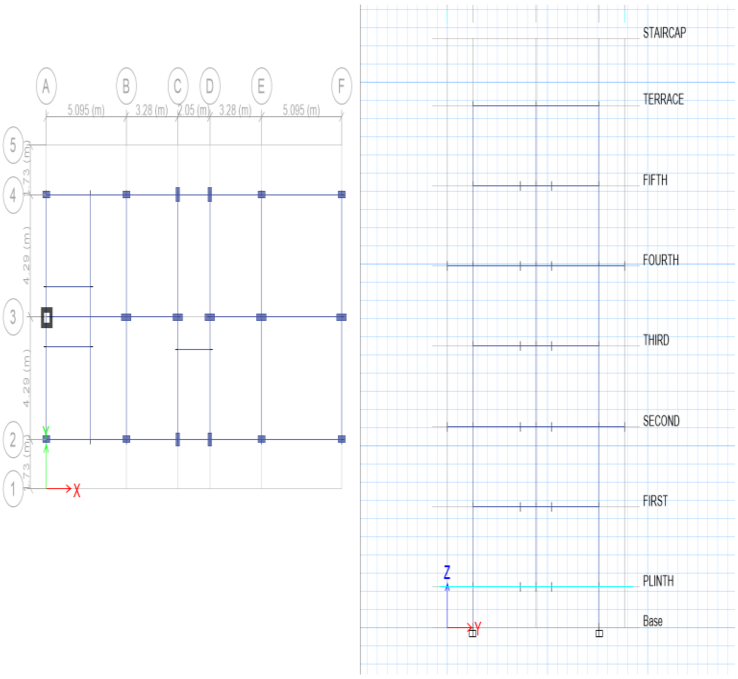

Fig.3.3 Case 1: Removal of Column C7

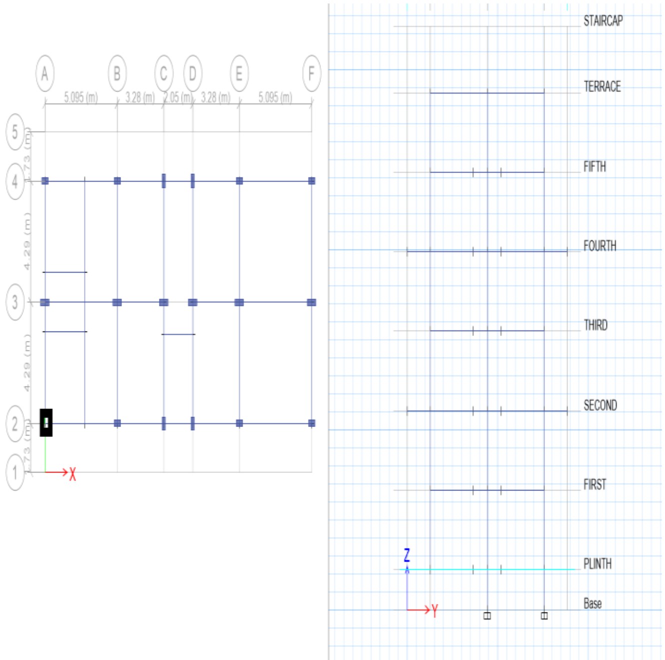

Fig.3.4 Case 2: Removal of Column C13

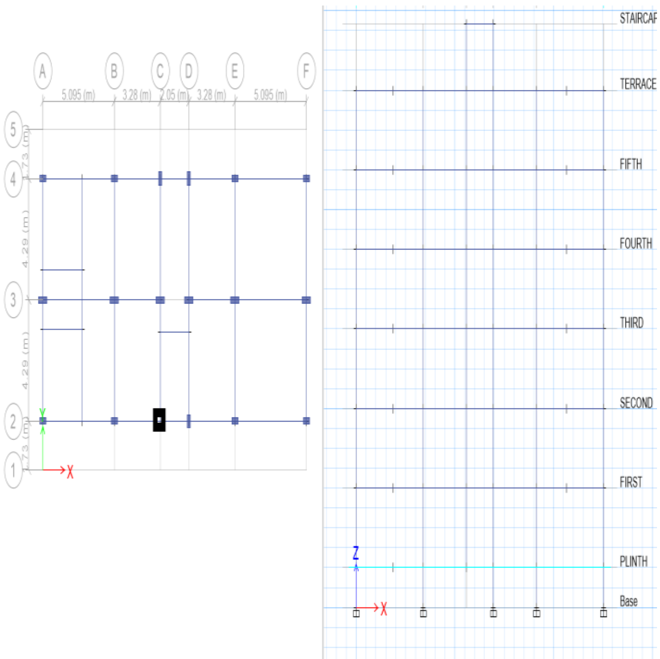

Fig.3.5 Case 3: Removal of Column C15

IV. Result and discussion

4.1 RESULTS OF MODEL G+5

4.1.1 Static Linear Analysis

Calculation of demand capacity ratio:

The member capacity at any section is calculated as per IS 456:2000 using increased material strength (see Table 1) at critical sections.

DCR values for the first and second floor are found out as below, which indicates that DCR for flexure does not exceed permissible value specified by GSA guidelines for seismically designed building.

REMOVED COLUMN	CONNECTED BEAM	DEMAND (M3)	CAPACITY (M3)	DCR
SHORT SIDED COLUMN ELIMINATED	B17	65.76	231.891	0.284
	B6	24.71	270.36	0.09
	B16	62.22	183.293	0.361
CORNER COLUMN ELIMINATED	B16	55.807	183.293	0.304
	B11	55	230.335	0.239
LONG SIDE COLUMN ELIMINATED	B12	32.259	196.045	0.165
	B20	3.059	214.679	0.014
	B13	40.988	179.708	0.228

Table -1 DCR values for first floor

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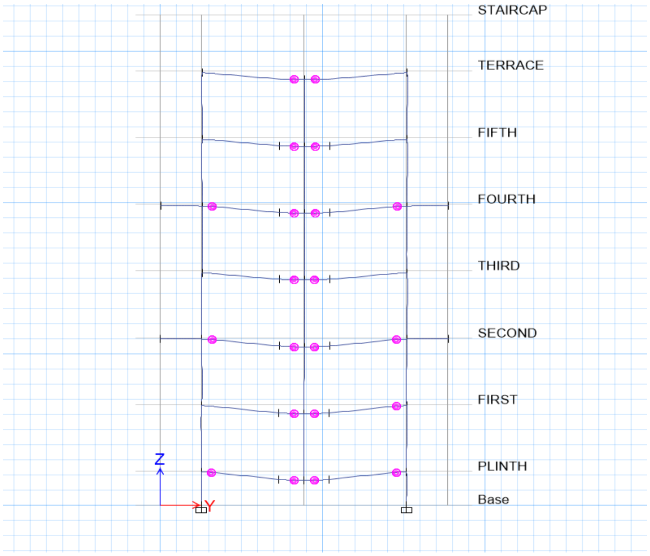
REMOVED COLUMN	CONNECTED BEAM	DEMAND (M3)	CAPACITY (M3)	DCR
SHORT SIDED COLUMN ELIMINATED	B17	72.24	201.421	0.359
	B6	16.812	174.536	0.096
	B16	85.013	250.24	0.339
CORNER COLUMN ELIMINATED	B16	26.748	250.24	0.1068
	B11	42.218	343.985	0.123
LONG SIDE COLUMN ELIMINATED	B12	27.142	217.788	0.125
	B20	2.11	190.763	0.011
	B13	29.738	179.677	0.166

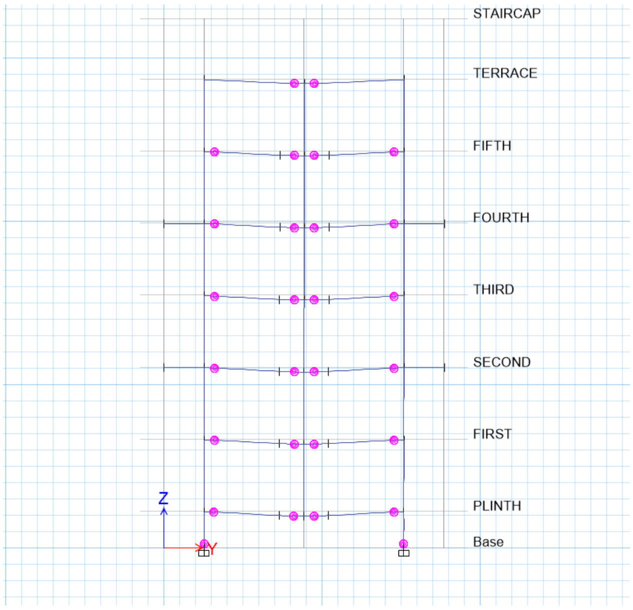
Table -2 DCR values for second floor

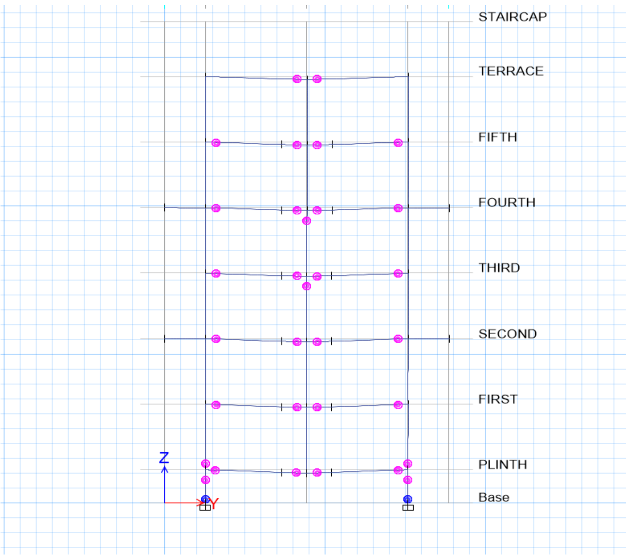
4.1.2 Pushover Analysis

Three column loss scenarios have been considered. The analysis for each case of column failure is performed separately. The hinge formation pattern for various displacement levels are observed for all the three cases of column removal in the building designed, after the completion of analysis. Steps of the hinge formation at some of the displacement levels for seismically designed building for first column removal case are shown.

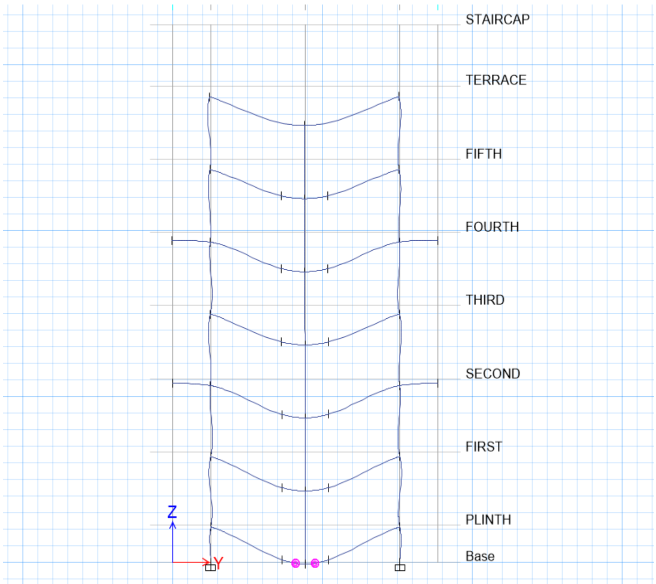
4.1.2.1 PA-x Deformation

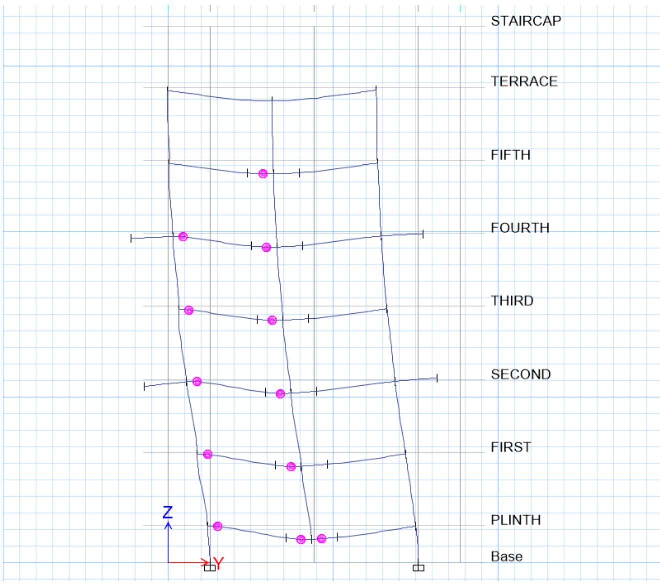


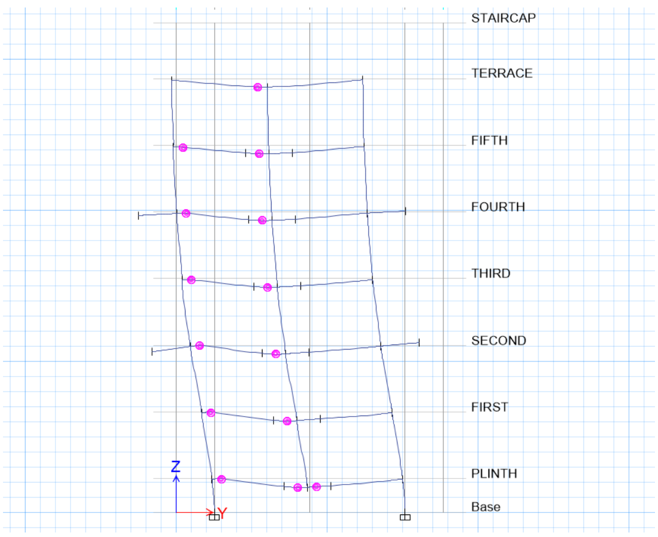




4.1.2.2 Pa-y Deformation







V. CONCLUSIONS

1)From the nonlinear static analysis, it can be concluded that hinge formation starts from the location having maximum demand capacity ratio.

2)The formation of hinges carry on through the locations having higher DCR in various displacement levels.

3)The positions where the demand capacity ratio surpasses the permissible values in linear static analysis, there is a high probability that the member components surpass its elastic limits during column failure scenario.

4)All the formation of hinges in Pushover analysis are formed within the ultimate capacity and thus structure is safe and is able to provide an alternative path for load transfer.

5)From this study, it is observed that to avoid the progressive failure of beams and columns, after failure of particular column due to extreme loading, sufficient reinforcement and adequate detailing can be useful to limit the DCR within the acceptance criteria.

6)In general, if the structures are designed and detailed with an adequate level of continuity, redundancy, and ductility can develop alternative load paths which in return prevents the loss of an individual member and prevent progressive collapse.

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