Progressive Collapse Behaviour of Reinforced Concrete Building Based on Non-Linear Static Analysis

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Abstract- The terminology of progressive collapse is defined as "the spread of local failure from element to element, eventually resulting in the collapse of entire structure or a disproportionately large part of it" In this paper it is propose d to study progressive collapse analysis of G+12 storey reinforced concrete frame building by Non-Linear Static analysis. Structural model of building has been created with the help of ETABS software and load are applied as per the General Service Administration (GSA) guidelines. As per GSA guidelines three column (corner column, exterior column and interior column) removal case one at a time has studied. For all three cases nonlinear analysis is done and it is observed that columns are not critical in any case but beams are going to fail in flexure in progressive collapse.

Key Words: **Building Design, ETABS, Non-Linear Analysis, U.S. General Service Administration (GSA) Guidelines, Removal of Columns**

1. INTRODUCTION

Progressive collapse is defined as a situation where local failure of a primary structural component leads to the collapse of adjoining members, which in turn leads to an additional collapse. Local failure is always caused by an accidental action. An accidental action can be expressed as a design situation involving exceptional conditions of the structure or its exposure to explosion, impact or local failure.

This phenomenon was first realized after the progressive as well as disproportionate collapse of a 22-story apartment tower due to gas explosion at Ronan Point, London, UK, in 1968.After the event of 11 September 2001, more and more researchers have started to refocus on the cause of progressive collapse in building structure.

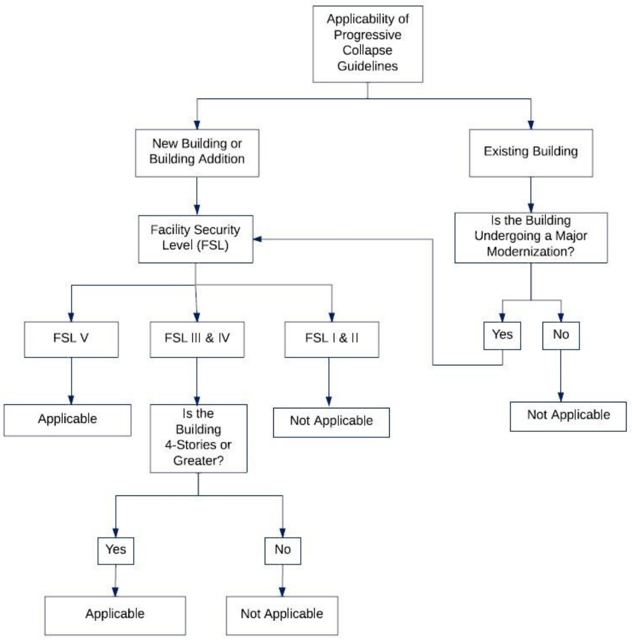
Partial collapse at Ronan Point, UK

2. Need of Progressive collapse Resisting Design

There is a need to design against progressive collapse due to an increasing trend of terrorist action against important facilities such as loss of those leads to heavy loss of life and property. Now a day Probability of terrorist attack is increased and they can target any Facility which are important. Sometimes a small explosion of cylinder in kitchen will also leads to progressive collapse, or hitting of a heavy vehicle at ground level will also leads to progressive collapse. There is also probability of Striking of Airplane on building which may leads to progressive collapse. Due to all of above reasons it is necessary to consider progressive collapse failure of Structures while designing.

3. Applicability Flow Chart

According to GSA applicability of progressive collapse guidelines in based on Facility Security Levels (FSL). The facility security level determination defines the criteria and process for the determining the FSL of a federal facility, which categorizes facilities based on the analysis of several security related facility factors, including its target attractiveness, as well as its value or criticality.



Applicability Flow Chart

4. Methodology

Progressive collapse is carried out as per GSA guidelines by three different methods.

- Liner static analysis
- Non-Linear static analysis
- Non-Linear dynamic analysis

In this paper Non-Linear static analysis is carried out.

5. Modeling of Building

Consider a regular reinforced concrete building(SMRF type) of G+12 floors, which is 25m long with 5 No. of bays in both directions, is carried out for progressive collapse analysis. The height of each floor is considered 3m and live load is 3 kN/m^2 . Slab thickness is 175mm and use M30 and Fe500.

The models are analysed in ETABS 2016. Plan, elevation and 3D modelling of structures are given below:

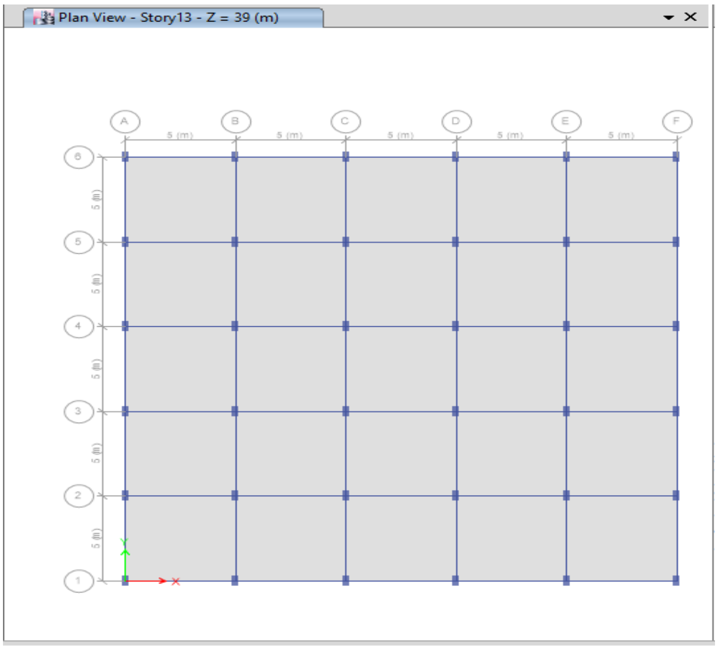


Fig -1: Plan of Building

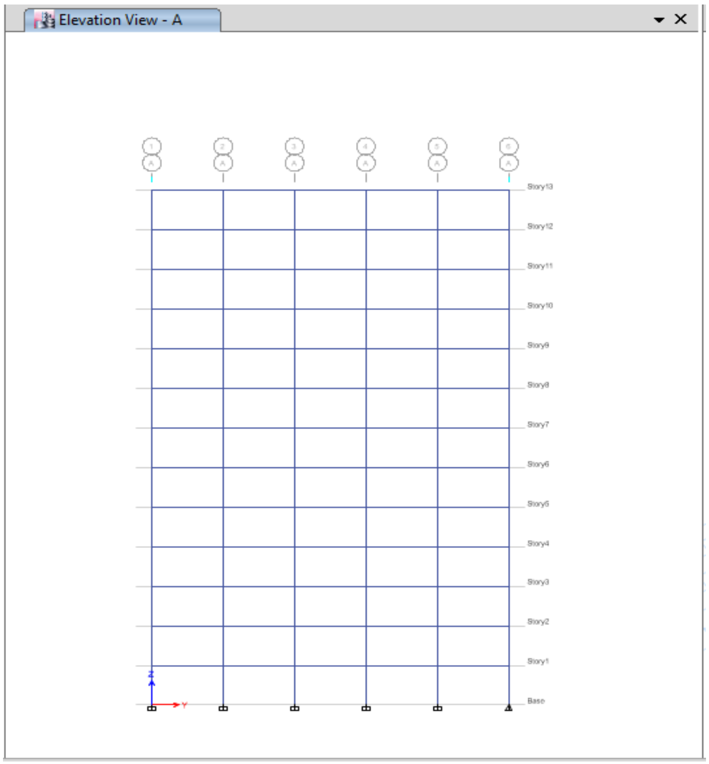


Fig -2: **Elevation of Building**

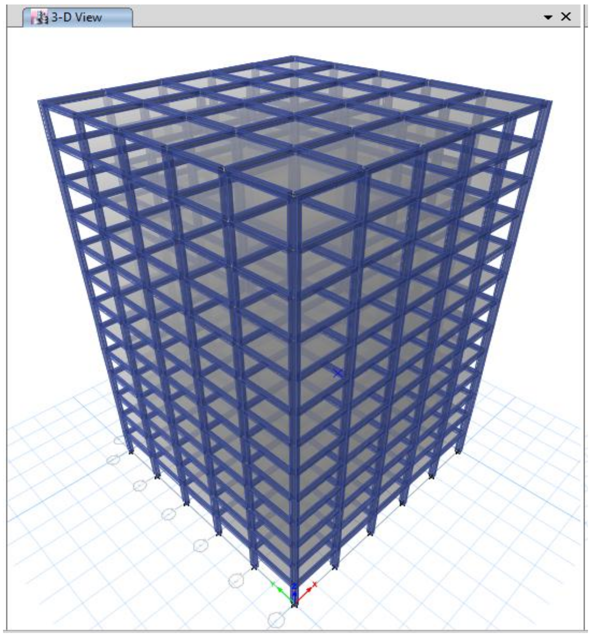


Fig-3: 3D Modeling of Building

6. Non-Linear Static Analysis of Structure

Nonlinear static analysis is carried out here by using ETABS software. A 3D modelling of building is done first and loads are applied as per GSA guidelines. Nonlinear hinges are provided at the end of beams and columns. Default nonlinear hinges M3 in ETABS are provided to beams and for column P-M-M hinges are provided to columns. After that structure is pushed down and vertical displacement at column removed location are monitored.

6.1 Corner column removal case

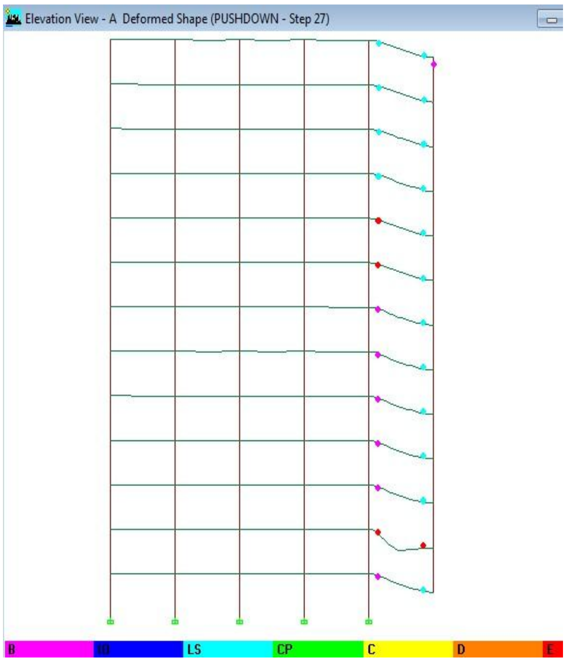


FIG. 4 (Hinge formation for corner column removal)

By observing the pushdown and hinge formation sequence, following conclusions of pushdown of corner removal case can be made:

- Hinge formation sequence shows that the most critical beam is the second storey beam in which hinge goes beyond E state.
- Almost no hinges are formed in column therefore columns are not too much critical as beams in this case (In earthquake resistance structure).

6.2 EXTERIOR COLUMN REMOVAL CASE

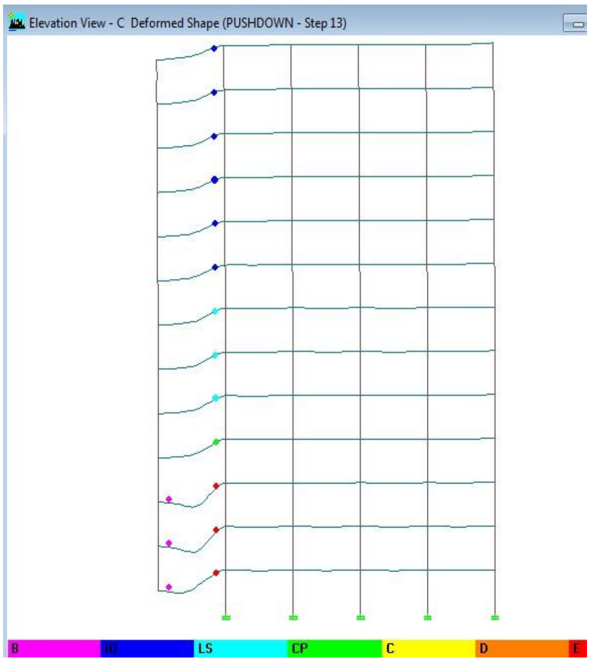


FIG. 5 (Hinge formation for exterior column removal)

By observing hinge formation sequence, following conclusions of pushdown of corner removal case can be made:

- Hinge formation sequence shows that the most critical beams are the first, second third and fourth storey beams in elevation C below which column is removed in these beams hinges goes beyond E state.
- Almost no hinges are formed in column therefore columns are not too much critical as beams in this case (In earthquake resistance structure).

6.3 INTERIOR COLUMN REMOVAL CASE

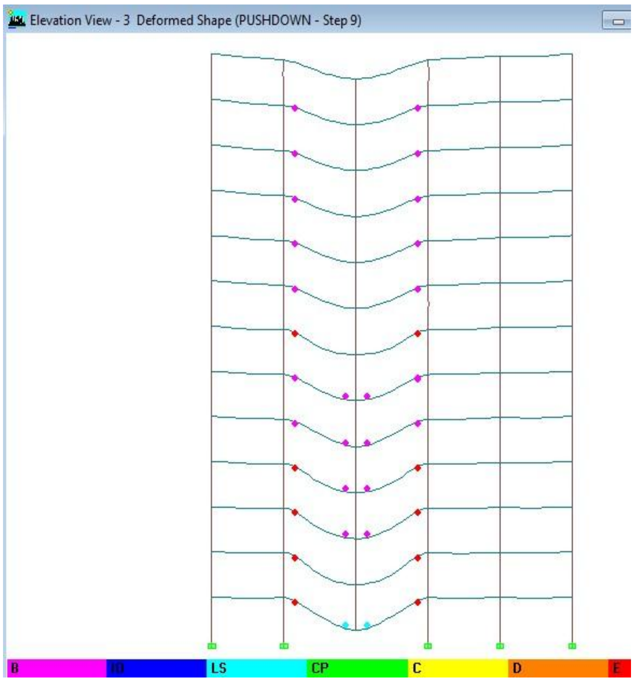


FIG. 6 (Hinge formation for Interior column removal)

By observing the hinge formation sequence, following conclusions of pushdown of corner removal case can be made:

- Hinge formation sequence shows that the most critical beams are the first, second third and fourth storey beams in elevation C and 3 below which column is removed in these beams hinges goes beyond E-state. Almost no hinges are formed in column therefore columns are not too much critical as beams in this case (In earthquake resistance structure).

7. CONCLUSIONS

- By Observing hinge formation pattern in all the three cases of column removal of nonlinear static analysis it is clear that interior column removal is most dangerous and corner column removal is least dangerous.

- observing all the three case it has found that Nonlinear hinge in lower storey beams has gone beyond E-state (failure) which means that lower storey beams are more critical than upper storey beams.

- A Special moment resistance frame designed by IS 456 and detailed by IS 13920 does not provide resistance to progressive collapse this is because of that SMRF is designed for lateral loads and in progressive collapse the failure loads are gravity loads.

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