Progressive Collapse Analysis of a Regular Structure

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Abstract: - Steel frame structures are constructed in seismic areas they are main targets of seismic activities. Due to such conditions nowadays, there is heavy demand of earthquake resisting steel frame structural design. Not only seismic activities but also due some of accidental failures, structure can fail. To analyze steel frame structure for different earthquake zones have to make model of steel structure using E-tabs software which can resist all types of loading such as dead load, live load, seismic load, using IS 800-2000 and IS 1893. In this study, we have selected a high-rise G+10 steel-framed structure. The structure is analyzed for seismic loading, due to which partial collapse or total collapse (progressive collapse) may occur which can be studied. From above analysis, we can study the type failure of structure under the guidelines of GSA for progressive collapse effect due to seismic load.

Key Words: — ***Low rise steel building, Demand Capacity Ratio (D.C.R.), bending moments (B.M), Shear Force (S.F), Deflection, Story Drift.***

I. INTRODUCTION

Progressive collapse of structures is initiated by the loss of one or more load-carrying members. As a result, the structure will seek alternate load paths to transfer the load to structural elements, which may or may not have been designed to resist the additional loads. Failure of overloaded structural elements will cause further redistribution of loads, a process that may continue until stable equilibrium is reached. Equilibrium may be reached when a substantial part of the structure has already collapsed. The resulting overall damage may be disproportionate to the damage in the local region near the lost member. Loss of primary members and the ensuing progressive collapse are dynamic nonlinear processes.

The concept of progressive collapse comes to image after the collapse of the 22 story Ronan Point Apartment Tower in1968.The gas explosion occurred on the 18th floor that vigorously rapped out the exterior load bearing panels of the kitchen near the corner of the building. This results in loss of support at that story (i.e., 18th floor) & triggered above floors to collapse. The potential of this collapsing floors causes, impact load on lower stories & set up a progressive collapse. The entire exterior corner of the building collapsed from top to bottom. Recently, an interest in this topic has been increased after the destruction of Murrah Federal Office building in Oklahoma City due to terrorist attacks, and also the collapse of the unforgettable Twin tower of the World Trade Center in New York (Sept 2001).

In this topic study, the behavior of Steel framed structures to progressive collapse located in different seismic zones is investigated. A Structure with a 20 stories is analyzed for different seismic zones. As per the provisions of GSA guidelines.

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II. METHODOLOGY

The present study is carried out on analysis and design of low-rise steel building using ETABS 2015 software. Modeling of G+10 storey structure is done in ETABS 2015.The models are analyzed and designed for design loading and load combinations.

The structures in the present work are designed for progressive collapse according to "GSA Alternate Path Analysis and Design Guidelines for Progressive Collapse Resistance." The GSA guidelines are applicable in following cases.

Modeling of building structure is done by using ETABS 2015. The complete modeling, analysis and design of structure is done in three phase namely preprocessing, processing and post processing. For the validation of analytical results of ETABS 2015 software, a G+10 steel frame structures are analyzed by using ETABS 2015 and by considering GSA guidelines. The design procedures given by GSA Guidelines aim to reduce the potential for progressive collapse by bridging over the loss of a structural element, limiting the extent of damage to a localized area (Alternate Path) and providing a redundant and balanced structural system along the height of the building.

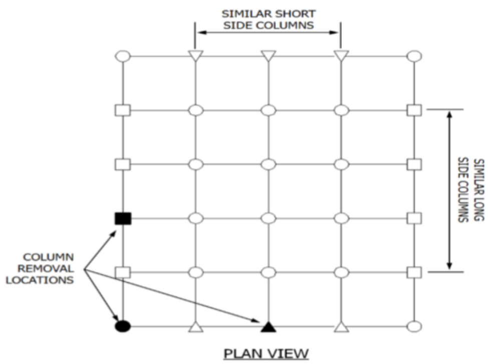

Fig.1. Location of External Column Removal

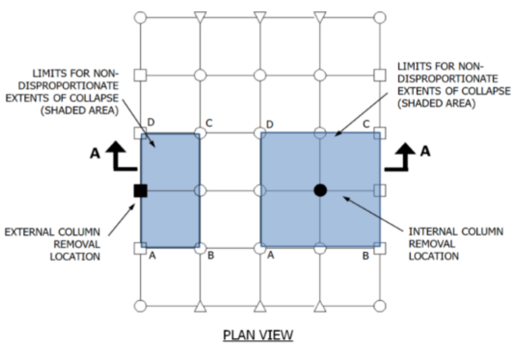

Fig.2. Allowable Extents of Collapse for Interior and Exterior Column Removal in Plan

III. Result

The results of analysis and design of a G+10 steel frame structures using Linear Static method are presented and discussed in the following manner:

- Verification of analysis results of G+10 steel frame structures by the results of ETABS 2015 software using Linear Static Analysis method.
- Demand Capacity Ratio (D.C.R) verses Storey Level Graph carried for G+10 steel frame structures.
- Joint displacement of Steel Structures provided for G+10 frame structures.
- Axial Force (P), Shear Force (V2) and Bending Moment(M3) have been carried for before and after column removal and for bracing system for G+10 steel frame structures.

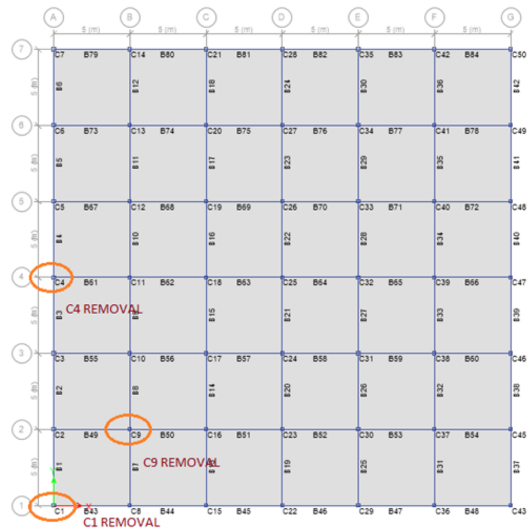

Fig.3. Column Removal Position

IV. Conclusion

It is observed that effect of progressive collapse was more when corner column was suddenly removed, as the number of story increases effect of progressive collapse decreases since the number of members for taking distributed load is more.

- As the number of storey increases effect of progressive collapse decreases since number of members for taking distributed load are more and hence DCR values of beam go on decreasing for upper levels beams. Which shows the more failure occurs in nearby area of removed column.
- DCR values of beam go on decreasing towards upper levels but DCR values of column go on increasing towards.
- It is observed that effect of progressive collapse was more when corner column was suddenly removed, as the number of members participating in progressive collapse event is more.
- It is increase in bending moment of beam due to redistribution of loading on removed area location which leads to failure may be partial or fully but not shear force (strong column & weak beam)
- Because of removal of column, there is increase in load on the nearby columns but loss of strength of same column on succeeding levels & same effect is more hazardous when sudden column loss occurs on higher level.

- There is change in axial force as in axial force when we removed the critical column there is drastic decrease in axial force at the critical column whereas in other columns there is increase in axial force and after providing bracing there is decrease in axial force.
- In bending moment case there is increase in moment in clockwise direction for all adjoining beams near the critical column linear static as well as nonlinear static analysis, after providing bracing there is decrease in bending moment as it transfers the load to the interconnected beam and column. Sudden increase in bending moment value indicates increase in the strength of beam to avoid the progressive collapse in the structure.
- All the results discussed show the change in failure pattern and the increase various parameters in the member just near the vertical element removed. Surely, alternative path method would be one of the best remedies or precautions to overcome the progressive collapse apart from the other methods mentioned by various researchers in the past.
- From above results, it is found that the structure design in seismic zone II is less susceptible to progressive collapse as compare to design in seismic zone V.

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