Analysis of progressive Collapse in RCC structures with Conventional bracings and BRBS

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***Abstract*—Progressive collapse is a term used to describe the failure of a structure, such as a building or bridge, due to the structure's inability to reallocate the loads after the failure of a key component or portion of the structure. It is a destructive structural failure that may occur when a primary structural member or a portion of a structure is damaged or fails, resulting in a chain of structural failures that leads to the partial or complete breakdown of the structure. Progressive collapse is a term used to describe the failure of a structure, such as a building or bridge, due to the structure's inability to reallocate the loads after the failure of a key component or portion of the structure. It is a cataclysmic structural failure that may occur when a primary structural member or a portion of a structure is damaged or fails, resulting in a string of structural failures that leads to the partial or complete breakdown of the structure.**

I. INTRODUCTION

The failure of one component may lead the collapse of the entire structure is known disproportionate collapse. Every year lot of people loose their life and wealth due to progressive collapse. Progressive collapse is a type of failure which cannot be neglected. A single collapse in a main structural element can lead to a large destruction. Even if small failure occurs as if it non-structural or partition wall that may lead to entire collapse of a structure or a part of structure collapse. The collapse may be minor but it impacts large effect in failure of building. The attempt to prevent disproportionate collapse has made us to give importance on increasing redundancy and alternate load paths ways, to ensure that loss of one component would not lead to a collapse of entire structure. Progressive collapse is gravity driven extreme event that may lead to various failure which could be created by other extreme events as well as mistakes in design and methods of construction. The alternate load path method (APM) is one of a number of options to design buildings to mitigate progressive collapse. The present work aims to demonstrate the effect of progressive collapse on regular RCC structures. The building studied in this section is a 10 story Reinforced Concrete frame designed for Gravity and Seismic Loads. The research highlights the potential of BRBS as a promising retrofit option to counteract progressive collapse hazards in RCC structures.

II. UNDERSTANDING PROGRESIVE COLLAPSE

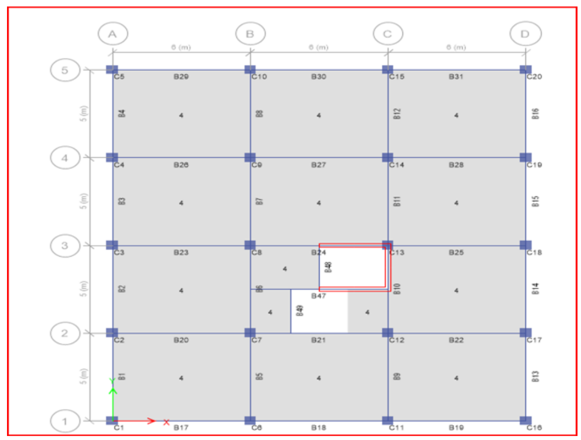
Progressive collapse is a failure in which failure of one structural member leads to a continuous failure of entire structure. When one or more major structural members sustain localized damage or fail, it can cause a series of failures in nearby members, which can result in a disproportionately large partial or complete collapse of the building. This phenomenon is known as progressive collapse in structures. This phenomenon, which is caused by sudden loads, actions, or natural and manmade disasters such as gas cylinder blast happens when the remaining structural components are unable to sufficiently redistribute the loads from the failed members. To stop the initial localized failure from becoming a widespread collapse, mitigation strategies emphasize increasing local resistance, increasing ductility, improving structural continuity and redundancy, and designing for alternate load paths. If the building is collapsing after removing of critical element, then providing mitigation. Mitigation is by ensuring that bridging occurs when a key element fails. This is due to alternate load paths available due to re-distribution ability and minimum reinforcement available. Bracing is a good option for mitigation.

III. CONVENTIONAL BRACING AND BUCKLING RESTRAINED BUCKLING SYSTEM

Conventional bracing consists of steel diagonals which make the structure rigid and rough. These are of various forms such as X bracing, diagonal bracing etc. Where BRBS consists of a steel core element and restrained mechanism. Although they are both used to increase a structure's resistance to lateral loads, especially during seismic events, conventional bracing systems and Buckling Restrained Bracing (BRB) systems work very differently. While conventional bracing, usually consists of steel diagonals, makes a building more rigid and hard, it can also buckle under compressive forces during an earthquake, reducing energy dissipation and possibly causing strength degradation. An asymmetrical hysteretic behavior (load-deformation response) is frequently the result of this buckling in systems in conventional bracings, on the other hand, BRBS made especially to stop the bracing members from buckling. They are made up of a steel core that can yield under both tension and compression, and they are protected from global buckling by a restraining mechanism (typically a steel tube filled with concrete or grout).

IV. METHODOLOGY

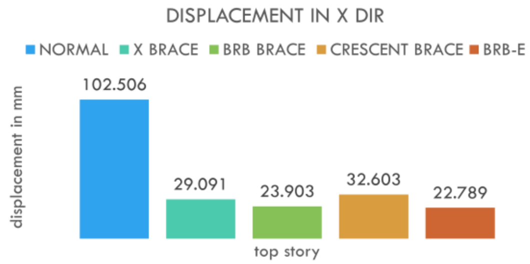
The study presented herein investigated the progressive collapse potential of a 10-story building that was designed only for gravity loads and lateral load resisting system. This study looked at the disproportionate collapse of a G+10 commercial building. The structure has five bays of five meters in the transverse Y direction and three bays of six meters in the longitudinal X direction. A wall that is 230 mm thick is taken into consideration on the entire beam, and the typical floor-to-floor height is 3 m. A slab thickness of 125 mm is taken into consideration. The beam size is 300 x 500 mm. For ten-story buildings, a column size of 500 x 500 mm is taken. There are no secondary beams present and the structure is in symmetric condition. The cross section of column is also square in shape. ETABS software is used for analysis and M30 grade concrete is used Fe 500 steel is used IS 875 standards. Build ETABS models with both conventional bracings and BRBS. Perform a column failure simulation starting from the base. Perform a pushdown structural analysis. Assess target parameters such as displacement, drift, shear forces, energy dissipation, Natural time period and others. In analysis firstly, the corner column is removed and analysis is done and the load of the columns which are beside the removed column and also the loads on the adjacent beams are noted and the percentage of increase of displacement, loads, shear force and axial force are noted. Then similar procedure is followed by removing the column which is present at the interior side of the building and then similar procedure is followed to find the deflection, drift, shear forces, bending moments etc by removing the column which is present at the edge of the building. The shear fore, axial force and bending moment is found before and after the removal of column and beam for all adjacent members of the column which is to be removed.

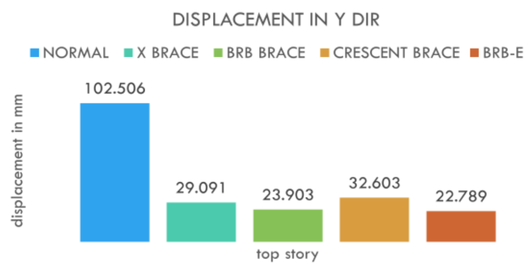


V. RESULTS

After analysis in ETAABS, the results shown are that the variation of axial forces before and after the removal of column are shown as axial force is a basic parameter used in the designing of column, if a corner column is removed the variation of axial force is 25.8%, as we can see that this variation is increases from ground floor to roof of a building. By removing the column which is present at the edge the percentage of increase of load on the adjacent column is 25% and the percentage of increase of load on the adjacent column when an interior column is removed is 50%.

The below graph shows that the amount of displacement occurred in both x and y direction with response spectrum method in case of a progressive collapse with use of various bracing such as X brace, BRB brace, BRB crescent brace and BRB E braces. As displacement is considered as a main factor for the start of a progressive collapse.





The results shows that the displacement is less, which is 77% less than normal building without braces. In the case of BRB E type bracing when compared to other type of bracing these means that this is very efficient against progressive collapse. From the above Stiffness results, BRB and BRB-E are moving very close to each other, but BRB-E tend to show slightly higher stiffness values at all stories. The BRB, however, is showing much more stiffness compared to the other two models and the line representing its stiffness is placed well above the other two. Note that the stiffness of BRB-E and other two models are much higher at lower levels, but gradually decrease in top floors. This is due to the influence of height on the stiffness and frames at different levels.

In case of story drift, the results are as similar as the displacements that is there is less story drift for BRB E bracing when compared with normal, X brace, BRB brace and BRB crescent brace. And also, the time period of the building with BRB E bracing this has high stiffness as the stiffness is the reciprocal of time period i.e. the time taken for one oscillating movement. Base shear of the BRB E bracing is also high which has been found by analysis.

CONCLUSION

As we have seen in recent times due to complications in structures there is lot of progressive collapse has bee taken place as we follow the good scheme and detailing practices, we can prevent progressive collapse. Since buildings are generally are anyways designed for seismic forces, the additional cost for taking care of accidental loads may not be huge. In a structural system when one element is failed the adjacent member should be designed capable to withstand additional load occurring on it through which disproportionate collapse can be prevented. The research shows that the use of BRBS helps in preventing the damage caused due to a progressive collapse. Specially BRB E is very useful. Maximum story displacement in model with a BRB-E, which happens on the top floor, is only about 35% of the displacement in a normal building. Note that story displacements in all models are below permissible limits. This indicates that BRB E is very efficient and a good alternative option for retrofitting to be prevented against progressive collapse. These also explains that the use of BRB bracing for the safety is a better option than the use of conventional bracings system such as diagonal system or x system. The lateral displacement values indicate that the model with eccentric Buckling-restrained brace is expected to have fewer problems in the lateral movement of the structure. Though it may add little additional cost but it would be a good practice to mitigate risk due to progressive collapse.

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