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PROGRESSIVE COLLAPSE ANALYSIS OF STEEL STRUCTURE USING STAAD PRO

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Abstract: Over the past three decades, extreme consideration has been given of how to prevent progressive collapse in structures and with all the extensive research carried out, structural engineers still seem confused with the term "progressive collapse". Several codes of practice such as the GSA, Euro code 1 and UFC provide methods on how to mitigate the possibility of progressive collapse as to help structural engineers when designing structures. In this project we calculate the progressive collapse potential of an asymmetric industrial building as per GSA (2003) Guidelines. Linear static and linear dynamic (response spectrum analysis) analysis have been done. The analysis showed that removal of the corner column triggered the failure of key structural components throughout the structure. After removing the corner column, the breams directly above the removed columns were about to fail. Even if member did not fail it pass the acceptance criteria but stronger connection are also required to avoid beam failure & progressive collapse in the structure. We have studied that due to corner column removal major deflection occurs in beams which are surrounded to removed column which result in increase in moment in other column from adjacent grid. Major deflection occurs along major axis of structure as it carry most of the moment. To avoid this we use higher member along with some tie member. To avoid progressive collapse of structure we need to provide brace frame along both frame moment frame & shear frame of structure. We can reduce progressive collapse of structure by providing alternate load path so that load redistribution can take place and some member deflection will occur. This can be achieved by providing ties in adjacent member

Keywords: *Progressive collapse analysis, steel structure, Staad pro*

I INTRODUCTION

1.1 INTRODUCTION:

Progressive collapse occurs as a consequence of a localized failure of one or two structural components, which results in a continuous progression of load transfer that surpasses the capacity of adjacent parts, starting the progression that results in the structure collapsing completely or partially. When one or more vertical load-bearing elements (usually columns) are removed, the building structure gradually collapses. Once a column is removed due to a car collision, a fire, an earthquake, or any other man-made or natural danger, the structure's weight (gravity load) is transferred to adjacent columns. As a result of the redistribution of forces, the stresses inside surviving structural components such as columns and beams are altered, and if the stresses surpass the element's yield stresses, the element collapses. This failure may propagate from one element to the next, until the whole structure collapses. The term "failure" refers to the gradual collapse of multi-story structures. Steel frames are often utilized as the primary structural supporting system in multi-story structures due to their efficiency. However, detailed behavior of steel frames during progressive collapse has been uncommon to date, and there is a dearth of knowledge about the design of steel frames to withstand progressive collapse, which prompted the present study. Full-scale studies to determine the gradual collapse of steel frames are very expensive and time consuming.

Although progressive collapse is a relatively uncommon occurrence in industrialized nations, its impact on structures is very hazardous and expensive. Without careful consideration of sufficient continuity, ductility, and redundancy, gradual collapse is unavoidable. Until date, just a few studies have been conducted on steel buildings. With advancements in steel materials, technology, and techniques, especially in industrialized nations, research on the progressive collapse resistance of steel framed structures is progressively expanding.

Progressive collapse is a phenomena in which a localized failure of a main structural element results in the breakdown of a section or the whole structural system, with no proportionality between the initial and ultimate damage.

On November 1, 1966, while under construction, the seven-story University of Aberdeen Zoology Department building in Aberdeen, Scotland, collapsed completely. The collapse was blamed on faulty girder welds caused by metal fatigue. Metal fatigue was produced on the structure by oscillating lateral forces (primarily wind). Five individuals were murdered and three were wounded in the attack. The structure was steel-framed, and it was the first known instance of a steel-framed structure collapsing completely.

The 26-story Skyline Towers Building in Fairfax County, Virginia, fell on March 2, 1973, as a consequence of premature removal of wooden shoring from an upper-story level during construction. There were 14 fatalities and 34 injuries. The skyscraper was constructed of steel-reinforced concrete.

On December 19, 1985, the Wed bush Skyscraper, a 22-story commercial office building located at 1000 Wilshire Boulevard in Los Angeles, suffered a partial collapse. Construction workers were unloading freshly arrived steel girders from a flatbed truck onto the newly constructed 5th floor deck by crane when a girder detached from the crane and plummeted into the existing stockpile below, which was already filled to double the floor's maximum intended load capacity. This precipitated the gradual collapse of the overloaded level, which resulted in the floor section and girders colliding with the 4th, 3rd, 2nd, and 1st floors before colliding into the parking garage. Three individuals were killed. The structure was steel-framed.

On May 10, 1993, the four-story Kader Toy Factory in Nacho Pathos, Thailand, collapsed after a fire that started on the ground level and quickly spread across the complex. At the time, the plant was operating at full capacity, and all fire exits were closed. There were 188 fatalities and nearly 500 injuries. The structure was steel-framed.

After the terrorist assault on the Alfred P. Murray building in Oklahoma City in 1995 and the collapse of the World Trade Center in 2001, both of which occurred in the United States, study in this area has intensified. This kind of event occurs in a variety of nations, including the United States, Germany, Japan, and Thailand.

To prevent structural failures that result in damage and the death of humans and animals. To avert this gradual breakdown, an analysis must be conducted. Which will be discussed in more depth later in this paper.

OBJECTIVE OF THE WORK:-

The present work aim at following objective

- To review various guidelines & techniques used for to analysis of progressive collapse analysis and to develop a report in the form of literature review.
- To identify an appropriate technique and suitable guideline from the reviewed literature for progressive collapse analysis of industrial shed.
- To analyses the asymmetrical building for identified technique of progressive collapse analysis and to determine different remedial measures for building
- To interpret the results derived from chosen technique and to derive conclusion

SCOPE OF THE WORK:-

- Industrial steel structure is analyses and design by conventional method for dead load, imposed load, and earthquake load in STAAD PRO V8 software.
- The structure is further analyses for removal column considering load combinations as per GSA guidelines.
- Results are compared with first case which is without accidental load to see the collapse path by using same software
- Remedial measures are provided to avoid progressive collapse like Bracing system meanwhile provided Alternative Bracing system,

II. PROBLEM STATEMENT

To calculate the progressive collapse potential of an asymmetric industrial building as per GSA (2003) Guidelines. Linear static and linear dynamic (response spectrum analysis) analysis have been done.

Location: Barauni (Bihar)

Seismic loading as per IS: 1893 - Seismic zone: III

Soil type – II & Type of soil: Medium

No of grids/Bays in X direction: 4

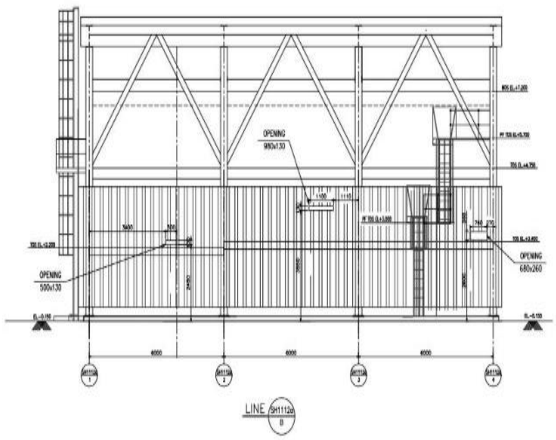
No of grids/Bays in Y direction: 3

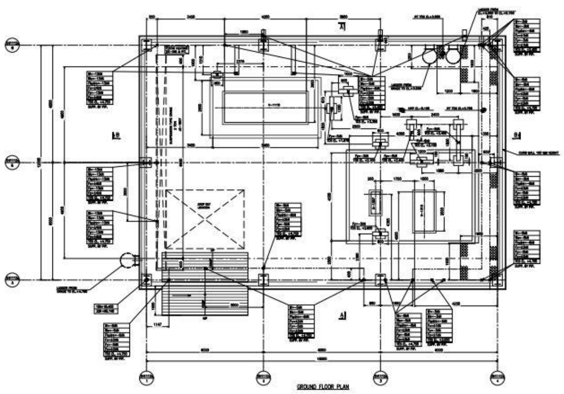
Materials: Steel – IS2062, M 45 concrete,

Material Unit weight of concrete: 25 kN/m^2

Software Uses: STAAD PRO V8. – Analytical Calculation

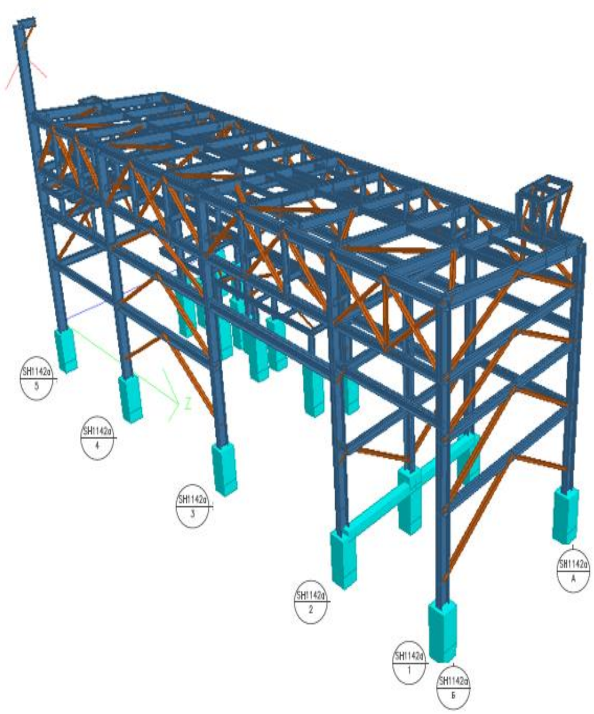
MS OFFICE 365 – Results & Graph Analysis



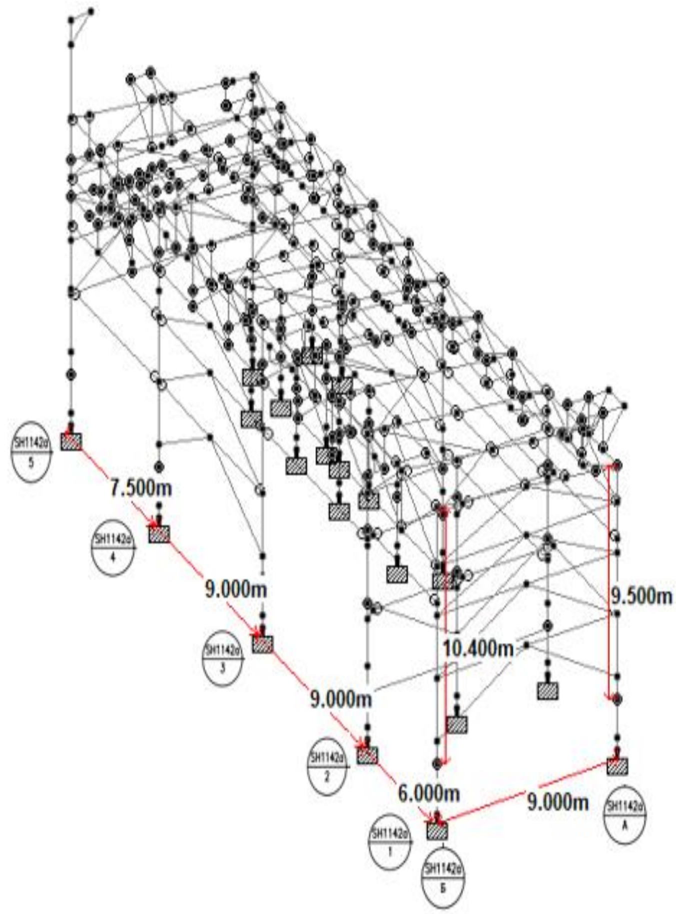


III. ANALYSE

GEOMTERY OF STRUCTURE



ISOMETRIC VIEW



Overall STAAD Geometry of Shed

Definitions and Combinations of Design Loads shall be considered in the Design of Industrial Shed Structure Design shall be done with due consideration of functional requirements, the conditions at site so that the requirement of this Specification is met and economical, effective methods and materials be used the following design loadings shall be considered.

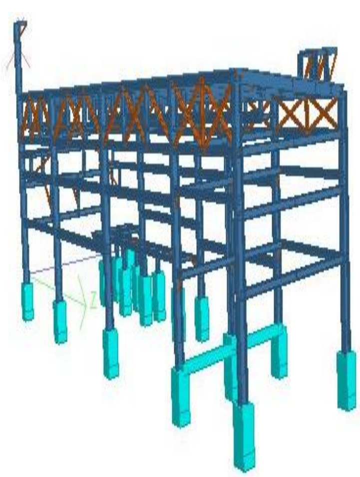
1. DEAD LOAD (DL)
2. LIVE LOAD (LL)
3. EQUIPMENT LOAD (EL)
4. BUNDLE PULL (BP)
5. PIPING LOAD
6. IMPACT AND VIBRATION LOADS (VL)
7. WIND LOAD (WL)
8. EARTHQUAKE (SEISMIC) LOAD (SL)
9. HANDLING DEVICE LOAD (ML)

Unit weight for materials

Reinforced Concrete	25 kN/m3
Plain Concrete	24 kN/m3
Structural Steel	78.5 kN/m3
Brickwork	19 kN/m3
Backfill Soil	18 kN/m3
Operating floor with grating including joist	1.25 kN/m2
Saturated Soil	19 kN/m3
Ladder	0.40 kN/m
6 mm Thk. Chequered plate	0.55 kN/m2
Heavy duty tar felting	0.3 kN/m2
Platform (Pipe) Hand Rail , with Toe Plate	0.22 kN/m
Roof / Side GI sheeting (0.5mm to 0.65mm thk)	0.14 kN/m2

IV. RESULT & DISCUSSION

In this Results and Discussion we analyzed the three different Models for progressive collapse analysis. In this we compare Staad model for two different accidental scenario and we calculates & study the value of displacement, bending moment & shear forces.



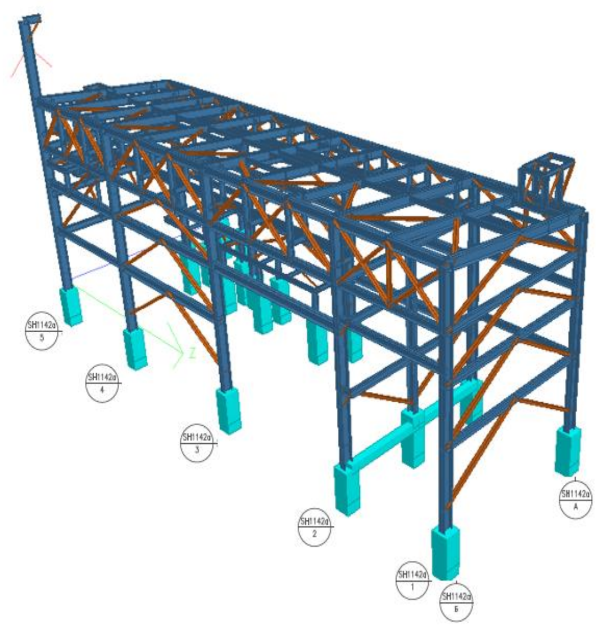
Structure without Mainframe bracing

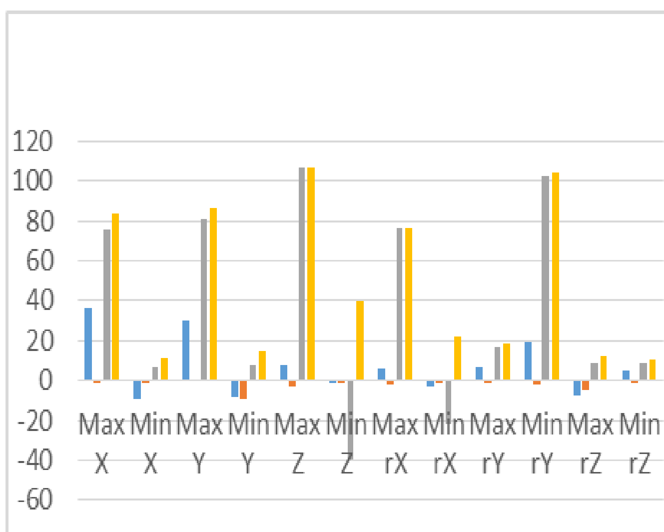
- First we analyzed structure for progressive collapse without having bracing to main frame. First of all we take check for serviceability of structure. Then we analyses structure on strength parameter

STRUCTURE WITH BRACING

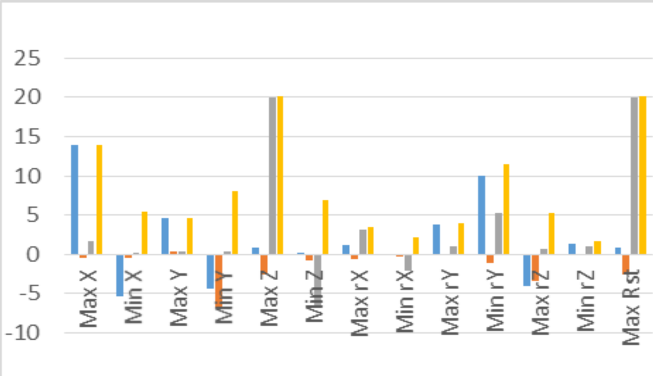
- To reduce deflection along major axis & make it safe we added single angle elevation bracings. So that we can reduce progressive collapse.

First we analyzed structure for progressive collapse with having bracing to main frame. First of all we take check for serviceability of structure. Then we analyze structure on strength parameter





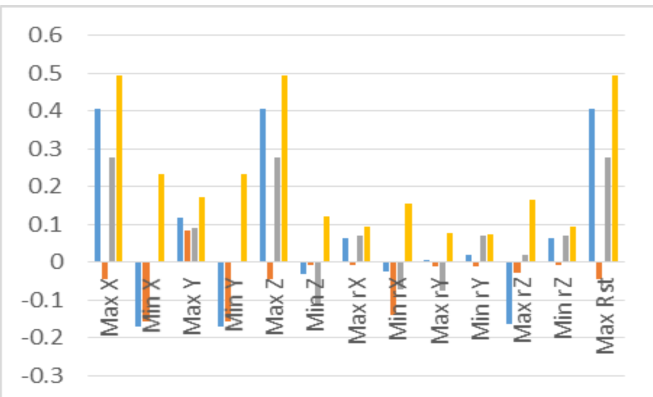
Graphical representation of Deflection of Structure without having Mainframe bracing



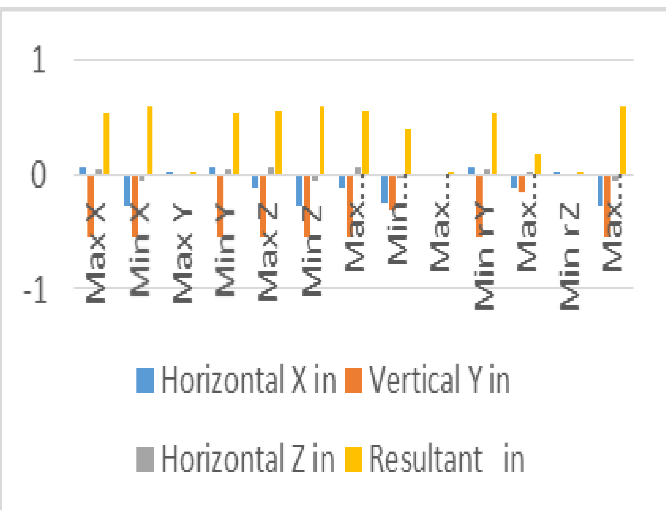
Graphical representation of Deflection of Structure with having Mainframe bracing

- From above graphs it is clear that in structure which does not have main frame bracing is deflect more in Z direction. Which means that structure is has more deflection on its major axis. Which is comparatively five times higher than the structure having elevation bracing on its main frame.

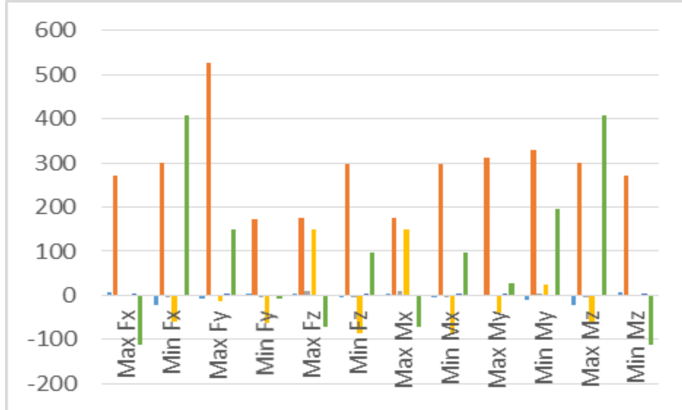
As deflection of structure is reduced it will be helpful to avoid progressive collapse of structure



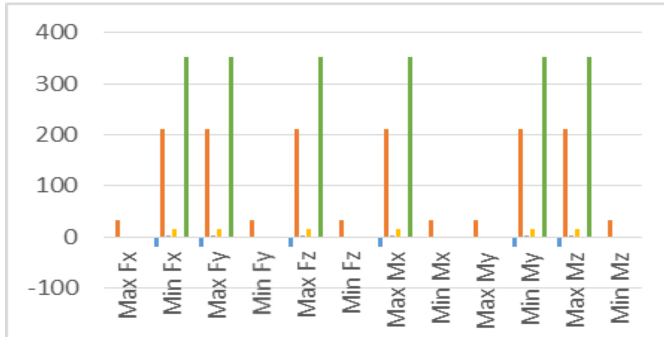
Graphical Representation of Deflection when Corner Column Was Not Removed



Graphical Representation of Deflection when Corner Column Was Removed

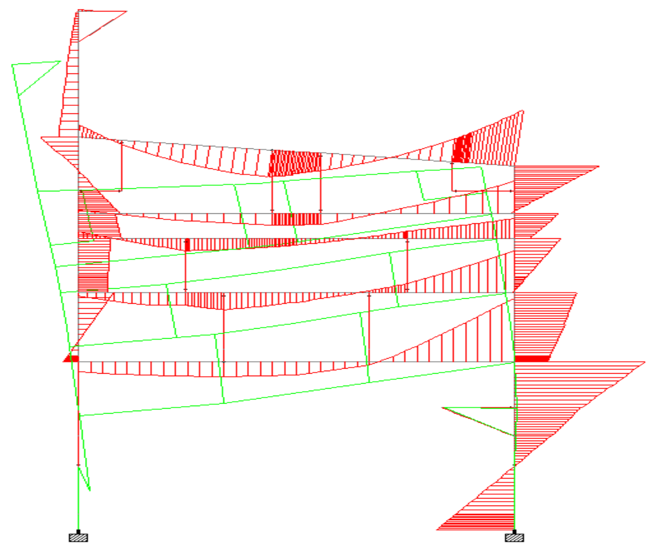


Graphical Representation of SF & BM when Corner Column Was Not Removed



Graphical Representation of SF & BM when Corner Column Was Removed

- From above graphical representation it is clear that there is lot of increase in horizontal forces & moment in frame which has column is removed.
- There major forces are seen on major axis of structure are increase a lot. The moment which was supposed to transfer on two column is getting transferred to only one column due to this we can see such reaction & moment on column.



Deflection & BM when Corner Column Was Removed

- From above figure we can see that as deflection increase on one side of structure as member is inactive due to which moment is increases on other column i.e. right side column.

V.CONCLUSION

Over the past three decades, extreme consideration has been given of how to prevent progressive collapse in structures and with all the extensive research carried out, structural engineers still seem confused with the term "progressive collapse". Several codes of practice such as the GSA, Euro code 1 and UFC provide methods on how to mitigate the possibility of progressive collapse as to help structural engineers when designing structures.

COLUMN REMOVAL SCENARIO

- The analysis showed that removal of the corner column triggered the failure of key structural components throughout the structure. After removing the corner column, the breams directly above the removed columns were about to fail.
- Even if member did not fail it pass the acceptance criteria but stronger connection are also required to avoid beam failure & progressive collapse in the structure.
- We have studied that due to corner column removal major deflection occurs in beams which are surrounded to removed column which result in increase in moment in other column from adjacent grid.
- Major deflection occurs along major axis of structure as it carry most of the moment. To avoid this we use higher member along with some tie member.
- If member not getting passed then we will have provide higher section along with some tie member but it will be not economical.
- In this process structure bending i.e. deflection will occurs but sequential collapse of entire structure will not happen. Which result in less hazard & structure will be safer?

PREVENTIVE MEASURE FOR PROGRESSIVE COLLAPSE OF STRUCTURE

- To avoid progressive collapse of structure we need to provide brace frame along both frame moment frame & shear frame of structure.
- We can reduce progressive collapse of structure by providing alternate load path so that load redistribution can take place and some member deflection will occur. This can be achieved by providing ties in adjacent member.
- In catastrophic event member & their connection may have to maintain strength through large deformation (Deflection & rotation) & load redistribution associated with loss of key structural element. To maintain ductility we can design connection for higher capacity & use higher grade of material.
- The primary structural elements (columns, girder, roof beams & lateral load resisting system) & secondary structural element (floor beams & slab) should be designed to resist reversal in load direction at vulnerable location such as joints.

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