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“Seismic Effects on the Progressive Collapse Behavior of Reinforced Concrete Frames”

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Abstract:
Progressive collapse means the initial failure is spreader from element to element. The initial failure results in redistribution of loads in the structure, which finally leads to failure of entire structure. This situation occurs due to local failure of primary structural components leading excessive stresses on adjoining member which leads to additional collapse. Progressive collapse may be accidental as the result of design deficiencies, fire, unintentional overload, material failure or natural phenomenon e.g. erosion, wind, earthquake If one of the member fails it will lead to collapse of the entire structure, if preventative measures are taken the collapse of building can be prevented or least it will increase time required for complete collapse and will help to save Human life. Structural engineering Profession has experienced many significant and complex changes in the past several years' .Higher strength material and improved computational method permit to design building to new limits of height and span. Recent events involving earthquake produced many unexpected structural problems. This project deals with the various analyses of multi-story frames for seismic load as well as gravity load using the suitable software to achieve followings. Comparative study of various story and bays of RCC Structure in plane. Study of various internal forces in the column after progressive collapse. Study of various deflection parameters. To study various internal forces and bending moment in the beam after progressive collapse

Keywords: Progressive Collapse, Earth quake, Bending Moment, Shear force, Axial force, Deflection

INTRODUCTION

Building that collapse in a progressive way could lead to catastrophic event, a large number of deaths & injuries & loss of properties. The structural components of buildings subject to extreme loading events are likely to undergo large inelastic deformations, which can induce excessive ductility demands in the joint regions of the members involved.

Progressive collapse is defined as “The spread of an initial failure from element to element, eventually resulting in the collapse of an entire structure or disproportionately large part of it”.

When local failure of primary structural members propagate to failure of adjoining members, progressive collapse will ensue unless adjoining structural members arrest further progression of failure. For example, if a column in multi-story framed building is destroyed due to explosion, the structural members above the failed column will sustain large displacements instantaneously, and also will fail unless the beams that are framed to the column develop a centenary response to arrest collapse of the floor area that was supported by

the failed column. Progressive collapse is a dynamic & nonlinear event, as it takes place in very short time; frame & structural members undergo nonlinear deformation before failure.
The failure of small structural element, initiates a chain reaction that causes other structural elements to fail in a domino effect, creating a larger and more destructive collapse of the structure. A good example of progressive collapse is a house of cards; if one card falls near the top, it causes multiple cards to fall below it due to the impact of the first card, resulting in a full.
There are usually multiple factors that take place in order to initiate a progressive collapse. Miscommunication between contractors and engineering documents can cause a progressive collapse, Workers may improperly install specific structural elements that can lead to weakened structural members throughout the building, Improper inspection or overlooking structural issues also leads to factors that initiate a progressive collapse, If structures go for years without receiving proper maintenance, rust or other material failures can occur which weaken the structure and make it more susceptible to a progressive collapse.

LITERATURE REVIEW

Ram Shankar Singh. Meraj A. Khan. (2015) Progressive collapse is a chain reaction of failures that propagates either throughout or a portion of the structure disproportionate to the original local failure. The progressive collapse of building structure is initiated when one or more vertical load carrying members are removed. Once a column is removed or made weak, due to man-made or natural hazards, load carried by column removed is transferred to neighboring columns in the structure, if the neighboring column is incapable of withstanding the extra load, leads to the progressive failure of adjoining members and finally to the failure of partial or whole structure. The collapsing system continually seeks alternative load paths in order to survive.

T.S.Moldovan, L.Breden & AM Loni. This paper presents the results of a parametric study regarding the influence of the Romanian seismic codes evolution on the progressive collapse behavior of mid-rise RC framed structures located in high seismicity zones. Three successive Romanian seismic design codes of the last 20 years are considered in the analysis. A typical 13-storey RC framed structure is designed according to each of the three seismic codes. Many parameters such as the ground acceleration of the location (ag), the provisions regarding the allowed minimum ductility class of structural elements as well as the magnitude of the behavior factor q, have been changed during this period. The progressive collapse potential is assessed, in terms of flexure and shear, through the static linear elastic procedure specified by GSA (2003) Guidelines. The analyses have been performed for all the "missing column" scenarios defined by GSA (2003) Guidelines.

Vishal Kumar BhaskarbhaiPatel (2018) The progressive collapse potential was researched utilizing the linear static analysis techniques suggested in the GSA guidelines. The progressive collapse analysis were conducted using ETABS 2016 software. Even though the linear static analysis technique has a benefit that it is theoretically easy as well as analyzed without advanced nonlinear modelling, a lot of manual works were required to assess DCR in every analysis step and to redesign the structure until DCR of any element does not exceed a given limit state. It was additionally discovered that the potential for the progressive collapse was highest when a corner column was suddenly removed, it had been additionally discovered that beams at the lower floor were affected in flexure and columns at the higher stories. Altogether cases, beams and columns were safe in shear as DCR values are within the permissible limit for shear. For central column removal case, DCR values for flexure and shear are lower compared to corner column removal case as distribution of load when column removal is symmetrical In central column case. To avoid the progressive collapse of structural members, caused by the failure of a specific column, adequate steel bars are needed

METHODOLOGY

Seismic Engineering is a sub discipline of the broader category of Structural engineering. Its main objectives are,

1) To understand interaction of structures with the shaky ground.
2) To foresee the consequences of possible earthquakes.
3) To design, construct and maintain structures to perform at earthquake exposure up to the expectations and in compliance with building codes.

The methodologies available so far for the evaluation of existing buildings can be divided into two categories-

1) Qualitative method
2) Analytical method.

In the same realm, seismic analysis is a subset of structural analysis and is the calculation of the response of a structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit in regions where earthquakes are prevalent.Structural analysis methods can be divided into the following categories,

1) Equivalent Static Analysis
2) Response Spectrum method
3) Time history method
4) Linear Dynamic Analysis

Equivalent Static Method

Seismic analysis of most structures is still carried out on the assumption that the lateral (horizontal) force is equivalent to the actual (dynamic) loading. In the equivalent static force procedure, the inertial forces are specified as static forces using empirical formulas. All design against earthquake effects must consider the dynamic nature of the load. However, for simple regular structures, analysis by equivalent linear static methods is often sufficient. This is permitted in most codes of practice for regular, low- to medium-rise buildings and begins with an estimate of peak earthquake load calculated as a function of the parameters given in the code.

In this method, mass of the structure multiplied by design seismic coefficient, acts statically in a horizontal direction. It is also assumed here that the magnitude of the coefficient is uniform for the entire members of the structure. Design shears at different levels in a building shall be computed from the assumption of linear distribution horizontal accelerations, varying from zero at the base of the structure to a maximum at the top. For important and complicated structures

this method is not adequate. The distribution of equivalent lateral static forces at each floor level (where the seismic masses are lumped) of a multi-degree of freedom (MDOF) system is based on the first (fundamental) mode of vibration of the cantilevered structure. It begins with an estimation of base shear load and its distribution on each story calculated by using formulas given in the code.

This method requires less effort because, except for the fundamental period, the periods and shapes of higher natural modes of vibration are not required. The base shear which is the total horizontal force on the structure is calculated on the basis of the structure's mass, its fundamental period of vibration, and corresponding shape. The base shear is distributed along the height of the structure, in terms of lateral force, according to the code formula. Planar models appropriate for each of the two orthogonal lateral directions are analyzed separately, the results of the two analyses and the various effects, including those due to torsional motions of the structure, are combined. This method is usually conservative for low to medium-height buildings with a regular configuration.

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Result and Discussion

3. EXPERIMENTAL INVESTIGATIONS

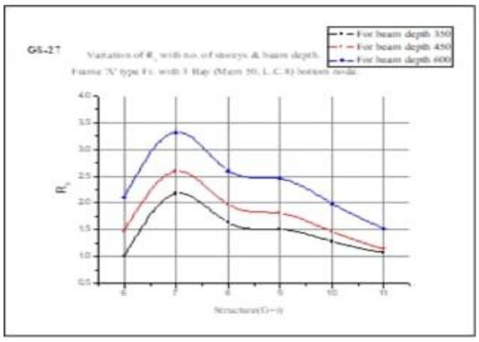
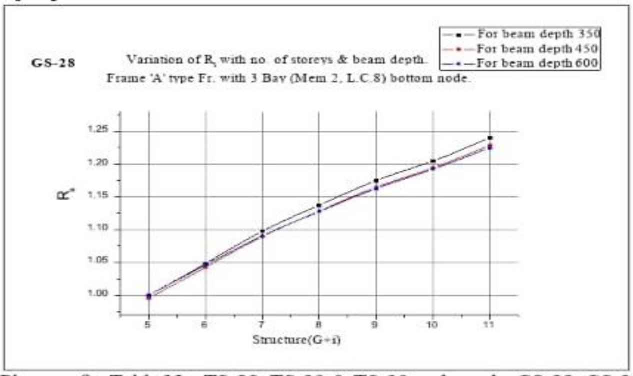


Table 4.2 variation of axial force, shear force and bending moment in member-164 i.e. bracing limbs adjoining member-50 of end column in 'A' braces

Structure	Load case	Node no.	Fx (KN)	Fy (KN)	Mz (KN-M)
G+6	8 1.5(DL-EQ)	29	77.204	2.076	1.633
G+7	8 1.5(DL-EQ)	29	154.608	2.036	1.771
G+8	8 1.5(DL-EQ)	29	192.139	1.861	1.552
G+9	8 1.5(DL-EQ)	29	215.344	1.79	1.494
G+10	8 1.5(DL-EQ)	29	234.171	1.752	1.457
G+11	8 1.5(DL-EQ)	29	249.517	1.732	1.437

In the context of combined dead and earthquake loads, it's unexpected for column shear to decrease with height, as typically lateral forces should increase. This suggests that other members in the braced frame are sharing the shear. Braces, indeed, absorb this shear, resulting in increased forces within them, especially as the structure's height increases. Bracing elements experience axial force growth, both with height and within bays, with these forces remaining within the section's capacity. Generally, bending moments and shears in bracing decrease as the frame's height-to-width ratio increases. The data also illustrates that shear initially rises as the frame's aspect ratio increases, with the rate of increase decreasing with greater beam depth.

B] In penultimate column



CONCLUSION

On the basis of the analyses result are carried out following conclusions are drawn for various types of structures.

1. It has been observed that in Axial force ,when there is progressive collapse, there will be sudden increase in Axial force ,when bracing are provided there will reduction in collapse

2. It has also been observed in Shear Force,Bending,and Deflection, when there is progressive collapse there will be suddenly increase im shear ,bending and Deflection,and when Bracing are Provided there will be Reduction in the Collapse.

A) Bare frame

1) Column segments at higher level attract larger axial forces as the beam depth increases. These segments are found to be more sensitive to the variation in stiffness of beam.

2) Despite allowing a large variation in column so as to minimize the lateral drift tall structures are found to violate the lateral drift criterion specified by IS: 1893 for all beams of same uniform depth, at all levels upto 450 mm. Heavy beams are necessary to limit maximum lateral drift to 0.004H in twelve storeyed structure.

B) 'A' and 'V' type braced frames

3) Axial forces attracted by column segment at upper levels are practically independent of stiffness of beam.

4) Axial force in columns increases as compared with that in bare frames.

5) Shear forces and bending moments in columns substantially reduce as compared with that in bare frame.

6) Braces are found to carry large axial forces compared with shear forces and bending moments, which are insignificantly small.

7) Axial force in brace in given structure goes on increasing at lower levels for 1.5(DL+EQ) combination. Neighboring braces are found to carry alternately compression & tension in 'A' type braces and tension & compression in 'V' type braces when one proceeds from left to right.

8) Axial force in brace at particular level goes on increasing as height of structure Increases.

9) Maximum lateral displacements are at found to reduce drastically as compared with bare frames.

C) **comparison of behaviors of 'A' and 'V' type braced frames**

10) 'A' type-braced frames are more rigid than 'V' type braced frames.

11) End columns in 'A' braced frames are loaded to smaller extent as compared to 'V' braced frames.

12) Shear in end column segment at intermediate level in 'A' type-braced frame reduces with increases in height of structure whereas that in 'V' type braced frame increases.

13) Axial forces carried by the braces in 'A' type-braced frames are smaller than those in 'V' type braced frames.

14) Considering all above points 10 to 13 'A' type-braced frames are found structurally more efficient than 'V' type braced frames.

D) Partially braced frames

15) For 5 bay G+11 structure that are braced along given number of bays with 'V' type bracing are found to be economical due to reduction in the column cross sections. These are more flexible than fully braced frames (but more rigid than bare frames) and yet

displacements produced are within permissible limits.

16) The section reduction referred to in 15 above is effected due to a substantial reduction in the bending moment in the worst loaded columns adjoining the braced bay as compared to the worst loaded column segment in bare frame. However the axial force in such column segment increases.

17) Forces and hence section requirements and increasing the flexibility to the extent possible so as to have displacement within permissible limit.

E) Variation of Various Internal Forces in the Columns after Progressive Collapse Various Internal Forces and Bending Moment in the Beam after Progressive Collapse

1) It can be observed that axial force, shear force, bending moment and Deflection increases with increase in story height.

2) It can be observed that there is not much variation in Ra with increase in bay width.

3) The variation of Axial Force Ra is approximately linear for Bare and Collapse frame and not for frame with bracings.

4) The variation of Bending Moment Rm increase with increase in story but the variation for bays is nearly similar in bare frame and Collapse frame

5) The variation of Deflection Rd is higher for higher story. Deflection can be reduced by Large amount by providing bracing.

6) The variation of Shear Force Rs is higher for lower width of structure for bare and collapse frame, but in case of bracing it is higher for large width.

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