A Review on Seismic and Progressive Collapse Evaluation of Reinforced Concrete Structure In-Filled with Masonry Infill Wall

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Abstract - *Buildings are subjected to a variety of natural hazards over their mean lives and around the globe structural multi-hazard analysis and design has become a hotbed of research. Earthquake and progressive collapse seem to be two of the major threats for these constructions. Consequently, limited research on the effects of seismic and progressive collapse designs on multi-story buildings has been done. A building's construction also contains a variety of structural and non-structural parts for various functions. When examining structural members, we as structural engineers, tend to focus on the structural members for resistance of buildings against any hazard and Non-structural components are often overlooked. However, several studies have shown that non-structural parts, such as infill walls, play a key role in increasing building resistance to natural disasters. As a result, the role of the infill wall against various risks must be investigated. The effect of infill walls in the case of progressive and seismic collapse of RC structures has received far less attention. In this study, it is decided to evaluate effect of different infill wall configuration in case of combine study of seismic and progressive collapse of reinforced concrete structures by using ETABS software. For this purpose four models 1) Bare Frame 2) Fully In-filled Frame 3) Open Ground Frame and 4) Open Ground & Intermediate Frame have been considered.*

Key Words: **Progressive Collapse, Seismic load, Infilled wall.**

1. INTRODUCTION

Eruptions often suddenly damage the structures. Primary members of building like columns and walls get damaged by intensive blasts and impacts. This results in loss of non-structural members, damage to some portion of structural members and collapse of structural components which leads progressive collapse in part or whole. As a consequence of failure of member in primary load resisting system, the loads are redistributed and if the redistributed loads exceed the capacity of the member, failure occurs. Building undergoes progressive collapse as this process continues throughout the structure. An isolated local failure may lead a significant deformation which then might result in collapse of structure. Present progressive collapse analysis and design methods are primarily concerned with preventing progressive collapse caused by abnormal gravity and blast loads. However, we haven't focused on issues related to the earthquake's progressive disintegration. The progressive collapse characteristic of structures produced by earthquake loading must be considered. It's crucial to think about how earthquake loading causes structures to progressively collapse. There are often irregular layouts in infill walls in structures, and the walls have a certain stiffness that will cause the infill walls to contribute the shear forces. As a result, the main frame of a masonry in-filled frame structure may be subjected to too great a shear force, which results in a safety hazard. A number of earthquake damage studies have shown that the damage to RC frame structures with infill walls differed from the damage to empty frames due to the interaction between the infill walls and frames. Several unforeseeable failure modes were present. Although masonry is not an engineered or structural element, it is known that it provides excellent resistance to earthquake than relatively flexible RC building could provide.

1.1 Progressive Collapse:

A progressive collapse of a structure is the development of an initial local failure which, if left unchecked, would ultimately result in the collapse of the entire structure. Increasingly, multi story collapse has become one of the key causes of structural failure. Blast, fire, seismic waves, aircraft hit and construction error are all examples of abnormal loading circumstances.

Types of progressive collapse:

- Zipper Type
- Pancake Type
- Instability Type
- Domino Type
- Section Type

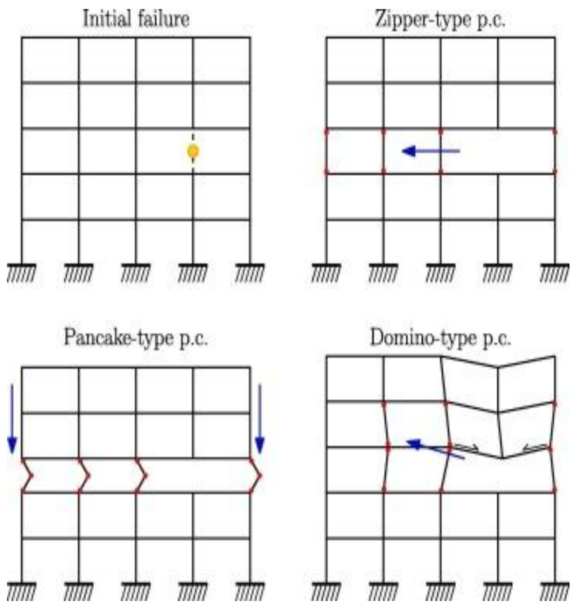

Fig -1: Types of Progressive Collapse

1.2 In-filled Wall:

In-filled material not only serves the purpose of peripheral protection and internal partition but many studies have proved that it also adds some strength and stiffness to resist lateral forces even not being structural component.

1.3 Objectives:

1. Assess the building's multi-hazard performance in terms of seismic and progressive collapse.
2. Checking the response of building to earthquakes and progressive collapse in the situation of abnormalities in mass caused by open and intermediate storeys as architectural requirements.
3. To determine the combined effect of seismic and progressive collapse affecting mass irregularity.

2. LITERATURE REVIEW:

A lot of research has been carried out on Reinforced concrete framed buildings subjected to earthquake. Studies contain behavior of RC frames for different conditions on the basis of different seismic zones, methods of analysis, types of construction materials and many different parameters to know the behavior of structure subjected to earthquake in various conditions. But structure does not tackle only seismic forces during its lifetime. Terrorist attacks, plane crashes, vehicle collapse, gas explosions, and other events can cause RC structures to be subjected to unexpected additional stresses, resulting in progressive collapse. Therefore, designing the structure to resist earthquake is not sufficient. We have to design important structure to resist these sudden loads too. Many researchers have carried out study on frames subjected to progressive collapse only. Construction materials and configuration, as we all know, have an important role in influencing the behavior of a structure in the event of various failures. Many researchers have analyzed effect of non structural materials and various architectural demands. But combine effect of all these parameters on structure is yet topic of study So in this research study several journal papers on previously explored issues are being referred and extensively studied.

L Decanini, F Mollaioli, A Mura and R Saragoni 2004 [1] A simplified equivalent discrete shear-type model, termed the ESTM model, was used to model MDOF systems. Its lateral stiffness, inertial, and strength qualities are similar to those of the frame structure, and its height can vary. Ten different R/C two bay-frames with identical story height and beam spans, with ten various numbers of stories were chosen in order to obtain data upon the seismic response of a broad range of current structures. In the analyses, three distinct types of masonry were used: weak in-fills, moderate in-fills and strong in-fills. It was discovered that the presence of infill walls causes the value of top displacement to fall significantly as they become stiffer and more resistant.

Digesh D. Joshi, Paresh V. Patel and Saumil J. Tank 2010 [2] In this study two frames of four-story and ten-story are analyzed according to GSA guidelines and demand capacity ratios are determined. The software SAP2000 is used to perform the linear and nonlinear static analysis. According to the findings of this study, appropriate reinforcing to restrict the DCR within the acceptability requirements and adequate detailing can be effective in preventing subsequent failure of beams and columns after failure of a specific column due to high loading from a blast. In general, It has been stated that structures planned and constructed with a suitable level of continuity, redundancy, and ductility can establish alternative load routes and prevent progressive collapse following the loss of an individual part.

Kaiqi Lin, Yi Li, Xinzheng Lu and Hong Guan 2017 [3] In this work, the seismic and progressive collapse designs of a series of six-story reinforced concrete (RC) frames are conducted separately according to the related design codes. The seismic and progressive collapse resistance is measured using fragility curves and collapse modes. Results found that under earthquakes, the RC frame's progressive collapse design may result in an unfavorable failure mode strong-beam-weak-column. So this investigation concluded that, for the multi-hazard prevention and reduction of building structures, a design strategy that takes individual dangers into account is inadequate.

Fabio Di Trapani, Luca Giordano and Giuseppe Mancini 2020 [4] In this study bare frame and in-filled frames have been investigated on the basis of parameters like aspect ratio, seismic detailing, and lateral constraint degree. Nonlinear finite-element modeling has done. On reference two-bay frames derived from several 5-story frame buildings, numerical pushdown tests depicting a column-loss situation are carried out. The projected dynamic load demand is compared to the bearing capacity in the column-loss scenario and capacity demand ratio has been determined. According to results it is found that In-filled frames have considerably higher strength and stiffness against vertical collapse than bare frames.

Babak Moaveni, Andreas Stavridis, Geert Lombaert and Joel P. Conte 2013 [5] A study on the detection of progressive damage is presented in this paper. The current approach employed was equivalent linear finite-element model updating. A two-thirds-scale, three-story, two-bay in-filled RC frame was tested on the UCSD–NEES shaking table to investigate the seismic performance of this style of construction. Between earthquake tests, low-amplitude white-noise base excitations were delivered to the in-filled RC frame at various damage levels. At various damage states for different modes, modal parameters of the infilled frame were discovered. The findings show that the approach can accurately pinpoint the location and level of damage in the tests but the level of damage indicated may not accurately reflect the loss of structural strength, as loss of stiffness is not well associated to actual loss of strength, according to a comparison of damage detection results with seismic shaking table test results.

Kai Qian, M.ASCE and Bing Li 2017 [6] In this investigation Push-down loading regimes were used to develop and test six multistory by multi bay RC sub frames and these Six sub frames were divided into two categories of bare frames without MI walls and infilled frames with MI walls. The impact of the MI wall on the load-bearing capacity, initial stiffness, and load-bearing mechanisms of RC frames to prevent progressive collapse was also assessed and discussed. According to this study, MI panels can raise first peak load and initial stiffness by 260 and 900 percent, respectively. Furthermore, when relative to bare frames, infilled model had a higher load resisting capacity in the major deformation phase and a nearly identical ultimate deformation capacity.

Trishna Choudhury1 and Hemant B. Kaushik 2018 [7] The goal of this study is to discover and statistically estimate the impact of uncertainty in the independent input factors that determine RC building seismic performance. In parametric nonlinear dynamic assessments of three variations of standard three-bay, four-story reinforced concrete frames, bare frame, open ground story frame, and fully infilled frame, random samples of uncertain parameters are employed. Employing various statistical and graphical methodologies, the relative impact of uncertainty in various input variables on response sensitivity is examined. By analyzing all the parameters it was found that the compressive strength of concrete and column size are shown to have the greatest impact on the seismic response of bare and open ground story frames.

Selim Gunay, Michael Korolyk, David Mar and Khalid Mosalam 2009 [8] The effectiveness of using rocking spines of strengthened infill walls as a retrofit strategy for non-ductile RC frames with un-reinforced masonry (URM) infill walls was investigated in this study. The study investigates the effects of stronger URM infill wall spines on the RC frame's behavior. A nine-story frame with five bays was chosen to demonstrate complex multi-story behavior, in which the collapse of stiff infill walls could result in the construction of a soft story mechanism. A comparison is made between a standard URM infilled frame and a retrofitted URM infilled frame. Nonlinear Static and dynamic analysis were performed. Results of analysis investigated that the proposed retrofit method is shown to be effective in decreasing interstory drifts and transforming concentrated drifts caused by soft story or shear failure of columns into uniform drifts over the height.

Kai Li, Curtis Wood and Halil Sezen 2017 [9] In this study Field experiments and computational models were used to analyze the progressive collapse performance of steel structures with unreinforced masonry walls and load-bearing wall structures using concrete masonry units (CMU). The major purpose of the field tests was to model the structural dynamic and static response of structures that might collapse due to the unexpected loss of a column or wall, as well as to look into how internal forces were transferred within the building after each wall or column was removed. The results of 2D and 3D models created with SAP2000 were compared. After analyzing the results it was found that Due to the sudden loss of a load-bearing element, the infill walls lower the deflection and amplitude in both 2D and 3D analytical results.

Kitnasamy Dhasindrakrishna and Priyan Dias 2019 [10] In this research Pushover analysis was used to investigate gradual collapse under lateral loads on a damaged structure. The proposed approach for calculating the collapse potential is demonstrated using a 10-story building with a short side middle column loss. A framework comparable to this one was previously utilized in a study on the adoption of linear static APM. The analysis was carried out using SAP 2000's direct integration time history analysis. It was observed that collapse began at the double-spanned beam directly above the removed column and went up to the highest floor, with the extent of the collapse being all short side beams framing into columns that are vertically aligned with the removed column.

Kamal Alogla, Laurence Weekes and Levingshan Augusthus 2017 [11] Nelson In this study two large-scale specimens were tested under quasi-static pressure to examine and evaluate the structural resistive capabilities of RC structures over progressive collapse. Two half-scale models were evaluated using the alternate load path method to explore progressive collapse resistance mechanisms as well as associated capacities for RC beam-columns. The structural characteristics of two RC sub-assemblage samples were exposed to a column loss scenario was explored in present research.

3. CONCLUSIONS

Above survey of literature informs that many researchers have carried out study on Reinforced concrete framed buildings subjected to earthquake. Studies contain behavior of RC frames for different conditions on the basis of different seismic zones, methods of analysis, types of construction materials and many different parameters to know the behavior of structure subjected to earthquake in various conditions. But structure does not tackle only seismic forces during its lifetime. RC structure may subject to sudden additional loads like impact loads due to terrorist attacks, airplane crash, vehicle collapse, gas explosion etc which leads progressive collapse. Therefore, designing the structure to resist earthquake is not sufficient. We have to design important structure to resist these sudden loads too. Many researchers have carried out study on frames subjected to progressive collapse only. As we all know, construction materials and configuration also play vital role in changing behaviour of structure in case of various failures and many researchers have analyzed effect of non structural materials and various architectural demands. However, because of advanced architectural features and shifting demands, the combined effect of all of these parameters on structure is still a subject of research.

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