REVIEW ON DIFFERENT FACTORS RESPONSIBLE FOR PROGRESSIVE COLLAPSE OF BUILDINGS

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Abstract- The term "progressive collapse" defined as the ultimate failure or proportionately large failure of a portion of a structure due to the spread of a local failure from element to element throughout the structure. Progressive collapse of building is initiated when one or more vertical load carrying members particularly columns are seriously damaged or collapsed during any of the abnormal event. Andsince the "911" event, progressive collapse of building structures has been widely concerned by engineers and researchers. This paper assesses the current researches on this issue. A progressive collapse can be triggered by accident actions, including fire hazard, gas explosion, terrorist attack, vehicle collision, design and construction errors, and environmental corrosion. With the development of industrialization, the buildings with multi-function and high complication become more common of which the safety and stability are far more concerned. Once a column is failed the building's gravity load transfers to the neighboring members in the structure. If those members are not properly designed to resist and redistribute the additional load that part of the structure will fails. As a result, a substantial part of the structure may collapse, causing greater damage to the structure than the initial impact.Different types of Progressive Collapse are studied in this review paper. Construction requirement parameters and a few related works on progressive collapse analysis are discussed in this paper.

Keywords- Progressive Collapse, Ductility, Earthquake, Shear Strength, Building Structure, Terrorist Attack.

I. INTRODUCTION

Awareness on the issue of progressive collapse took place after the structural failure of Ronan point in 1968. After the terrorist attack on Murrah federal office building in 1995 more and more research efforts were put to understand the progressive collapse. But it is important to note that collapse of the World Trade Centre (commonly known as 9/11) has led to the detailed investigations for the enhancement of robustness of structures in order to save precious loss of life and property under such attacks.

As per ASCE progressive collapse is defined as the dispersion of local damage, comprising any event which is initiated and transferred from one element to another element, ultimately resulting in the downfall collapse of the complete structure or disproportionately large part of it; also termed as disproportionate fall. The General Services Administration, USA adopts the basic definition of that "Progressive collapse is a situation where local failure of a primary structural component leads to the collapse of adjoining members which in turn leads to additional collapse". Department of defence (DoD) offers another definition as "A progressive collapse is a chain reaction of failure of building members to an extent disproportionate to the original localized damage". Progressive collapse is deformation of any load bearing element which initiate the local failure and transfer of additional load progression to the adjoining elements to generate disproportionate collapse. An increasing number of progressive collapse around the world leads more disastrous event leading to loss of life, injuries and large number of death. Considering this an important issue, United States Department of Defence (DOD) and United States General Services Administration (GSA), and Euro codes published a string of various guidelines and specifications. Two design approaches were recommended for design of new and existing building against the progressive collapse as: direct approach and indirect approach. Further, four levels of protection were recommended for the building according to department of defence i.e. HLOP (High level of protection), MLOP (Moderate level of protection), LLOP (Low level of protection) and VLOP (Very low level of protection) to classify the severity of the collapse. Based on the analysis, it was suggested that alternate load path analysis is necessary to perform for building to have high and moderate level of protection (HLOP and MLOP) and secure the tie forces on buildings which have low and very low level of protection (LLOP and VLLOP).

A. Types of Progressive Collapse

The progressive collapse might be categorized in to different types based on the reason of progression and as per the management of progressive collapse in the design rules and norms. The primary reasons resulting in progressive collapse includes the type of construction as well as the initiating event. The following section shows the categories of progressive collapse. The presented collapse modes are pancake, zipper, domino, instability, and section-type destruction.

1) Pancake-Type Collapse
2) Zipper-Type Collapse Research Elaborations
3) Domino-Type CollapseConclusions
4) Instability-Type Collapse
5) Section-Type Collapse

A. Construction Requirements

A considerable good project includes searching apart from the least requirements in construction as per the standards and norms. The presence of abnormal loads as well as their effects from position in addition with the probability of progressive collapse might be directly depicted in terms of codes and protocols as well as emerge as crucial portion of the design. Codes comprising the practice might be recorded and accounted regarding the risk involved in progressive collapse is essential component in design, regardless of whether the event while stimulating is a case of accident or normal load. Further, that this type of effect might be placed on the entire safety of the structure. In the general, the requirement to account the loads which are accidental as well as progressive collapse within the structures of design should be assumed in the structure norms and the standards regarding the performance requirement which appears in a normative document.

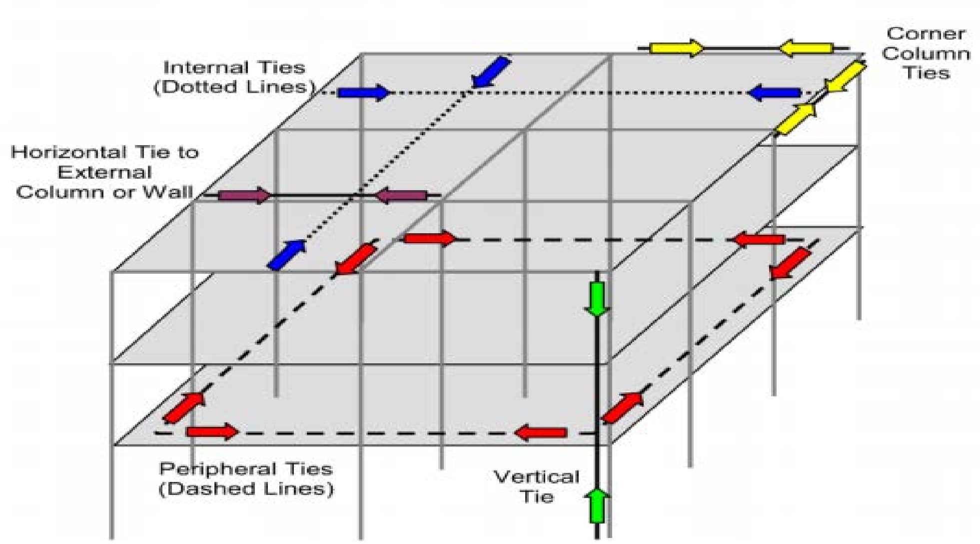

Figure 1 Different types of ties incorporated to provide structural integrity

1) Ductility

In case of shattering event, members along with the connections might have to sustain their strength by means of huge deformations (rotation as well as deflections) as well as dispersion of load linked with the loss of important elements. Regarding the reinforced concrete as well as masonry constructions, ductility is obtained by incorporating enough confinement comprising steel, giving the continuity in the reinforcement by the means of appropriate lap splices or couplers, sustaining the stability of the entire structure as well as forming links among the elements which expand the strength as well as toughness comprising the base members.

2) Adequate shear strength

Structural elements in vulnerable locations, such as perimeter beams or slabs, should be designed to withstand shear load in excess of that associated with the ultimate bending moment in the event of loss of an element. Direct shear failure is a brittle mode of failure and should not be the controlling failure mechanism. Shear capacity should always exceed flexural capacity to encourage a ductile response. Typical two-way slabs without beams must be capable of providing post-failure resistance in the presence of punching shear failures and severe distress around the columns.

3) Capacity for resisting load reversals

The primary structural elements (columns, girders, roof beams, and lateral load resisting system) and secondary structural elements (floor beams and slabs) should be designed, using acceptable techniques, to resist reversals in load direction at vulnerable locations.

II. LITERATURE REVIEW

Leslaw Kwasniewski (2010) presented a case study of progressive collapse analysis of a selected multi-story building. The subject of the numerical study is an existing 8-story steel framed structure built for fire tests in the Cardington Large Building Test Facility, UK. The problem is investigated using nonlinear dynamic finite element simulations carried out following the GSA guidelines. The paper focuses on model development for global models subject to increasing vertical loading and notional column removal. Taking advantage of parallel processing on multiprocessor computers, a detailed 3D model with large number of finite elements has been developed for the entire structure. The objective of the presented feasibility study is to identify modelling parameters affecting the final result (potential of progressive collapse) and propose a hierarchical verification and validation program for reducing outcome uncertainties.

Meng-Hao Tsai (2011) studied the effects of three common types of exterior non-structural RC walls on the progressive collapse potential of an RC frame are investigated. Linear and nonlinear static analyses are carried out for the RC frames with and without the non-structural walls under three different column-loss scenarios. Changes in demand-to-capacity ratios indicate that without considering the non-structural walls, the moment demand of beams may be overestimated while the shear demand may be underestimated, especially for the panel-type walls. They may increase the collapse resistance of the building frame under column loss, but with decreased ductility capacity. With a constant opening rate of 60%, the wing-type exterior wall is a better option than the parapet-type and panel-type walls from the structural aspect. The panel-type wall appears to be the worst choice since shear failure of their connected beam members may be induced.

P.P Chandurkar (2013) did a detail study to determine the solution for shear wall location in multi-storey building with the help of four different models. The buildings were modeled using software ETAB Nonlinear v 9.5.0.After analysing ten storey building for earthquake located in zone II, zone III, zone IV and zone V essential parameters like lateral displacement, story drift and total cost required for ground floor were found in both the cases by replacing column with shear wall and conclusion was drawn that shear wall in short span at corner (model 4) is economical as compared with other models. It was observed that shear wall is economical and effective in high rise buildings and providing shear walls at adequate locations substantially reduces the displacement due to earthquake. If the dimensions of shear wall are large then major amount of horizontal forces are taken by shear wall.

Samrat Prakash Khokale (2017) found critical Shear wall in building which causes maximum damage or collapse after the removal. Shear strength of Shear wall is the main factors considered for study. After this collapse pattern of building is studied using same software. This paper presents current design approaches found in the U.S. and European building codes and standards for the prevention of progressive collapse due to abnormal loading. Because the definition of abnormal loading is not well established, design provisions are based on an approach that protects buildings by means of strength, ductility and redundancy.

MD Goel et al (2017) had did investigations of 4 storey RCC building with 3 x 3 bays having longitudinal bay span of 5m and transverse bay span of 4m. The height of building is 3.5 m at each floor except the ground floor of 4m height. The behavioural changes have been investigated to sudden collapse of load bearing member.

Alok Rathore (2017) development of Tall building has been rapidly increasing worldwide introducing new challenges that require to be met through structural style by correct engineering judgments. In trendy tall buildings, lateral hundreds induced by wind or earthquake are typically resisted by a system of coupled shear walls. however once the building will increase in height say 90 m, the stiffness of the structure becomes additional vital as height of the building will increase, the stiffness of the building reduces then the lateral load resisting system is employed offer sufficient lateral stiffness by providing outrigger beams between the core and external columns is usually wont to provide spare lateral stiffness to the structure. The outrigger with Belt truss is employed as one of the structural system to effectively management the excessive drift because of lateral load. Thus, it'll improve the performance by preventing the structural and non-structural damage of the building below seismic loading and wind loading. The objective of this paper is to check the outrigger structural system in high rise RC building below the action of laterals hundreds like seismic hundreds and wind load.

Reddy, 2016 studied the stress concerning recognizing the presence of floating column in multi-storeyed buildings and the way to reduce the risk issue of earthquake effects by strengthening the floating columns building with Bracings. Throughout this present study four models are used specifically, ‘Model 1 (G+9 normal RC Building)’, ‘Model 2 (G+9 RC Floating column Building)’, ‘Model 3 (G+9 RC Floating column Building with Bracings at corner)’, ‘Model 4 (G+9 RC Floating column Building with Bracings at centre)’. Seismic analysis is meted out on all four models using Equivalent static technique and Response spectrum technique in 2 zones (III, V) severally. Comparison of results structure shears, structure Drifts, most Displacement, period of time and Base shear for all four models are dead. Because the Model four throw in higher results compared to different Models, its performance is reviewed using pushover analysis and also the performance levels are mentioned by comparison Model four with Model three. This seismic assessment is dead exploitation ETABS software system as per the code book IS:1893-2002.

Sharma et al, 2016 In the project studies the analysis of G+5, G+7, G+9, G+11 and G+13 floor building with floating column and while not floating is allotted. The analysis is finished by using Staad pro V8i computer code by exploitation Response spectrum analysis. The paper deals with the results variation in displacement of structure, base shear, and seismic weight calculation of building from manual calculation and Staad pro V8i. From the response spectrum analysis it's noticed that the floating column building has extra displacements than a building with none floating column. Therefore Floating column building is unsafe than a traditional building. It’s found that amount of steel and concrete got to increase in floating column building to stay it safe in earthquake excitation. Therefore floating column building becomes uneconomical as compare to traditional building.

Bhavya et al, 2016 in the present work, the recommendations like the impact of Infill, Bracings and Shear wall are introduced within the building so as to enhance the seismic performance. The structural action of masonry infill panels are taken into account by modelling them as diagonal struts. Equivalent static and response spectrum strategies are used for analysis by ETABS 15.2.0 software. The structure was assumed to be located in earthquake Zone III & V on a medium soil (type II). Floating column building shows poor performance throughout earthquake. RC frame buildings with open initial storeys are renowned to perform poorly throughout in robust earthquake shaking. The drift and also the strength demands within the initial structure columns are very giant for buildings with soft ground storeys. It’s not very simple to produce such capacities within the columns of the primary structure. Thus, it's clear that such buildings can exhibit poor performance throughout a powerful shaking. This hazardous feature of Indian RC frame buildings must be recognized at once and necessary measures taken to enhance the performance of the building. The displacement of building will increase from lower zones to higher zones, as a result of the magnitude of intensity are a lot of for higher zones, equally for drift, and as a result of it's related with the displacement. all told models the displacement values are less for lower zones and it goes on will increase for higher zones in ESA and RSA strategies.

Kumar, 2016 this study highlights the essentialness regarding clear recognition of the presence of a floating column within the evaluation of the building. Optional measures, that involve stiffness balance regarding the initial level and in addition with the level over, are strategized to degrade the irregularity penetrated by the floating columns. FEM codings were formed regarding the second multi-level framework on the other hand non-floating column to review the responses of the construction beneath entirely separated earthquake event comprised of varying frequency keeping the PGA as well as the length of time is consistent. The time history of floor displacement, inter story drift, base shear, overturning moment are computed for every the frames with and whereas not floating column. The compatible time history and Elcentro earthquake data has been thought-about. The PGA of every the earthquake has been scaled to 0.2g and length of excitation are unbroken same. A finite element model has been developed to review the dynamic behaviour of multi-story frame. The static and free vibration results obtained using present finite element code is valid. The dynamic analysis of frame is studied by varied the column dimension. It’s all over that with increase in ground floor column the most displacement; inter story drift values are reducing. The lowest shear and overturning moment vary with the modification in column dimension.

Motghare, 2016 researched the analytical studies administered to judge the performance of RCC frame underneath totally different position of floating column. Building with column that hangs or floats on beams at an intermediate story and don't go all the way to the foundation, have discontinuities within the load transfer. The analysis has been administered on a 5 story RCC frame structure that has been analysed. Analysis was administered considering totally different positions of floating column by using STAAD professional. The results of position of floating column were collectively studied. The bending moments are higher for all the floating column cases. The ultimate most bending moment’s values are influenced by the presence of floating column. The analysis proves that floating columns are harmful for the structures and it's necessary to possess less complicated and regular shapes of frames additionally as uniform load distribution round the building. Therefore, potential irregularities during a building should be avoided.

III. CONCLUSION

A range of factors have been shown to lead to progressive collapse, including accidental or deliberate impacts and explosions, design or construction errors, as well as poor maintenance. Progressive collapse is caused by a series of structural element failures due to large loads that exceed the elements capacities. A range of factors that lead to progressive collapse includes accidental or deliberate impacts and explosions, design or construction errors, as well as poor maintenance. Engineer’s main aim is to design the structure such that it causes less causality to people after accidental collapse. Researches need to be carried out and experimental programs are to be arranged so as to develop provisions to resist progressive collapse in structures. The existing methods to assess the structural robustness are mainly used in researches and the application of them in the practical design is rare due to the obscure physical and mathematic signification and the complex calculation. The engineering-friendly assessment is required to improve the progressive collapse design. The experimental technique for the dynamic collapse test should be investigated to promote the researches on this issue.

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