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Review on Analysis of Steel Connections in Progressive Collapse of Steel Structure

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ABSTRACT

This paper focuses only on the literature review about various concepts of Progressive Collapse Analysis. In this chapter we are going study in depth about progressive collapse analysis. In this chapter we will discuss various types of Progressive Collapse, various analysis methods of Progressive Collapse etc. Progressive collapse of structures is characterized by a disproportion in size between a triggering event and the resulting collapse. Although the disproportion between cause and effect is a defining and common feature, there are various differing mechanisms that produce such an outcome. Review various guidelines & techniques used for to analysis of progressive collapse analysis and to develop a report in the form of literature review. Identify an appropriate technique and suitable guideline from the reviewed literature for progressive collapse analysis of industrial shed. On basis of above characteristics progressive collapse of structure is differentiated which is as follows. Progressive collapse is the result of a localized failure of one or two structural elements that lead to a steady progression of load transfer that exceeds the capacity of other surrounding elements, thus initiating the progression that leads to a total or partial collapse of the structure.
Keywords- ***progressive collapse Analysis,localized failure, load transfer,partial collapse.***

1. INTRODUCTION:

Progressive collapse is referred to a localized failure, due to an unexpected event such as an accidental blast, causes the failure of adjoining structural elements, which in turn spread further resulting in the collapse of the entire structure or a disproportionally large part of it. Since the collapse of World Trade Centre twin towers in 2001, structural design to resist progressive collapse has garnered tremendous attentions from civil engineering community. The DoD guideline was the very first rigorous criteria on the design of buildings to resist progressive collapse. A recent Canadian standard also reflected many new developments in this field. Both direct and indirect approaches to resist progressive collapse have been outlined in these guidelines with various levels of details and effectiveness.

The alternate load path method, a direct design approach where in a building's integrity and robustness are assessed under a condition of instantaneous loss of a column or a wall, has become a commonplace in the design of buildings to resist progressive collapse. In this methodology, a building is mainly subjected to service gravitational loads while one of the columns is assumed to be removed. The design objective is to ensure that the building structure can bridge the resulting double-span condition to arrest the local failure. Traditionally, steel connections are designed for a shear force only (for a simple connection) or a shear force plus a bending moment (for a semirigid or rigid connection). The rotational ductility demand for the connections is not greater than 0.03 radians under gravity loads and not greater than 0.05 radians under earthquake events. However, under a double-span condition, the primary strength action on the affected connections is catenary tensile force and the moment and shear actions become secondary, while the rotational ductility demand on the connections could reach as large as 0.10 radians. A shear or semi-rigid connection is usually the weakest link in the loading path of bridging the removed column. Thus, the robustness design of the connections plays a critical role to the overall integrity of the structure. Gong was among the first to point out that the supply of connection ductility is at the core of connection robustness design. Gong further suggested that the capacity design principle, a method commonly adopted in seismic design, should be applied to connection detailing for ductility supply. how to obtain the strength and stiffness of connection components. Finally, an analysis of various steel connection under the removal of column which happens to be lost at start of progressive collapse.

1.1 PROGRESSIVE COLLAPSE –

Progressive collapse is the collapse of all or a large part of a structure precipitated by damage or failure of a relatively small part of it. The phenomenon is of particular concern since progressive collapse is often disproportionate, i.e., the collapse is out of proportion to the event that triggers it. Thus, in structures susceptible to progressive collapse, small events can have catastrophic consequences.It has also been suggested that the degree of "progressivity" in a collapse be defined as the ratio of total collapsed area or volume to the area or volume damaged or destroyed directly by the triggering event.To understand the progressive collapse we have studied some of past examples of progressive collapse as follows.

[1] **progressive and disproportionate collapse of the Ronan Point apartment tower in England in 1968,**prevention of progressive collapse became one of the unchallenged imperatives in structural engineering, and code-writing bodies and governmental user agencies attempted to develop design guidelines and criteria that would reduce or eliminate the susceptibility of buildings to this form of failure. These efforts tended to focus on improving redundancy and alternate load paths, to ensure that loss of any single component would not lead to a general collapse. But in fact, redundancy is only one of the ways of reducing susceptibility to disproportionate collapse. Improved local resistance for critical components and improved continuity and interconnection throughout the structure (which can improve both redundancy and local resistance) can be more effective than increased redundancy in many instances. Through an appropriate combination of improved redundancy, local resistance, and interconnection, it should be possible to greatly reduce the susceptibility of buildings to disproportionate collapse. On the morning of 16 May 1968, Mrs. Ivy Hodge, a tenant on the 18th floor of the 22-story Ronan Point apartment tower in Newham, east London, struck a match in her kitchen. The match set off a gas explosion that knocked out load-bearing precast concrete panels near the corner of the building. The loss of support at the 18th floor caused the floors above to collapse. The impact of these collapsing floors set off a chain reaction of collapses all the way to the ground.

[2]The Murrah Federal Office Building in Oklahoma City was destroyed by a bomb on 19 April 1995,The bomb, in a truck at the base of the building, destroyed or badly damaged three columns. Loss of support from these columns led to failure of a transfer girder. Failure of the transfer girder caused the collapse of columns supported by the girder and floor areas support ed by those columns. The Murrah Building disaster clearly was a progressive collapse by all the definitions of that term. Collapse of a large part of the building was precipitated by destruction of a small part of it (a few columns). The collapse also involved a clear sequence or progression of events: column destruction; transfer girder failure; collapse of structure above. But was the Murrah Building collapse disproportional? The answer is not nearly as clear as in the case of the Ronan Point collapse. The Murrah collapse was large. But the cause of the collapse, the bomb, was very large too, large enough to cause damage over an area of several city blocks. Ultimately, we must judge the Murrah Building collapse "possibly disproportional" only in the sense that we know now that with some fairly modest changes in the structural design (as will be discussed), the damage from the bomb might have been significantly reduced.

[3] **Twin towers of World Trade Center 1 and 2 collapsed on 11 September 2001 following this sequence of events:**A Boeing 767 jetliner crashed into the tower at high speed; the crash caused structural damage at and near the point of impact and also set off an intense fire within the building; the structure near the impact zone lost its ability to support the load above it as a result of some combination of impact damage and fire damage; the structure above collapsed, having lost its support; the weight and impact of the collapsing upper part of the tower caused a progression of failures extending downward all the way to the ground.

2. LITERATURE REVIEW-

[1]**A Thesis in Civil Engineering by Hyun Chang Yim 2007 –** Connections are one of the most significant contributors to decide the ductility and robustness of a steel framed structure. Particularly, moment connections have been used in lateral loading resistant frame design due to their ability to reduce the relative rotation between beams and columns. However, they are vulnerable to static and dynamic loads, such as progressive collapse rate, earthquake, and blast-rate loads. Therefore, it is essential to understand and determine the steel connection behaviours in order to offer the necessary structural capabilities in design for resisting blast and progressive collapse. In present study the welded unreinforced flange-bolted-web connections (WUF-B), one of the commonly used moment connections, were characterized with respect to the quasi-static and blast-rate pressure loads. The characterization process was carried out by finite element analyses of a full three-dimensional connection assembly. Moment-rotation curves, moment-tip displacement relationships, rotation dynamic increase factors, and moment-impulse diagrams were utilized as static and dynamic connection properties. The complicated connection configurations were simplified using infinitesimal point element with the mechanical properties. Other possible configuration of WUF-B connections was designed and analysed in both quasi-static and short duration loading environment. The characterized resistant functions were compiled in the database. Steel connections are divided into three categories based on the degree of restraint, such as fully rigid, partially rigid, and simple connections. The target connection details in the current study are fully restrained connections. Several experimental and numerical studies were carried out that investigate the static

and cyclic behaviour of steel connections. Very little information, however, is available on steel connections subjected to high-speed loading, such as impact and blast. This study is aimed at the determination of connection properties under both quasi-static and high-speed loads. M–θ curves and Pi diagrams will be derived in this study to accomplish the static and dynamic characterizations of the connections, respectively. The last section of this chapter introduced a numerical approach that converts highly detailed beam-column connections to a simple frame model utilizing beam and connector elements that include the corresponding properties.

[2]**Basics of Progressive collapse - R. Shankar Nair, Ph.D., P.E., S.E. (senior vice president of Teng & Associates, Inc. in Chicago.) –**Progressive collapse is the collapse of all, or a large part of a structure precipitated by damage or failure of a relatively small part of it. The phenomenon is of particular concern since progressive collapse is often (though not always) disproportionate, i.e., the collapse is out of proportion to the event that triggers it. Thus, in structures susceptible to progressive collapse, small events can have catastrophic consequences. After the progressive and disproportionate collapse of the Ronan Point apartment tower in England in 1968, prevention of progressive collapse became one of the unchallenged imperatives in structural engineering, and code-writing bodies and governmental user agencies attempted to develop design guidelines and criteria that would reduce or eliminate the susceptibility of buildings to this form of failure. These efforts tended to focus on improving redundancy and alternate load paths, to ensure that loss of any single component would not lead to a general collapse. But in fact, redundancy is only one of the ways of reducing susceptibility to disproportionate collapse. Improved local resistance for critical components and improved continuity and interconnection throughout the structure (which can improve both redundancy and local resistance) can be more effective than increased redundancy in many instances. Through an appropriate combination of improved redundancy, local resistance, and interconnection, it should be possible to greatly reduce the susceptibility of buildings to disproportionate collapse.

[2] **The ability of single angle connections to resist specified horizontal tie forces by Roddis and Blass (2012)-**In order to investigate the ability of single angle connections to resist specified horizontal tie forces, a finite element study of single angle connections in tension was completed by Roddis and Blass (2012). The study found that the method presented in AISC 360-10 (AISC, 2010) for calculating prying forces grossly underpredicts the capacity of single angles in tension due to the flexibility of the angle leg that generates the prying force. Future physical testing of single angle connections under high tensile loads was recommended to augment the limited data currently available on the topic.

3 AIM & OBJECTIVE -

AIM: Analysis of steel connection in progressive collapse of steel structure.

OBJECTIVE:

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

4. THEORETICAL CONTENT-

4.1 PROBLEM STATEMENT-

In the present study, the analytical approach on the steel structure behaviour due to progressive collapse of steel structure is studied. In this study, especially the response or behaviour of steel connection provided at the joints of members will be studied such as bolted, welded, riveted. These connections will be modelled in Ansys software. In Ansys software finite element analysis of connection will be observed. For this we are using General Service Administration Guidelines 2016 (GSA 2016).

4.2 METHODOLOGY-

1. Data collection and literature survey with respect to topic.
2. Fixing the objective and methodology.
3. Development of the analytical model of a steel connection joint in Abacus.
4. Application of loads due to critical member loss as per GSA and UFC guidelines.
5. Analysis of the steel connection in every possible scenario for every case.
6. Finding and Interpretation of results and making a fine conclusion.

4.3LIMITATIONS-

1. It is impossible to achieve perfect progressive collapse as a practical study as it will be very costly.

2. Performing such a test physically needs large funding and involvement of senior engineers having high industrial and commercial EPC (engineering, procurement, and construction) experience.
3. It is also impossible to achieve the exact increase in load on particular steel connection in progressive collapse.
4. we can only assume such a load by repetitive progressive collapse analysis of structure.
5. In case of building study if we found a flaw in connection or member that might overcome by upgrading the connection or member. The existing architectural and building services systems and the operational requirements of existing facilities place practical limitations on the hardening of existing facilities.

4.CONCLUSION-

1.This paper focuses only on the literature review about various concepts of Progressive Collapse Analysis. This project will go into the intricacies of progressive collapse analysis.
2.This chapter will cover the different kinds of Progressive Collapse, as well as the various techniques for analyzing Progressive Collapse.
3.Progressive collapse of structures is defined by a size disparity between the triggering event and the collapsed structure. Although the imbalance between cause and effect is a defining and widespread characteristic, it is produced by a variety of distinct processes.
4.The structures have been built to withstand both gravity and lateral loads in line with Iranian law and have passed all seismic criteria pertaining to strength and drift limitations. In this article, buildings are built according to the Iranian building code, and the results of push-over analysis in target displacement are compared to the UFC and GSA nonlinear analysis approval criteria.

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