PROGRESSIVE COLLAPSE OF SHEARWALL STRUCTURE UNDER ACCIDENTAL LOAD

Prof. Samrat Prakash Khokale[1] , Lalit Narendra Chaudhari[2]

[1]Department of Civil Engineering,
Sandip Institute of Technology & Research Centre, Nashik. Maharashtra, (India)
[2]Department of Civil Engineering,
Jawahar Education Society's Institute of Technology, Management & Research, Nashik, Maharashtra, (India)

ABSTRACT

In 21th century structural Hazard occurs more due to some reasons. The objective of this project is to find 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.

Keywords**: *Abnormal loading, Critical Shear wall, Ductility, Hazard, Shear Strength.***

I. INTRODUCTION

In the United States and other Western nations, progressive collapse is a relatively rare event. But after the remarkable partial collapse of the Ronan Point apartment tower in 1968 initiated an intellectual discussion among the engineering community on the possible ways to design buildings against such catastrophic progressive types of failure. While there have been several notable building collapses with similar characteristics in the years since Ronan Point, the debate considerably intensified after the World Trade Center disaster on 11 September 2001. In the after that of these events, a wide range of explanations were offered in an attempt to help the public understand the cause of the tragedy. Moreover, the performance of buildings under extreme loading conditions which can lead to progressive collapse, such as aircraft impacts, vapor cloud explosions and bomb blasts, has been under meticulous scrutiny. The main issues that have been identified include: i) the dynamic robustness of tall buildings which are susceptible due to their size, location, or function to a deliberate or accidental extreme loading event, ii) the mechanisms that could possibly trigger propagation of the initial damage following the event, and iii) the design guidance that needs to be introduced in order for buildings to survive such events and assure life safety of their occupants.

Prescriptive code provisions used in conventional structural design for normal loads usually provide a structural system with a degree of strength and ductility that is also available to resist extreme loads and prevent progressive collapse. Older building frame construction, which typically employed relatively small structural bays and reinforced concrete or masonry infill panels, was inherently robust and resistant to progressive failure (Burnett 2005). The change in architectural trends in combination with the evolution in building practices facilitated by computer-aided design and the use of high- performance materials has led to modern building systems that are relatively light and flexible.

Therefore more vulnerable to loading condition beyond the anticipated design envelope new construction technologies intended to minimize erection costs are also likely to result in structures with limited continuity and energy absorption capacity, which both are crucial factors in reducing susceptibility to progressive collapse

II. BACKGROUND

2.1. Ronan Point Apartment Building ,London, England, May 1968-

Ronan Point was a development of apartment buildings in London. It was built between 1966 and 1968. On the morning of May 16, 1968, a gas leak caused an explosion in an apartment of the 18th floor of one of the buildings. The explosion blew out an exterior wall panel. The loss of an exterior wall triggered the collapse of the upper floors followed by the collapse of the floors below due to the impact of the falling upper floors As a result, the British adopted explicit progressive collapse design measures into their building code.

B. Skyline Plaza March 2, 1973:

While concrete was being placed on the 24th floor and shoring removal was occurring on the 22nd floor, a collapse occurred for the full height of the tower. Impact of debris also caused

Horizontal progressive collapse of entire parking garage under construction adjacent to the tower. As a result 14 workers killed, 34 injured.

C. Alfred P. Murrah Federal Building, April 19, 1995:

The Alfred P. Murrah Building located in Oklahoma City, Oklahoma, was an office facility for the U.S. government. On the morning of April 19, 1995 the Murrah Building was the target of a terrorist attack in which a truck bomb was detonated in front of its north side. The explosion caused extensive structural damage to the building.

D. Khobar Towers, Saudi Arabia, June 25, 1996:

Khobar Towers was a complex of numerous apartment buildings in Al-Khobar near Dhahran, Saudi Arabia. On June 25, 1996, one of the apartment buildings was extensively damaged and others were seriously damaged when a massive bomb was detonated in the road way that passed in front of the building.

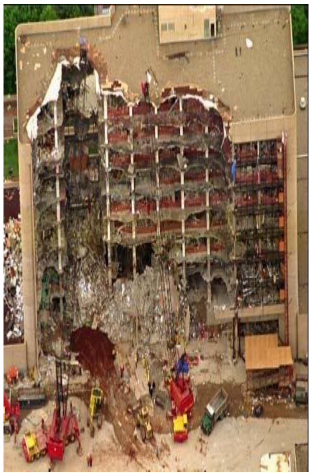

Fig.1. Ronan point after collapse. **Fig.2. Khobar towers** **Fig.3. World trade centre**

III. OBJECTIVE AND SCOPE OF STUDY

3.1 .Objective

In the present study High rise Shear wall structure is analyzed with and without removal of Shear wall. A detailed evaluation of behavior of structure is carried out under the loss of shear wall. Main object of study is to find out the critical shear wall locations performing maximum no iterations and study the collapse path of structure. Then to provide remedial measures to avoid the collapse.

3.2. Scope of Study

To fulfill the above objective following scope of work was outlined.

1 High rise shear wall structure (building) is analyzed and design by conventional method for dead load, live load, wind or earthquake load in ETAB software.

2 The above structure is further analyzed for removal shear wall considering impact load.

3 Then compare these results with first case which is without accidental load to see the collapse path by using same software.

4 The main aspects considered in the comparison point of view are Shear strength of shear wall.

3.3. What is Progressive Collapse?

A building undergoes progressive collapse when a primary structural element fails, resulting in the failure of adjoining structural elements, which in turn causes further structural failure. The resulting damage is disproportionate to the original cause, so the term disproportionate collapse is also used to describe this collapse type.

As per the American Society of Civil Engineers (ASCE) Standard: the spread of an initial local failure from element to element, eventually result the collapse of an entire structure or a disproportionately large part of it.

IV. HAZARDS

A number of potential abnormal load hazards, which could trigger progressive collapse, are considered in the following paragraphs.

1. Gas Explosions
2. Bomb explosion (Blast load)
3. Design/Construction error
4. Fire
5. Overload due to occupant misuse
6. Vehicular collision
7. Aircraft Impact
8. Transportation and storage of hazardous materials

V. LITERATURE REVIEW

5.1 Name: Progressive collapse basics

By: R. Shankar Nair

Paper related to prevention of progressive collapse using different method. Researcher study different cases and suggest preventive measures.

5.1.1 Methods of preventing progressive collapse:

Redundancy or alternate load path:

In this approach, the structure is designed such that if any one component fails, alternate paths are available for the load in that Component and a general collapse does not occur. This approach has the benefit of simplicity and directness. In its most common application, design for redundancy requires that a building structure be able to tolerate loss of any one column without collapse. This is an objective, easily-understood performance requirement. In fact, since it is generally much easier to design for redundancy of a small and lightly-loaded column, redundancy requirements may have the unfortunate consequence of encouraging designs with many small (and vulnerable) columns rather than fewer larger columns. For safety against deliberate attacks (as opposed to random accidents), this may be a step in the wrong direction.

Local resistance:

In this approach, susceptibility to progressive/disproportionate collapse is reduced by providing critical components that might be subject to attack with additional resistance to such attacks. This requires some knowledge of the nature of potential attacks. And it is very difficult to codify in a simple and objective way.

Interconnection or continuity:

This is, strictly speaking, not a third approach separate from redundancy and local resistance, but a means of improving either redundancy or local resistance (or both). Studies of many recent building collapses have shown that the failure could have been avoided or at least reduced in scale, at fairly small additional cost, if structural components had been interconnected more effectively. This is the basis of the structural integrity requirements in the ACI 318 specification (ACI, 2002).

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 Prevention of progressive collapse is one of the unchallenged imperatives in structural engineering today. But in fact, a building's susceptibility to progressive collapse should be of particular concern only if the collapse is also disproportionate. Indeed, the engineering imperative should be not the prevention of progressive collapse but the prevention of disproportionate collapse (be it progressive or not).

There are, in general, three approaches to designing structures to reduce their susceptibility to disproportionate collapse:

Redundancy or alternate load paths, where the structure is designed such that if any one component fails, alternate paths are available for the load in that component and a general collapse does not occur.

Local resistance, where susceptibility to progressive/disproportionate collapse is reduced by providing critical components that might be subject to attack with additional resistance to such attacks.

Interconnection or continuity, which is, strictly speaking, not a third approach
separate from redundancy and local resistance, but a means of improving redundancy or local resistance or both.

The emphasis on redundancy over all alternatives in some recent codes and standards and user- agency requirements may not lead to buildings that are less susceptible to disproportionate collapse as a result of deliberate attack.

5.2 Methods: GSA Criteria

The method discussed in the GSA publication is normally used for buildings 10 stories above grade and less, but can be applied to taller buildings.

To analyze for progressive collapse potential, different scenarios are assumed. Each scenario assumes the instantaneous removal of a shear wall in the first story, for a pre- scribed set of load combinations and material strength factors. The GSA procedure is as follows:

1. Shear wall to be removed are selected near the middle of the short side of the building, near the middle of the long side of the building, and at the building corners. For buildings that have underground parking areas or uncontrolled ground floor area, an interior shear wall loss also has to be evaluated.

2. Building dead load factors are amplified to account for the dynamic effects' resulting from the blast. The small probability for the presence of full live load during this extreme event is accounted for by decreasing the live load factor.

3. Material strengths are increased to account for the effect of the increased Rate of loading caused by the instantaneous support removal

4. The potential for progressive collapse is evaluated based on a demand-capacity-ratio (DCR). DCR is defined as the ratio of the force (bending moment, axial force, shear force) in the structural member after the instantaneous removal of a Shear wall for each scenario to the member capacity.

5 .The maximum allowable extent of collapse resulting from the instantaneous loss of a shearwall should be confined to the smaller of the following two areas:

1) Structural bays directly associated with the instantaneously removed shear wall or

2) 1,800 square feet at the floor level directly above the instantaneously removed exterior shear wall or

3) 3,600 square feet for an interior shear wall. If the damaged area exceeds the maximum allowed above, strengthening of structural members is required.

5.3 Progressive Collapse Provisions in Codes and Guidelines

Since the progressive collapse of the Ronan Point apartment tower in 1968, many Codes standards have attempted to address this type of collapse. A sampling of current and recent provisions related to progressive collapse highlights alternative approaches and the direction in which these efforts are evolving.

ASCE 7-02: The American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures (ASCE, 2002) has a section on general structural integrity that reads: Buildings and other structures shall be designed to sustain local damage with the structural system as a whole remaining stable and not being damaged to an extent disproportionate to the original local damage. This shall be achieved through an arrangement of the structural elements that provides stability to the entire structural system by transfer ring loads from any locally damaged region to adjacent regions capable of resisting those loads without collapse. This shall be accomplished by providing sufficient continuity, redundancy, or energy-dissipating capacity (Ductility), or a combination thereof, in the members of the structure.

The focus in the ASCE standard is on redundancy and alternate load paths over all other means of avoiding susceptibility to disproportionate collapse. But the degree of redundancy is not specified, and the requirements are entirely threat-independent.

ACI 318-02: The American Concrete Institute Building Code Requirements for Structural Concrete (ACI, 2002) include extensive Requirements for structural integrity in the chapter on reinforcing steel details. Though the Commentary states that it is the intent of section to improve redundancy there is no explicit mention of redundancy or alternate load paths in the Code. The Code provisions include a general statement that In the detailing of reinforcement and connections, members of a structure shall be effectively tied together to improve integrity of the overall structure and many specific prescriptive requirements for continuity of reinforcing steel and interconnection of components. There are additional requirements for the tying together of precast structural components. None of the ACI provisions are threat-specific in any way. removal of one column or one 30' length of bearing wall without collapse. Considerable detail is provided regarding the features of the analysis and the acceptance criteria. In some ways, these guidelines appear to be a throwback to the GSA's PBS Facilities Standards of 2000, in that their central provision is a requirement f or one-member redundancy, unrelated to the degree of vulnerability of the member or the level of threat to the structure

VI. MODELING OF HIGH RISE R.C.C. BUILDING IN ETAB 9.7.2 V

Here high rise Shear wall Building considered for the analysis purpose. This kind of structure is generally used as residential apartments, hotels, office buildings, School building purpose.

6.1 Loads Coming on high rise buildings

Generally following loads comes on the tall buildings

Dead Load

Live Load

Wind Load

Earthquake Load

The lateral forces are primarily generated by the wind and the earthquake forces.

ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS Version 9.7.2 features an intuitive and powerful graphical interface coupled with unmatched modeling, analytical, and design procedures, all integrated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviors, making it the tool of choice for structural engineers in the building industry.

Many of the floor levels in buildings are similar. This common-laity can be used to dramatically reduce modeling and design time.The input and output conventions used correspond to common building terminology. With ETABS, the models are defined logically floor-by-floor, bay-by-bay and wall-by-wall and not as a stream of non-descript nodes. and elements as in general purpose programs. Thus the structural definition is simple, concise and meaningful.In most buildings, the dimensions of the members are large in relation to the bay widths and story heights. Those dimensions have a significant effect on the stiffness of the frame. ETABS corrects for such effects in the formulation of the member stiffness, unlike most general-purpose programs that work on center-line-to-centerline dimensions.

The results produced by the programs should be in a form directly usable by the engineer. General-purpose computer pro-grams produce results in a general form that may need additional processing before they are usable in structural design.For the modeling here we considered the plan of existing building having appropriate shear wall sizes. Modeling of plan is done in ETAB software of 9.7.2 V.

6.2 Preliminary Data

1. Type of structure: High Rise Shear wall Structure
2. Number of stories: G+10
3. Live load: 2 KN/m²
4. Floor Finish: 1.5 KN/m²

5. Depth of slabs: 125 mm, 140 mm,

6. Unit weight of RCC: 25 KN/m^3

7. Unit weight of masonry: 20 KN/m^3

8. Height of each storey: 3 m

9. Height of the building: 30 m

10. Zone : III

11. Software used: ETAB 9.7.2

6.3 Basic load cases.

1. Dead Load.
2. Live Load.
3. Earthquake load in X direction.
4. Earthquake load in Y direction.
5. Wind load in X direction.
6. Wind Load in Y direction.

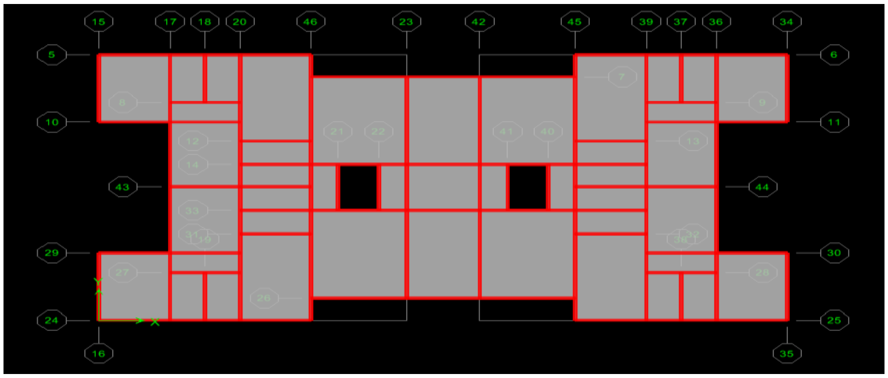

Fig.4. Plan of G+10 Residential building

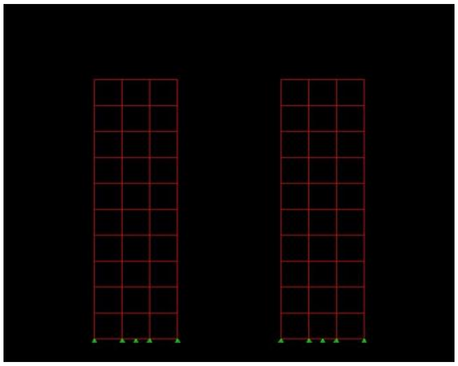

Fig.5. Elevation before Shearwall Removal

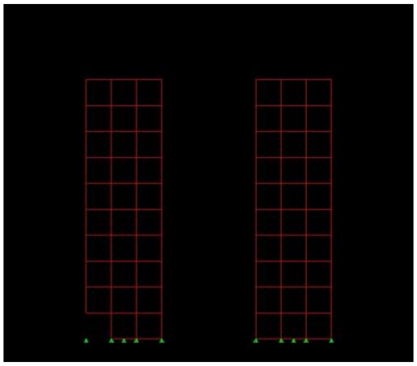

Fig.6. Elevation after Shearwall Removal

6.4 Effect on shear wall

Table: Shear Wall Failure by considering Shear strength i.e. nominal shear stress should be less than maximum shear stress ($\tau_v < \tau_{c, max}$) of adjacent shear wall

Storey Name	No. of failed shear wall after iteration			
	Long side Corner wall Removal	Long side Middle wall Removal	Short side Corner wall Removal	Short side Corner wall Removal
1	9	16	17	7
2	9	16	17	8
3	21	15	21	13
4	21	19	21	13
5	21	19	17	14
6	26	19	21	14
7	24	19	21	14
8	24	19	21	14
9	24	19	21	14
10	21	19	21	14

VII. CONCLUSION

The objective of this project is to find critical shearwall in building which causes maximum damage or collapse after the removal. 6th floor longer corner side shearwall is critical. Shear strength ($\tau_v < \tau_{c, max}$) of shear wall is the main factors considered for study. After this collapse pattern of building is studied using same software. Some important points are highlighted below:

Each element of structure like shearwalls and slabs should not be designed for critical loads. The above elements should be designed for extra margin considering abnormal loads.

As effect of progressive collapse reduces as we move upward from ground floor to upper floors. Hence, ground floor shearwalls are more critical. Since these shearwalls are such as (all corner, near the middle of short and long side of building) designed for twice of their normal load carrying capacity designed for twice of their normal load carrying capacity.

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