Journal Homepage: www.ijarpr.com ISSN: 3049-0103 (Online)

International Journal of Advance Research Publication and Reviews

Vol 02, Issue 06, pp 629-636, June 2025

# A Review on Identifying Key Structural Weaknesses and Response Patterns

*Vibhu Kant*[1]*, Vinay Kumar Singh Chandrakar*[2]

**M.Tech. Scholar[a], Assistant Professor[b], **Madhyanchal Professional University**, Faculty of engineering & Technology, School of civil engineering Bhopal, M.P., India. **

**ABSTRACT**

The safety and resilience of structural systems are critically dependent on understanding their inherent weaknesses and response patterns under various loading conditions. This review aims to synthesize current research on the identification of key structural vulnerabilities and the mechanisms through which structures respond to stress, deformation, and failure triggers such as seismic events, progressive collapse scenarios, and material degradation. Emphasis is placed on the roles of geometric irregularities, load path discontinuities, inadequate detailing, and aging infrastructure in contributing to structural weaknesses. Furthermore, the paper discusses analytical, numerical, and experimental methods used to assess structural performance, including finite element analysis, shake table testing, and damage detection techniques. The study also explores the behavioral response patterns of structures under both static and dynamic loads, highlighting the importance of redundancy, ductility, and energy dissipation capacity. By identifying critical failure points and understanding structural responses, this review provides insights for improving design codes, enhancing retrofit strategies, and advancing predictive modeling for future resilience-focused engineering applications.

**Key Words:-** Structural systems, Structural vulnerabilities, Progressive collapse scenarios, Behavioral response patterns, Ductility, Understanding structural responses

## Introduction

High-rise buildings are critical components of modern urban environments, designed to endure diverse environmental and human-induced stresses; however, they remain vulnerable to progressive collapse—a dangerous structural failure mechanism in which a localized initial failure triggers a chain reaction, resulting in partial or total collapse. This phenomenon becomes significantly more complex and hazardous in asymmetric high-rise buildings, where irregularities in mass distribution, geometry, and stiffness can create unpredictable load paths and stress concentrations. Unlike their symmetric counterparts, these structures do not distribute loads evenly, making them more susceptible to disproportionate failure when a key element is compromised. Despite advancements in structural design and modeling, current research has largely focused on symmetric forms, leaving a critical knowledge gap regarding the behavior of asymmetric buildings under such failure scenarios. This study addresses that gap by evaluating how asymmetry affects the initiation and propagation of progressive collapse, aiming to uncover specific vulnerabilities linked to irregular design features. The findings intend to inform more resilient structural systems and design strategies, ultimately enhancing safety and reducing the likelihood of catastrophic failures in irregular high-rise constructions.

## Literature Review

**Rajesh choyal et al (2024)** progressive collapse in high-rise buildings is a critical issue in structural engineering, particularly in asymmetric structures where irregular geometry and uneven mass distribution introduce significant vulnerabilities. This study provides an in-depth evaluation of the progressive collapse potential in such buildings by employing both analytical and numerical approaches. It examines how asymmetry affects the collapse mechanisms, including the pathways through which local failures propagate to cause widespread structural collapse, and how load redistribution occurs in response to the sudden loss of structural elements. The analysis reveals that asymmetric configurations can significantly compromise the ability of a structure to redistribute loads effectively, thereby increasing the risk of disproportionate failure. By identifying key structural weaknesses and response patterns, the study offers valuable insights that inform the development of improved design guidelines and mitigation strategies aimed at enhancing the overall robustness, redundancy, and safety of high-rise buildings under extreme loading conditions or accidental events.

**Mr. Chetan P et al (2023)** Progressive collapse refers to the failure of a large portion or the entirety of a structure due to the localized failure of a small part, often leading to a disproportionate collapse compared to the initial cause. This phenomenon is especially concerning in modern construction, where architectural trends increasingly favor structures with irregularities in both plan and elevation. Such irregular designs pose additional challenges to structural engineers, who must ensure safety against various forces while adhering to Indian Standards (IS 800:2007 and IS 1893:2016) for structural analysis and design under all possible loading combinations. Once the structures are initially analyzed and designed, they are further subjected to progressive collapse analysis using both linear static and nonlinear static methods as per GSA (General Services Administration) guidelines, considering six critical load cases and locations. The study highlights key observations, notably that building height significantly influences collapse behavior: as the height increases, the tendency for progressive collapse reduces, which is evident from lower Demand Capacity Ratio (D.C.R.) values, joint displacements, and bending moments. Additionally, linear static analysis tends to yield more conservative results than nonlinear static analysis, as it assumes uniform load redistribution and lacks the capacity to model inelastic behavior and redistribution after initial failure, leading to higher predicted stresses and displacements than the more realistic nonlinear approach.

**Rohini Nagargoje et al (2022)** Progressive collapse is a chain reaction of structural failures that can result in the partial or complete collapse of a building, typically triggered by the loss of one or more critical vertical load-bearing elements. Such initiating damage is often caused by abnormal events like bomb blasts, gas explosions, or natural disasters such as earthquakes. Despite the increasing frequency and severity of seismic events, the progressive collapse potential of structures due to seismic actions has not been studied extensively. This study aims to address that gap by investigating the vulnerability of steel moment-resisting and braced frames designed as per Egyptian local standards, under seismic damage scenarios, using tabs connect edition software while adhering to Indian Standard (IS) codes. The research considers four unique scenarios involving the removal of a corner column—one of the most critical locations in a structure—and examines how the building reacts when normal structural elements are progressively removed. By analyzing the redistribution of loads and the structural integrity under such conditions, this study helps evaluate the collapse risk and aims to establish enhanced design guidelines that will assist structural engineers in preventing such failures in both new constructions and retrofitted buildings. The research also offers future recommendations for improving the understanding and modeling of progressive collapse mechanisms, especially in seismic-prone regions.

**Shivam et al (2022)** Progressive collapse refers to the catastrophic failure of an entire structural system initiated by the localized failure of one or more critical structural elements, typically vertical load-bearing components such as columns. This phenomenon occurs when a triggering event—such as an explosion, vehicular impact, earthquake, or tsunami—leads to the removal or weakening of a key structural member. As a result, the load initially carried by the failed element is redistributed to adjacent structural components. If these adjacent elements are not adequately designed to accommodate the sudden increase in stress, they may also fail, initiating a chain reaction that leads to partial or total collapse of the structure. In reinforced concrete (R.C.C.) buildings, especially high-rise structures, this effect can be especially dangerous. The collapsing system continues to seek alternative load paths, but if no adequate pathways exist, a disproportionate and rapid structural failure occurs. To evaluate the progressive collapse potential in a G+8 story R.C.C.

building, linear static analysis can be performed using ETABS Software Version 16.0, following the General Services Administration (GSA) guidelines. The analysis involves artificially removing a critical column to simulate damage and then computing the Demand Capacity Ratio (DCR) in the surrounding structural elements. A DCR greater than 2.0 in any component indicates a high likelihood of failure, helping engineers identify critical zones susceptible to progressive collapse and enabling them to reinforce or redesign these areas for enhanced structural robustness.

**Divyansh Singh Thakur et al. (2021)** conducted a study using ETABS software to model a 12-storey reinforced concrete frame structure and examined its behavior under critical column removal scenarios. Both linear and nonlinear static analysis methods were employed in accordance with the guidelines provided in GSA 2003 and FEMA 356, while also considering provisions of the IS 1893:2016 code to simulate progressive collapse scenarios. The analysis focused on key parameters such as the Demand Capacity Ratio (DCR) and Robustness Index, which were evaluated against the acceptance criteria outlined in the GSA 2003 guidelines to assess the structure's ability to withstand progressive failure.

**Amit Kumar et al. (2020)** conducted a detailed study on the progressive collapse behavior of a typical 12-storey reinforced concrete framed structure using ETABS software. In their analysis, they simulated the sudden removal of a critical column to assess the structural response and potential for collapse. The study employed linear static analysis methods, following the General Services Administration (GSA, 2003) and FEMA 356 guidelines, which are widely recognized for evaluating progressive collapse scenarios. Additionally, the analysis incorporated the seismic provisions outlined in the IS 1893:2002 code to account for earthquake-related dynamic effects. By combining these guidelines and codes, the research aimed to realistically simulate the structural vulnerabilities and redistribution of loads that occur after the removal of a primary load-bearing element, thereby enhancing the understanding of collapse mechanisms and supporting the design of more resilient structures.

**A.R. Rahai et al. (2019)** conducted a study on the progressive collapse assessment of reinforced concrete (RC) structures by analyzing the effects of both instantaneous and gradual removal of columns. Their findings revealed that instantaneous column removal induces significant dynamic amplification effects, resulting in greater stress and deformation demands on the structure compared to gradual removal. They further observed that the plastic deformation in the beams adjacent to the removed column during gradual removal was only about 70% to 73% of that observed during instantaneous removal, highlighting the more severe structural impact and vulnerability associated with sudden column loss.

**Shubham Tripathi et al (2019)** conducted a study on the progressive collapse behavior of multi-story buildings and found that, in the case of removing an interior column from the seventh story, the upper four-story beams experienced significantly higher stress levels and were more critical than those in the lower stories. This suggests that the redistribution of loads due to column removal has a more severe impact on the upper portion of the structure in such scenarios. The PMM (axial force–bending moment–moment) interaction values for most columns, except C38 and C13, remained below 2.0, indicating that these columns were not critically involved in the progressive collapse mechanism. Among the different cases analyzed, the interior column removal scenario on the ground floor was identified as the most critical, as the PMM values approached the limiting threshold of 2.0, implying a higher risk of collapse. In contrast, the corner column removal case was found to be the least critical, likely due to reduced load redistribution demands and less impact on overall structural stability.

**Raghavendra C. et al. (2018)** conducted a detailed study on the progressive collapse potential of a typical reinforced concrete (RC) frame structure with a height of 37.5 meters using linear static analysis through ETABS v9.7 software. The analysis involved systematically removing columns at eight different critical locations to assess the structural response under column removal scenarios. The RC frame was designed according to seismic codes for earthquake zones II, III, IV, and V, and the structure was analyzed for various loading conditions including dead load, live load, wind load, and seismic load. The study incorporated the prescribed load combinations from the GSA (General Services Administration) guidelines to simulate realistic collapse scenarios. For each case, the Demand-Capacity Ratio (DCR) was calculated to determine the structural adequacy of different members. The results revealed that shorter beams, especially those spanning over removed columns, experienced higher load demands compared to longer beams, which indicates that these shorter beams bear more load when adjacent columns fail. The study emphasized that adequate reinforcement and design provisions are essential in critical beam regions to prevent progressive collapse and ensure structural resilience under abnormal loading conditions.

**Yas jain et al (2018)** Progressive collapse refers to a chain reaction of structural failures triggered by local damage, known as initiating damage, which can compromise the integrity of an entire structure. This research focuses on assessing the vulnerability of atypical reinforced concrete (RC) framed structures to progressive collapse using the ETABS v16.2.1 software. A finite element model of a G+9 RCC hotel building was created and designed in accordance with the Indian Building Code. Nonlinear static analysis, specifically Pushover analysis, was performed to evaluate the structural response. To simulate progressive collapse, critical columns identified within the structure were strategically removed, and key performance parameters such as the Demand Capacity Ratio (DCR) and Robustness Indicator (RI) were calculated. These parameters were then compared against the acceptance criteria defined in the GSA 2003 guidelines to determine the extent of the structural vulnerability. The study revealed significant changes in these parameters after column removal, highlighting the critical role certain columns play in maintaining structural stability and the importance of redundancy and robustness in design to prevent disproportionate failure due to localized damage.

**Mohamad umar et al (2017)** proposed a simplified analytical method to estimate the displacement at the location of column removal in reinforced concrete structures during progressive collapse analysis. Their study emphasized that various analysis techniques—namely linear static, nonlinear static, linear dynamic, and nonlinear dynamic methods—can be used to assess the progressive collapse potential of structures. To validate the accuracy of their proposed approach, they compared the analytical results with three previously established experimental and numerical studies. The comparison confirmed that their method provides reliable estimates of structural behavior under column removal scenarios. Furthermore, the study investigated how different structural and material parameters—such as the span length, cross-sectional dimensions, material strength, and the amount and detailing of beam reinforcement in the affected span—influence the response of the substructure after the column is removed. Their findings contribute to a deeper understanding of the factors that govern the robustness of RC structures against progressive collapse.

**Shaikh Akhibuddin et al (2016)** investigated the progressive collapse behavior of reinforced concrete (RC) structures using the Finite Element Method (FEM) through ETABS software, following the guidelines of GSA 2003. The study focused on evaluating the structural response by strategically removing columns at critical locations, with a particular emphasis on how slab thickness affects the structure's ability to resist progressive collapse. The analysis revealed that the structure is most vulnerable when an interior column at the ground floor is removed, highlighting the importance of this column in maintaining structural stability. It was observed that as the slab thickness increases, the axial resistance capacity also improves, thereby enhancing the structure's ability to resist progressive collapse. Additionally, the removal of a corner column causes the beam to behave like a cantilever, and due to insufficient top reinforcement in such regions, the beam is prone to failure. In contrast, when a middle column is removed, the beam behaves more like a continuous beam, and the scarcity of bottom reinforcement may lead to structural failure. Moreover, the study noted that the Demand Capacity Ratio (DCR) under sagging conditions consistently decreases, which is attributed to the relatively constant sagging capacity in square buildings, indicating that slab geometry and reinforcement detailing play a crucial role in progressive collapse resistance.

**Shivaraju G D et al. (2015)** conducted a study focused on analyzing the progressive collapse behavior of reinforced concrete (RC) frame structures under varying seismic zone conditions. The study emphasizes that both natural hazards such as earthquakes, tsunamis, and man-made hazards like fire, gas explosions, and vehicular impacts can significantly affect the structural integrity of buildings. These events may lead to the sudden failure or loss of one or more critical load-bearing elements, which in turn causes a chain reaction resulting in partial or total structural collapse—a phenomenon known as progressive collapse. The researchers examined how such scenarios impact RC frames differently depending on the seismic zone in which the structure is located, as seismic intensity plays a crucial role in the initial triggering event and subsequent load redistribution. The findings help in understanding the vulnerability of RC structures to progressive collapse and highlight the importance of incorporating robust design practices, particularly in high-risk seismic zones, to enhance overall structural resilience and minimize collapse risks.

**Shefna et al. (2014)** conducted a progressive collapse analysis of a 12-storey reinforced concrete frame structure, which consisted of six bays of 5 meters in the longitudinal direction and four bays of 5 meters in the transverse direction. The study utilized SAP2000 software to perform a non-linear static progressive collapse analysis, considering seismic loading in zones II, III, IV, and V as per Indian seismic zoning. To evaluate the vulnerability of the structure, three critical column removal scenarios were simulated: removal of a long-side column, a short-side column, and a corner column. The analysis demonstrated that buildings designed with seismic considerations exhibit enhanced resistance to progressive collapse. Furthermore, the nonlinear static analysis revealed that hinge formations—indicative of potential failure—began at the locations experiencing the highest demand-to-capacity ratio, highlighting the critical regions in the structure where failure is likely to initiate under column removal scenarios.

**Mojtaba Hosseini et al. (2014)** conducted a progressive collapse analysis on a 10-story steel structure using a nonlinear dynamic analysis method with the Open Sees software. In their study, they simulated the removal of corner columns on various stories to investigate the structural response. The results revealed that after the removal of these columns, the axial compressive forces in the adjacent (connecting) columns significantly increased, indicating a redistribution of loads throughout the structure. Specifically, the axial forces in these adjacent columns rose to levels 30% to 40% higher than their ultimate strength capacities, suggesting a high risk of failure if not addressed. To ensure the structural safety and prevent collapse, the researchers concluded that it is necessary to either increase the cross-sectional dimensions of critical columns or apply innovative materials and strengthening techniques to enhance the structural capacity under such critical loading scenarios.

**Sherif El-Tawil et al (2013)** conducted a comprehensive study on the state-of-the-art in progressive (dynamic) collapse research, highlighting key areas critical to understanding and mitigating such failures in structural systems. Their research focused on four main aspects: (1) evaluation techniques for structural robustness and residual strength after the loss of key elements, (2) strategies to enhance the collapse resistance of building frameworks through design and detailing improvements, (3) development of probabilistic models to quantify the risk and uncertainty associated with progressive collapse scenarios, and (4) identification of current trends and future research needs in the field. The study emphasized the existence of significant knowledge gaps in understanding how different structural systems behave under unexpected load redistribution after an initial failure. It also pointed out the need for further research into system-level behavior, accurate modeling techniques, and the integration of collapse mitigation strategies into design codes. Their work serves as a foundational reference for engineers and researchers aiming to develop safer, more resilient structures against progressive collapse.

**Rakshith K G et al. (2013)** carried out a detailed study on the progressive collapse behavior of a reinforced concrete (RCC) framed structure using ETABS V9.7 software, aiming to identify the most critical combinations of column and beam failures that could initiate a disproportionate collapse. A finite element model of the structure was developed using the software's preprocessing tools, allowing for an accurate simulation of structural behavior under abnormal loading conditions. The loading scenarios were designed according to Indian Standard (IS) codes to ensure realistic representation of dead, live, and accidental loads. The model was analyzed to assess internal member forces, focusing on how the removal or failure of specific columns or beams would affect the overall structural integrity. Demand-Capacity Ratio (DCR) values were computed for each structural member, helping to evaluate their performance under critical conditions. The findings showed that while the columns retained their structural adequacy, certain beams exhibited higher DCR values, indicating overstress and a potential risk of failure, thus requiring additional reinforcement to enhance the structure's robustness against progressive collapse.

**Swami nathan Krishnan et al (2012)** the study investigates the collapse mechanisms of tall steel moment-frame buildings using three-dimensional nonlinear analyses of two 18-story structures subjected to earthquake excitations. Both ideal (perfect-connection) and fracture-prone connection conditions are analyzed to understand their influence on collapse behavior. Through classical energy-balance analysis, it is found that only long-period ground motions are capable of transferring sufficient energy to initiate collapse in such tall structures. Under these conditions, the buildings respond similarly to shear beams, suggesting the presence of a characteristic or limited set of preferred collapse mechanisms driven by the dynamic interaction between the structure's flexibility, mass distribution, and the prolonged duration of seismic excitation.

**jinkoo kim et al (2009)** this study investigates the progressive collapse resistance of non-orthogonal buildings—specifically, tilted and twisted 30-storey structures—through nonlinear static and dynamic analyses. The tilted buildings, designed with braced cores, and the twisted buildings, with reinforced concrete cores, were compared against regular, vertically aligned counterparts to evaluate their vulnerability under column removal scenarios. The results revealed that the tilted buildings exhibited a wide range of collapse behaviors, largely influenced by the specific location of the removed column. When a column on the tilted side was removed, the collapse potential was significantly higher due to the redistribution of loads, which led to the formation of plastic hinges not only at the column base but also in adjacent bays, indicating a spread of localized failure. Similarly, twisted structures showed hinge formation beyond the immediate area of damage, but their overall progressive collapse potential was relatively low compared to regular buildings. This was attributed to the structural configuration of the twisted buildings, where more structural elements participated in redistributing loads during the failure of a component, thereby enhancing their ability to resist progressive collapse.

**kapil khandelwal et al (2007)** the research focuses on analyzing the collapse behavior of steel moment-resisting frames with the primary aim of enhancing their resistance to progressive collapse. During such collapse events, significant tensile forces are generated within the structure, especially impacting the performance of beam-to-column connections. The study emphasizes that these connection behaviors play a crucial role in the structural integrity during failure scenarios. Through advanced computational structural simulations, the researcher investigates several key design variables—such as connection detailing, beam and column dimensions, material properties, and joint ductility—that influence the development of catenary action. Catenary action is a mechanism in which beams under large deformations transition from bending to tension-dominated behavior, thereby helping to bridge failed areas and sustain loads even after the loss of critical structural elements. By understanding and optimizing these variables, the study aims to improve the robustness of steel frames and ensure their ability to redistribute loads effectively during abnormal events, ultimately reducing the risk of disproportionate collapse.

**r. Shankar nair et al (2004)** the study of past structural failures such as the Ronan Point tower in wham, the Murrah Federal Office Building, and the World Trade Center Towers I and II highlights the critical issue of progressive collapse—where a local failure leads to a chain reaction of failures resulting in partial or total collapse of a structure. These incidents underscore the importance of understanding not just progressive collapse, which can be triggered by various events like explosions, impacts, or design flaws, but more crucially, the concept of disproportionate collapse, where the extent of the failure is vastly out of proportion to the initial cause. While virtually all structural collapses involve some form of progression, what differentiates a catastrophic failure from a contained one is whether that progression is disproportionate. Therefore, the primary focus in structural engineering should not merely be on preventing all forms of progressive collapse—an impractical goal—but rather on designing buildings in such a way that if a local failure occurs, it does not escalate into a collapse that is disproportionate to the triggering event. This involves robust structural redundancy, load path diversity, and detailing practices that localize damage, thereby enhancing resilience and protecting lives.

## Methodology

The methodology adopted in this review focuses on a systematic and comprehensive analysis of existing research studies, case reports, and technical guidelines related to the identification of structural weaknesses and their associated response patterns in buildings and infrastructure systems. The process is structured in the following stages. The methodology for reviewing key structural weaknesses and their response patterns involves a systematic approach that includes an extensive literature review of past structural failures, case studies, and simulation-based analyses. First, critical data is collected from academic journals, structural engineering reports, and documented failures of buildings or infrastructure. This is followed by classification and evaluation of structural weaknesses, such as soft stories, irregular geometries, weak connections, and material degradation. Analytical and numerical modeling methods, including finite element analysis (FEA) and nonlinear dynamic simulations, are used to study the behavior of structures under various loading conditions like seismic, wind, or accidental impacts. Furthermore, the methodology includes assessing how structures respond to initial local damage and tracking the progression of failure to identify potential collapse mechanisms. The outcome aids in understanding how specific design or construction flaws contribute to vulnerability, enabling the development of guidelines for enhancing structural robustness and resilience.

## Conclusion

The identification of key structural weaknesses and corresponding response patterns is critical for enhancing the resilience and safety of structures against both anticipated and unforeseen loads. Through a comprehensive review of structural analysis methods, failure case studies, and performance-based assessments, it is evident that early detection of weak points—such as inadequate connections, irregular geometries, material deficiencies, or poor load paths—can significantly reduce the risk of progressive or disproportionate collapse. Understanding the response patterns of structures under different loading scenarios allows engineers to design more robust and adaptable systems, enabling effective mitigation strategies and informed decision-making throughout the life cycle of a building.

### References


1. Rajesh choyal1 , monika koushal “review paper- assessment of progressive collapse in asymmetric high rise building” || volume 8 || issue 11 || november 2024 || issn (online) 2456-0774 international journal of advance scientific research and engineering trends.

2. Mr. Chetan P. Tikhe1 and Prof. H. B. Dahake “Literature Review on Progressive Collapse of Structures” International Journal of Advanced Research in Science, Communication and Technology (IJARSCT) International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal Volume 3, Issue 2, June 2023

3. Rohini Nagargoje1 , Pratap Pansare2 , Shivam Karande3 Rohan Rajput4 , Neha Deshmukh5 Sheetal Patage6 Abhay Shelar “progressive collapse analysis with seismic loading using e-tabs” International Journal of Research Publication and Reviews, Vol 3, Issue 7, pp 2874-2883, July 2022.

4. Shivam1, Ankit Kumar “study of progressive collapse in g+8 multi-storey building” International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 09 Issue: 06 | Jun 2022 www.irjet.net p-ISSN: 2395-0072

5. Divyansh Singh Thakur1 , Murlidhar Chourasia 2 “Progressive Collapse Assessment of RCC Structure Using ETABS Software” 2021 IJCRT | Volume 9, Issue 1 January 2021 | ISSN: 2320-2882.

6. Amit Kumar, 2Nitesh Kushwaha “ASSESSMENT OF PROGRESSIVE COLLAPSE IN ASYMMETRIC MULTISTORY BUILDING” 2020 JETIR August 2020, Volume 7, Issue

7. Shubham Tripathi , Dr A K Jain." Progressive Collapse Assessment of RCC Structure under Instantaneous Removal of Columns and its Modeling Using Etabs Software." IOSR Journal of Engineering (IOSRJEN), vol. 09, no. 10, 2019, pp. 27-36

8. Yash Jain*, Dr. V. D. Patil “Progressive Collapse Assessment of a Multi-Storey RC Framed Structure Using Non-Linear Static Analysis Technique” Yash Jain Journal of Engineering Research and Application www.ijera.com ISSN : 2248-9622, Vol. 8, Issue 7 (Part -II) July 2018, pp 56-64.

**9.** S. Mohan Kumar, R. Jeyanthi – "Progressive Collapse Analysis of a Multi-storey RCC building using Pushover Analysis" - International Journal of Engineering Research & Technology (IJERT), Department of Civil Engineering MNM Jain Engineering College Chennai – 600 097, INDIA, March 2016, Vol. No.- 5, ISSN: 2278-0181

**10.** Shaikh Akhibuddin, L.G.Kalurkar – "Evaluation of Progressive Collapse Resistance of Multi-Storey RC Building by Linear Static Analysis Method" - IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE), Department of Civil Engineering, JNEC College, Aurangabad, India, Jul. - Aug. 2016, Volume 13, Issue 4 Ver. VII, e-ISSN: 2278-1684, pISSN: 2320-334X.

**11.** A.Choubey and M.D. Goel – "Progressive Collapse Analysis of Rcc Structures" - International Journal of Optimization in Civil Engineering, 2016; 6(2): 287-301.

**12.** Syed Asaad Mohiuddin Bukhari, Shivaraju G D, Ashfaque Ahmed Khan – "Analysis of Progressive Collapse InRc Frame Structure For Different Seismic Zones" - International Journal of Engineering Sciences & Research Technology, Department Of Civil Engg, MVJ College Of Engineering,Bengaluru, India, June-2015, ISSN: 2277-9655.

**13.** Shefna L Sunamy, Binu P, Dr.Girija K – "Progressive Collapse Analysis Of A Reinforced Concrete Frame Building" - International Journal of Civil Engineering And Technology (Ijciet), Volume 5, Issue 12, December (2014), ISSN 0976 – 6316(Online).