A Review of "Seismic Response of RC Structures Having Plan and Vertical Irregularity with and Without Infill Action"

Kiran Pradeep Patil[1], Dr. A.B. Pujari[2]

[1]*Post Graduate Student, Department of Civil Engineering, KJCOEMR, Pune, India*
[2]*Associate Professor, P.G Coordinator, Department of Civil Engineering, KJCOEMR, Pune, India*

***

Abstract - *A structural engineer's greatest challenge in today's scenario is constructing seismic-resistant structures. Uncertainties involved and behaviour studies are vital for all civil engineering structures. The presence of a vertical irregular frame subject to devastating earthquakes is a matter of concern. The extent of the damage seen following the most recent large earthquakes indicates how important it is to reduce the seismic risk associated with infilled reinforced concrete buildings in seismically active areas. Most seismic codes treat infill walls as non-structural features when evaluating existing structures or designing new ones, and they typically lack thorough guidelines for practitioners. However, the community now understands the significance of infills in the seismic behaviour of reinforced concrete structures. The behavior of infill walls, design, and vertical irregularity on the seismic performance of multi-story high-rise structures during different earthquake ground motions were the main topics of this study. Under the linear static & dynamic analysis, reaction characteristics such as story drift, story deflection, and story shear of the structure under seismic stress are studied. This examination focuses on a structure's base shear bearing capability and how well it performs in areas with strong earthquakes. This paper's primary goal is to present an analysis of the damage typologies seen in the most recent earthquakes, along with a discussion of the causes and potential fixes. Subsequently, an overview of both in-plane and out-of-plane testing campaigns related to infilled reinforced concrete frames is provided, together with their pertinent results.*

Key Words**: Infill Action, Non-Linear Static and Dynamic Analysis, Story Displacement, Story Shear, Story Drift, Plan and Vertical Irregularity, ETABS.**

1.INTRODUCTION

These days, the development of efficient strengthening procedures and the evaluation of the seismic vulnerability of existing buildings that were not constructed in accordance with current and modern norms are of utmost importance in the field of seismic engineering. The increase in numerical and experimental research accessible in the literature over the past few years indicates a growing interest in the study of masonry infill walls and their impact on the behaviour of reinforced concrete (RC) buildings during earthquakes. Their presence may or may not improve the building's seismic performance, depending on several factors, including their layout and height distribution, whether or not they are connected to the surrounding frame, boundary conditions, the material and mechanical charact-eristics of the infills, as well as the relative stiffness and strength between the infill panel and the frame elements.

2. LITERATURE REVIEW

In S.H. Basha, H.B. Kaushik [1], the performance of eleven half-scale, one-story masonry frames filled with reinforced concrete (RC). The effects of slow cyclic in-plane lateral loading were investigated experimentally in two phases. The frames loaded with full-scale and half-scale bricks demonstrated greater strength, stiffness, and energy dissipation than their bare frame counterparts, according to results from the first stage (eight frames). The majority of the time, despite the relatively weak masonry, columns crumbled under shear. Shear design of columns was changed in accordance with current seismic requirements in order to postpone shear failure, and tests were repeated on three upgraded frames in the second stage.

Even though the shear failure in the columns of the enhanced frame happened at a higher drift level, the insufficiency of the current design codes was demonstrated by the inability to prevent the shear failure in the columns. An idealized load–displacement relationship for RC frames with brick infill was created for various performance levels based on the experimental findings.

It has been stated that the weak frame-strong infill arrangement is linked to the frame failure mode, along with the number of stories and bays, axial load ratio on columns, kind of infill, and construction process. It is necessary to design infilled frames to withstand the extra shear force caused by infill. Many nations' seismic design codes treat reinforced concrete (RC) frames like bare frames and ignore the role that masonry infills play in providing lateral load resistance.

In R.M. Desai, V.G. Khurd, S.P. Patil, N.U. Bavane [2], According to research, the majority of building structures in use today have asymmetrical elevations because of variations in mass and stiffness distributed throughout the building's height on each story. The unequal distribution of mass, stiffness, and strengths in structural systems can lead to significant destruction, as the most recent earthquakes have shown.

Examination of the response spectrum applied to both symmetric and asymmetric structures. The buildings vertical uneven story distribution is asymmetrical. Consideration is given to the impact of eccentricity between the center of mass (CM) and the center of stiffness (CR). Three building types (G+3), (G+6), and (G+9) that are built on medium soil in India's seismic zone II are taken into consideration for this study (as per IS:1893-2002), In an irregular vertical distribution, there are two: one symmetric and one asymmetric. A multistory framed building's ability to withstand ground vibrations is contingent upon the way its mass, stiffness, and strength are distributed over its horizontal and vertical planes. Sometimes discontinuities in mass, stiffness, or strength between adjacent floors might cause these issues. These story-to-story discontinuities are frequently associated with abrupt changes in the height-wise frame geometry.

M.L. Moretti, Theocharis Papatheocharis; and Philip C. Perdikaris [3], This work presents a study on diagonal strut model width calculation for the design of reinforced concrete (RC) infilled frames. This model is already widely used as a design tool for RC frames filled with masonry. An examination is conducted of the presumptions that underpin the strut model provisions found in codes. Additionally, a summary of some of the findings from an experimental investigation into the reaction of eight 1=3-scale RC infilled frames to quasi-static cyclic horizontal displacements is provided. Investigations have been done on two distinct aspect ratios and several ways to attach the infill to the frame. Code-mandated design parameters for infilled frames are used to characterize the behavior of the tested specimens concerning stiffness, ultimate strength, and anticipated mode of failure. There includes a discussion of the findings and some recommendations for enhancing the design processes and came to the following conclusions:

1) Using dowels with an embedment length longer than necessary may increase lateral stiffness and shear resistance while reducing ductility.

2) To prevent the frame from failing too soon, it's critical to manage the relative frame/infill slippage.

It is challenging to forecast the critical slip and the corresponding shear force, though.

3) Because of the observed frame/infill relative slip, the Bernoulli concept calculation of the flexural resistance at the base of an RC infilled wall is inaccurate.

4) When the RC infill is represented by a diagonal strut with an effective width w that is determined in accordance with ASCE 41-06, the measured stiffness of the tested specimens is typically accurately predicted. Nonetheless, the overall rigidity of the infilled frame is overestimated in the event of a strong infill/frame connection (which is often on the safe side for design purposes).

M.H. Jinya, V.R. Patel [4], Brick masonry walls and reinforced concrete frame buildings are utilized as infills and designed as partitions by architects so that they don't reduce the vertical gravity load-bearing capacity of the building. Infill walls separate interior spaces and shield building occupants from environmental threats. Furthermore, infills significantly impact the seismic response of the structural systems. Soft floors and short columns are the two main structural damages that are frequently seen in earthquakes that are brought on by masonry infill walls. In this instance, the brick compressive strength is applied in accordance with IS: 1905-1987, meaning that the brick masonry strength is 0.50 and 1.06 N/mm2 and the center aperture is delivered in the periphery wall with varying percentages, namely 15% and 25%.

Building models with G+9 R.C.C. frames have been created using the seismic coefficient approach in the ETABS software. (SCM) and time-history (TH) analyses have been conducted in accordance with IS 1893:2002. The criteria taken into consideration in this study include story displacement, base shear, story drift, and axial force with and without soft story while taking into account the effect of infill walls with varying percentages of opening. For the macro model, the width of the strut is determined using the FEMA approach method and the equivalent diagonal strut (EDS) method. In this study, the outcomes of bare frame, soft story, and infill walls are examined, and conclusions are drawn. This study presents the findings of sixteen models built for both dynamic analysis (TH) and static linear analysis. For example, strut-free and strut-equipped infill walls with central outer openings at 15% and 25% are contrasted.

This research leads to the conclusion that the diagonal strut will alter the RC building's seismic performance. Higher infill stiffness results in greater base shear, decreased story displacement and store drift, and increased axial force in the column. The soft story effect can be reduced if at least a peripheral wall is present at ground level. Additionally, it can be said that a decrease in lateral stiffness is caused by an increase in the percentage of openness.

In Y.P. Yuen, J.S. Kuang [5], Reinforced concrete frames filled with masonry are particularly popular structural forms for buildings because of their benefits from both an architectural and structural standpoint. The structural behavior of these frames may be dramatically altered by the infills, though, and this could have a negative impact on how well structures perform during earthquakes.

The five distinct infill configurations that are presented in this analytical investigation are full infills, 2/3-story-height infills, a soft first story, infills with window openings, and infills with door openings. The purpose of the investigation is to examine the seismic response and failure mechanisms of these infilled RC-frame structures. Using discrete-finite element analysis and damage-based constitutive relations, the nonlinear response of the masonry-infilled RC frames was simulated under four realistic earthquakes: the 1979 El Centrro, 1987 Superstition Hills, 1995 Kobe, and 1999 Chi-Chi earthquakes.

It was found that the infill panels levels of regularity and continuity had a substantial impact on the seismic the way those structures function. Full-height and continuous-infill panels can improve the overall stability and energy dissipation of frame structures, provided that out-of-plane collapse of infills does not occur. When discontinuous infills are applied to frame members, they can seriously harm the area where they discontinue. Additionally, the analysis showed that infilled frames might not always be able to use the "strong column–weak beam" design idea.

A thorough investigation was conducted into the seismic behavior of five common types of infilled RC frame structures: a fully infilled frame, an infilled frame with a height of two thirds of a story, an infilled frame with a soft first story, an infilled frame with window openings, and an infilled frame with door openings. The analysis's findings validate the subsequent conclusions.

In M. Yousuf, P.M. shimpale [6], Designing and constructing a structure with the intention of minimizing structural component damage during an earthquake is the primary goal of earthquake engineering. The dynamic analysis of a reinforced concrete structure with irregular plans is presented in this work. For the analysis, four G+5 building models with one symmetric plan and one remaining irregular design were used.

The R.C.C. structure analysis is done using ETABS 9.5 software. It is done to assess response factors like story drift, base shear, lateral forces, and story shear. In order to examine how well they resist lateral forces, four cross sections in columns are taken into consideration. The impact of the building plan variation on the structural reaction building is also covered in this study. Dynamic analysis connected to IS 1893-2002 (part 1) has been done for a number of notable earthquakes. Response spectrum analysis is a technique used in dynamic analysis. For each model, the complete quadratic combination (CQC) approach has also been employed to estimate the dynamic response at 5%, 10%, 15%, and 20% damping. The dynamic responses were compared, and the following conclusions were reached:

(a) For structures that are higher and asymmetrical When creating symmetric structures, we should apply the Response Spectrum Method. can optimally employ the lateral load equivalent approach. However, Response Spectrum Method should be applied for more accurate analysis required for asymmetrical building needs.

(b) In cases where there are plan irregularities, use a dynamic analysis to verify the lateral-force resisting elements in order to achieve a more realistic lateral load distribution. Since irregularities in plans can lead to irregular responses, it is imperative to verify lateral-force resisting elements in order to resist lateral loads. The equivalent width of these struts is a crucial factor that influences their strength and stiffness. This work offers a consensus analysis of many formulations that have been put up by scholars to determine this equal breadth.

In Arvindreddy, R.J. Fernandes [7], research, it was discovered that the primary cause of the RC building's downfall was an anomaly in its plan. dimension as well as the mechanism that resists lateral forces. This work concludes an analytical investigation to ascertain the response of several regular and irregular structures situated in severe zone V. A 15-story building is examined utilizing IS code 1893-2002 (part 1) and ETABS 2013 for both static and dynamic analysis. For regular buildings up to 90 meters in height, zone I and zone II complete linear equivalent static analysis; for regular and irregular buildings, zones IV and V should complete dynamic analysis. It is necessary to compare reactions in the form of story displacement for regular and irregular structures in order to determine how these structures behave. Pushover analysis is used to determine the displacement vs. base shear graph, and it also conducts a time history analysis using the BHUJ earthquake. We examine fifteen stories of both regular and irregular structures, utilizing both static and dynamic analysis techniques. In order to examine the behavior of any structure, historical ground motion records from earthquakes are obtained for time history analysis. There are currently six models: one regular and the other five irregular.

This essay demonstrates how irregular structures behave differently from regular structures,

(1) In comparison to response spectrum analysis, the results obtained from the static analysis method show lower story displacement values. One possible explanation for this variation is a nonlinear force distribution.

(2) In both the static and response spectrum methods, it was discovered that story displacement and story drift were less in irregular diaphragm structures than in regular structures.

(3) The stiffness irregularity exhibits nonlinear behavior at an earlier stage in comparison to the other structures, as demonstrated by the pushover curve. As a result, an earthquake damages a structure's rigidity and irregularity more. (4) Stiffness irregularity exhibits the least base shear for 15 stories, according to time history research.

In C. Rajesh, R.P. Kumar, S. Kandru [8], Due to its ease of construction and quick development, RC framed buildings are widely utilized worldwide. In many nations located in seismic zones, these frames are typically filled with concrete blocks or masonry infill panels. The stiffness and strength of the frame are greatly increased by infill panels; they act as a compression strut between the column and the beam, transferring compression stresses from one node to another. Building performance during earthquakes, such as the Bhuj Earthquake, amply demonstrates the major impact infill walls have on the stability of a structure. The performance of RC frame buildings with and without infill walls is summarized in this study. We evaluate the role of masonry infill walls in conventional reinforced concrete buildings' seismic resilience by applying the equivalent diagonal strut idea. Using software, we developed and assessed the two distinct structures one with and one without infill walls for seismic and gravity loads (SAP2000). Contrasting the outcomes of the computerized model analyses for bare-frame and single-strut models, respectively, with and without infill structures. We compared the effects on the building's total weight, time frame, base shear, modal participation mass ratio, and overall results.

Based on the data, it can be concluded that a shorter time frame will result in Comparing strut models to bare-frame models, there is a decrease in both the building's overall weight and increase in base shear. Strut model buildings exhibit a shorter construction time, a higher base shear, and a lower total building weight. Since time period and stiffness are known to be inversely correlated, it is evident that strut model buildings have a shorter time period than bare-frame buildings. This suggests that strut model buildings are more earthquake-resistant and safer than bare-frame models. From the previous earthquakes like Bhuj in 2001 many of the buildings are collapsed due to the improper analysis and design of buildings which are analyzed without considering the stiffness of the walls which leads to the sudden collapse of the buildings. From this analysis, it concludes that strut model buildings gives better and best performance than bare frame model buildings in the high seismic prone areas.

In G. de stefano, C. Lima, E. Martinelli [9], Despite the general consensus that the relationship between structural components and masonry filling has a substantial impact on the seismic response of reinforced concrete (RC) frames; nevertheless, present design-oriented seismic assessments of structures typically ignore this interaction. Because masonry infill can drastically alter both lateral strength and stiffness, it becomes even more important to simulate it when doing seismic research on existing structures.

Non-Linear 2D elements should be used for accurate modeling of infill as a matter of principle. However, there are already a number of design-oriented approaches for modeling masonry infill that define analogous (nonlinear) strut elements that may be found in both scientific research and engineering practice. The implementation of such models in nonlinear static and dynamic analysis is demonstrated in this publication by Open SEES. This research used "practice-oriented" numerical models that were implemented in Open SEES to analyze the seismic response of reinforced concrete frames while accounting for the potential impact of masonry infill.

First, a summary of the main characteristics of the structural behavior of RC structural members and masonry was provided. In particular, defining an equivalent strut whose monotonic behavior can be explained by analytical expressions found in scientific literature to define the essential characteristics of the force–displacement skeleton curve reduced the simulation of the response of masonry walls to that. Furthermore, the cyclic behavior of such equivalent struts has been simulated by accounting for both stiffness and strength degradation (in load and unload branches). The outcomes of the parametric analysis shown here validate how crucial it is to consider the function of brick infill, since their impact is impossible to measure or replicate in any other way and frequently has unanticipated consequences, particularly when there is an uneven distribution of elevation.

In H. Bansal, Gagandeep [10], The paper's goal is to do time history analysis (THA) and response spectrum analysis (RSA) of vertically uneven reinforced concrete building frames and to carry out the ductility-based design utilizing IS 13920, which is equivalent to both time history analysis and static analysis. Three main categories of abnormalities were taken into consideration: mass irregularity, stiffness irregularity, and vertical geometry irregularity. Our observations indicate that the story shear force is always at its lowest in the top story and reaches its highest in the first story. It was found that the base shear of the mass irregular structures was greater than that of comparable regular structures.

The uneven toughness structure reduced base shear and features wider drifts between stories. For upper stories, the absolute displacements from the time history analysis of the geometrically irregular structure at each node were found to be greater than those from the regular structure; however, as we descended to lower stories, the displacements in both structures gradually tended to converge. Higher displacements of upper stories are the result of less stiffness in the structure. Time history analysis of a mass irregular structure yields somewhat larger displacements for the top stories than for regular structures, whereas lower stories result in higher displacements than for regular structures.

After completing time histories for both toughness irregular and regular structures, it was discovered that while displacements of upper stories were relatively consistent, as one descended to lower stories, the absolute displacement in the case of soft stories was greater than that of corresponding stories in regular structures. Little displacements occur when a high-rise building with low natural frequency is left vulnerable to high frequency ground motion. Comparably, when a high-rise structure experiences low frequency ground motion, it causes tiny displacements, but a low-rise structure with a high natural frequency experiences bigger displacements from high frequency ground motion.

3. CONCLUSIONS

The majority of researchers examined how infill affected regular-shaped structures' seismic performance in the debate above.

Additionally, they found that the Pualay and Preist formula is the most appropriate for calculating the width of a single diagonal strut, and that bricks are the best material to use as an infill.

We find that the influence of irregularity on the seismic behavior of structures with respect to their regularity can be compared, and that the effect of infill on the seismic performance of irregularly shaped high- rise structures can be put into observation.

Additionally, an assessment of the impact of infill on irregularity could be made.

REFERENCES

[1] S.H. Basha, H.B. Kaushik. “Behavior and failure mechanisms of masonryinfilled RC frames (in low-rise buildings) subject to lateral loading”.

www.elsevier.com,http://dx.doi.org/10.1016/j.engstruct.2015.12.034.

[2] R.M. Desai, V.G. Khurd, S.P. Patil, N.U. Bavane, “Behavior of symmetric and asymmetric structure in high seismic zone”, Int J Eng Tech.– 2016; 2(6).

[3] M.L. Moretti, Theocharis Papatheocharis; and Philip C. Perdikaris, M. ASCE, In: “Design of Reinforced Concrete Infilled Frames”. American Society of Civil Engineers.

DOI:10.1061/(ASCE)ST.1943- 541X.0001042. © 2014.

[4] M.H. Jinya, V.R. Patel. “Analysis of RC frame with and without masonry infill wall with different stiffness with outer central opening”, Int J Res Eng Technol. eISSN: 2319-1163 | pISSN: 2321-7308.

[5] Y.P. Yuen, J.S. Kuang. “Nonlinear seismic responses and lateral force transfer mechanisms of RC frames with different infill configurations”, www.elsevier.com http://dx.doi.org/10.1016/j.engstruct.2

[6] M. Yousuf, P.M. shimpale, “Dynamic analysis of reinforced concrete building with plan irregularities”, Int J Emerg Technol Adv Eng. 2013; 3(9). Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008.

[7] Arvindreddy, R.J. Fernandes.” Seismic analysis of RC regular and irregular frame structures”, Int Res J Eng Technol. 2015; 2(5).

[8] C. Rajesh, R.P. Kumar, S. Kandru. “Seismic performance of RC framed buildings with & without infill walls”, Int J Eng Res Technol. 2014; 3(10). ISSN: 2278-0181 IJERTV3IS100280 www.ijert.org.

[9] G. de stefano, C. Lima, E. Martinelli. On the “seismic response of masonry infilled RC frames”.

[10] H. Bansal, Gagandeep. “Seismic analysis and design of vertically irregular RC building frames”, Int J Sci Res (IJSR). 2014; 3(8).