

Comparative Seismic Analysis of Reinforced Concrete Frame Structures with and without Masonry Infill Walls in Different Seismic Zones

Nukathoti Gangadhar¹, Karnena Venugopal²

1.Research Scholar,

2.HOD, Civil Engineering,

Kakinada Institute of technological Sciences (JP)

Abstract - Reinforced concrete frames filled with masonry walls are frequently used in countries such as India, especially in areas susceptible to earthquakes. Typically, these masonry infill walls are regarded as non-structural elements during structural analysis; only their mass is accounted for, while their structural characteristics like strength and stiffness are usually overlooked. Structures located in high seismic zones face a significant risk of severe damage. In addition to the gravity load, these structures must also resist lateral loads, which can create considerable stresses. Nowadays, reinforced concrete frames are the predominant choice in building construction worldwide. The vertical spaces in these frames, formed by columns and beams, are usually filled with brick or masonry, commonly referred to as brick infill walls or panels. This study aims to analyze the seismic resistance of reinforced concrete frames in G+8 story buildings with infill walls using ETABS software across various seismic zones. A comparison was conducted regarding story drift, story shear, bending moments, and building torsion between structures with and without infill walls.

Key Words: Key words: infill walls, reinforced concrete frames, RCC frames, ETABS software.

1.Introduction

An earthquake causes ground movement in unpredictable ways, shaking horizontally and vertically in every direction from its epicenter. As a result, these ground vibrations affect structures built on them, creating forces that act upon them. Buildings in high seismic zones face a higher risk of serious damage. Along with gravitational forces, buildings also have to withstand lateral loads, which can create high stress levels. Today, reinforced concrete frames are widely used in construction around the world. The spaces between the columns and beams in these frames are usually filled with brick or masonry, known as brick infill walls or panels. Once the frame is built, these walls are made with burnt clay bricks set in cement mortar, with thicknesses typically ranging from 200 to 115 mm. To meet practical needs, frames often have openings for windows, doors, and other features.

Wall infill are the supported wall that encircles a building with a three-dimensional framework structure—typically composed of steel or reinforced concrete—is known as the infill wall. Thus, while the infill wall fills the boxes of the outer frames and acts as a barrier between inner and outer space, the structural frame guarantees the bearing function. The infill wall's special static function allows it to support its own weight. An external vertical opaque closure type is the infill wall. The infill wall is different from the load-bearing wall and the partition that divides two interior spaces, both of which are non-load-bearing. The latter performs the same functions of the infill wall, hydro thermically and acoustically,

In typical cases of adherent robust infill walls, the effect of stiffness increase (as well as dissipation) affects the building response when there is perimeter contact between the masonry infill walls and the frame. It is likely that infill walls will only act as an extra mass applied to the structure when they are built apart from structure not in adherence with the frame elements and they shouldn't have any other notable effects. Regardless of the structure's lateral resistance capacity the infill typically interacts with the RC structure in the most common scenario of perimeter contact between the masonry panels and the beams and columns.

2. Objective:

1. To investigate the seismic behavior of a G+8 multi-story reinforced concrete building in accordance with the provisions of IS 1893:2002.
2. To perform a comparative study of G+8 multi-story buildings with and without masonry infill walls under seismic loading.
3. To compare the structural response parameters, including story drift, story shear, bending moment, and building torsion, for buildings with and without masonry infill walls.

4. To model and analyze the G+8 multi-story building using ETABS V9.7.4 by employing the Response Spectrum Analysis method.

Reinforced concrete (RC) framed buildings with masonry infill walls are widely constructed in countries such as India, particularly in regions vulnerable to seismic activity. In conventional structural design, masonry infill walls are generally treated as non-load-bearing components, and only their self-weight is considered in the analysis. Their contribution to the overall stiffness, strength, and lateral load resistance of the structure is often neglected.

Buildings located in earthquake-prone areas are required to withstand not only gravity loads but also significant lateral forces generated during seismic events. These lateral forces can induce substantial stresses and deformations, making seismic performance an important aspect of structural design. Reinforced concrete framed systems have become the most widely adopted structural form for multistory buildings because of their strength, durability, and construction efficiency. The spaces enclosed by beams and columns are commonly filled with brick or masonry panels, known as masonry infill walls, which can significantly influence the structural response during earthquakes.

The present study investigates the seismic behavior of G+8 reinforced concrete framed buildings with masonry infill walls using ETABS software for different seismic zones. A comparative analysis is carried out between bare frame and infilled frame models by evaluating key response parameters such as story drift, story shear, bending moment, and torsional behavior to assess the influence of masonry infill walls on the overall seismic performance of the building.

3. Literature review:

Yadunandan et al. performed a linear dynamic ETABS analysis on a G+3 building to evaluate how masonry infills—modeled as equivalent diagonal struts—affect structural behavior across models with wall openings and soft stories. The findings reveal that infill panels significantly increase stiffness and base shear capacity while reducing the fundamental time period, deflections, and storey drifts compared to bare frames. However, wall openings increase time periods and deflections; if openings exceed 40%, the infill's stiffness contribution becomes negligible, making the structure

behave like a bare frame. Additionally, a ground-floor soft story exhibits higher displacement and time periods than a higher-floor soft story, emphasizing that accounting for masonry infills is essential for accurate seismic design. Prakash Paudel et al. evaluated open ground story (OGS) buildings to address how discontinuous infill walls cause sudden stiffness drops and heavy column stress. Contrary to common industry practice and IS 1893: 2002 guidelines—which suggest a 2.5 multiplication factor for OGS design—the study found that a factor of only 1.15 is realistic for low-rise structures. While infill walls shorten the building's fundamental time period (attracting higher seismic forces) and reduce overall drift, ground-floor column forces increase, and ground-story drift remains highest in OGS configurations. Ultimately, the authors conclude that infill stiffness must be explicitly modeled rather than relying on overconservative code factors. Kiran Tidke and Sneha Jangave et al evaluated a G+7 RC frame building using SAP2000 and the equivalent diagonal strut method to examine how masonry infill walls impact structural performance during seismic and wind loads. The study revealed that incorporating infill walls significantly enhances structural strength and stiffness—yielding higher base shear while drastically reducing maximum storey drift and lateral displacement compared to bare frames. However, introducing soft storeys progressively increases both drift and displacement, demonstrating that while infills improve overall stability, softstoreys diminish these structural benefits. Mohammed Nauman, Nazrul Islam et al. Modeling a G+11 building with equivalent compression struts showed that masonry infills significantly enhance stiffness and seismic performance compared to bare frames. Infill panels reduced lateral deflection, column axial forces, shear forces, bending moments, and storey drifts (by up to 69.64% in X and 76.1% in Z directions). However, the added stiffness increases storey shear, attracting larger lateral earthquake loads as the infills absorb most of the axial forces. Akshay Grover, Dr. S.K. Verma et al. Analyzing a G+5 building in Zone IV across five ETABS models showed that fully infilled frames increase strength and stiffness, reducing displacements by 70–80%, storey drifts by up to 75%, and increasing base shear. Introducing wall openings (10%) or an open ground soft storey decreases overall stiffness, thereby increasing displacement, drift, and the fundamental time period. Ignoring infill stiffness underestimates base shear, while Response Spectrum Analysis yielded lower response values than the Equivalent Static Method.

4. Methodology:

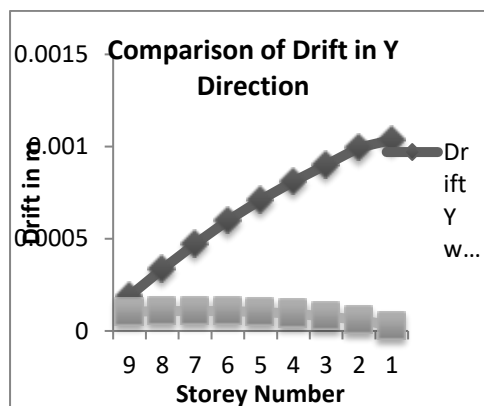
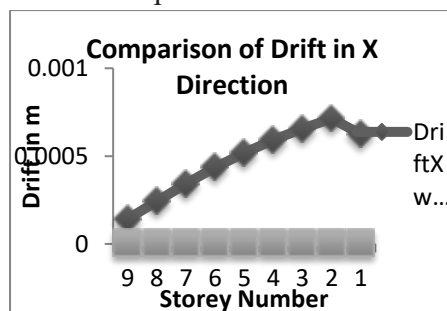
Response Spectrum Analysis models the peak seismic response of an idealized single-degree-of-freedom system across varying periods and damping ratios based on soil type and zone factors. In ETABS 2013, standard spectra (plotted as time period vs. spectral acceleration coefficient S_a/g) evaluate multi-mode structural responses in the frequency domain. Modal responses are read from the design spectrum using each mode's frequency and mass, then combined along the X, Y, and Z axes using methods such as Absolute Sum, SRSS, or CQC (preferred for closely spaced modes). Because phase information is lost when generating the spectrum, results differ from direct linear dynamic analysis. For highly irregular, exceptionally tall, or critical disaster-response structures, Response Spectrum Analysis is insufficient, requiring advanced nonlinear static or dynamic methods.

ETABS is a comprehensive, intuitive software package for the 3D modeling, analysis, and design of structures ranging from single-story buildings to complex high-rises. It integrates the entire engineering workflow—from importing CAD layouts to automatically designing steel, concrete, composite frames, and shear walls. Powered by the high-speed 64-bit SAPFire solver, it handles complex linear and nonlinear analyses, including construction sequencing and time-dependent creep and shrinkage effects. The platform provides customized reports, 3D rendered outputs, and automated schematic construction drawings for effortless result interpretation. Key core capabilities include structural modeling, versatile loading and analysis, automated design, and robust editing features across plan, elevation, and 3D views.

5. Results:

Story drift measures lateral displacement between adjacent floors during an earthquake, normalized by story height (e.g., a 0.10 drift on a 10-foot story equals a 1-foot relative displacement). Larger drift values signal progressively severe structural damage: values exceeding **0.025** pose life-safety risks, values above **0.06** indicate severe damage, and values over **0.10** suggest probable building collapse.

Graph -1- X- Direction



Graph-2- Y- Direction

Story Shears and Overturning Moments

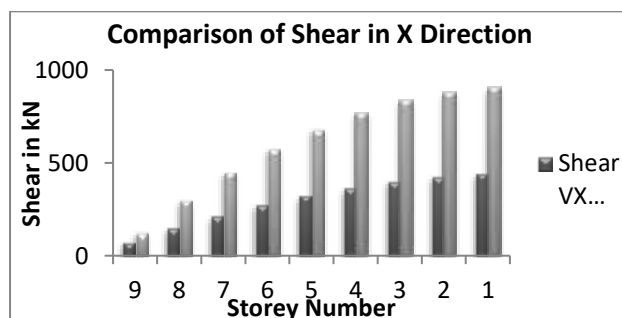
Story shears and overturning moments are reported in the global coordinate system as axial force (P_x), shear forces (V_X , V_Y), torque (T), and bending moments (M_X , M_Y) at the top (j-end) and bottom (i-end) of each story at $X=0$, $Y=0$.

Frame element internal forces present along every cross-section include:

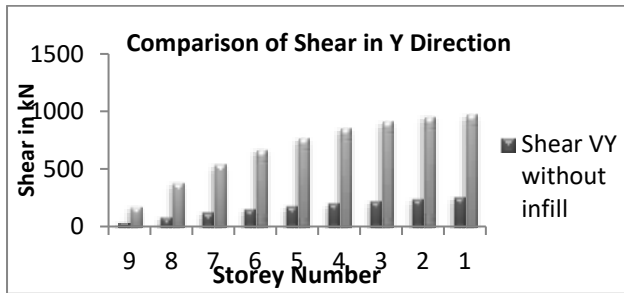
- P_x : Axial force
- V_X , V_Y : Shear forces (1-2 and 1-3 planes)
- T : Axial torque (about 1-axis)
- M_X , M_Y : Bending moments (about 2 and 3 axes)

Story shear

X Direction



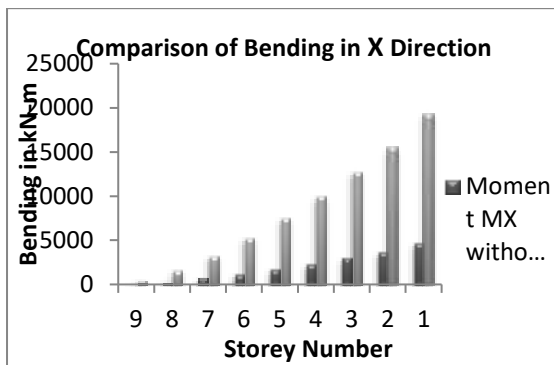
Graph -3-Comparison of shear in X direction



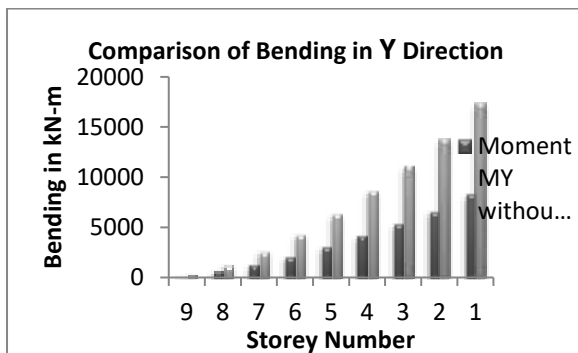
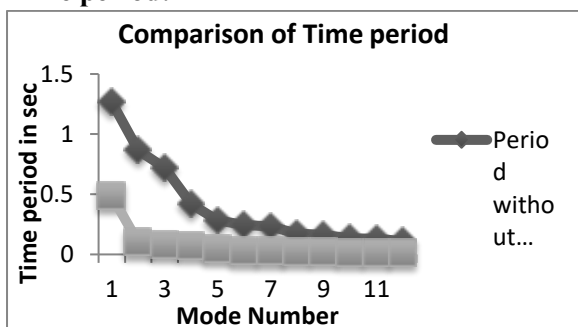
Graph -4-Comparison of shear in Y direction

Bending moment

The Bending moment at the cross section of the beam may be defined as the un balanced vertical moment to the right or left of the section.



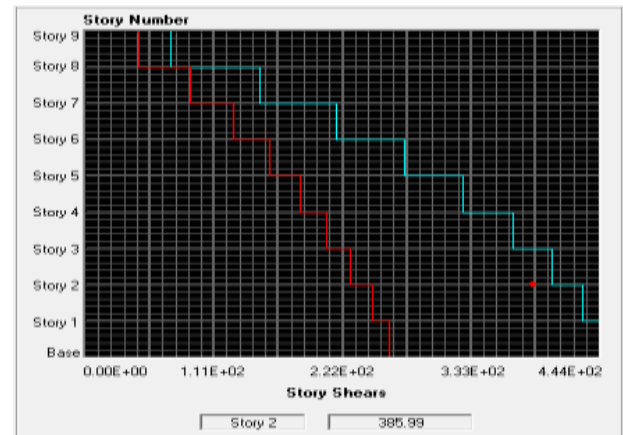
Graph – 5- Comparison of bending in X direction


Graph – 6- Comparison of bending in Y direction
Time period:


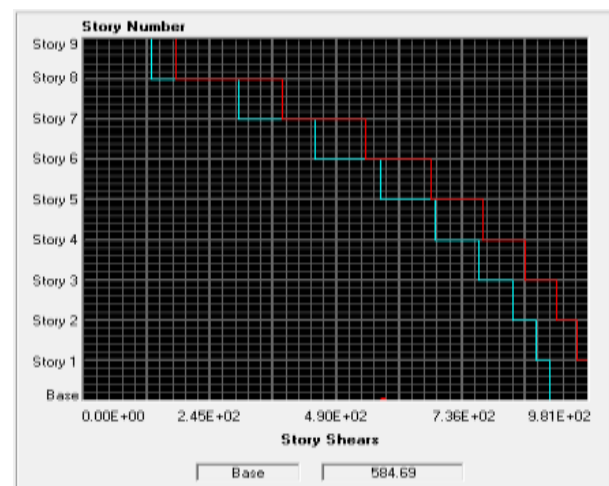
Graph – 7 – Comparison of Time period

Storey Shear Curves

Without infill walls



Graph – 8- Storey shear without infill walls



Graph – 9 Storey shear with infill walls

6. Conclusion:

Masonry infills provide an economical, durable partition wall system that fundamentally alters structural behavior, making their explicit inclusion essential in seismic analysis. Incorporating infill panels significantly increases overall frame stiffness, reducing both lateral deflection and story drift in the X and Y directions compared to bare frames. Due to the added weight and stiffness of the infill walls, the story shear, bending moments, and torsion are higher in fully infilled models than in bare frame models during response spectrum analysis.

7. References:

- [1]. Yadunandan C1, Kiran Kuldeep K N2, "Study on behavior of RC structure with infill walls due to seismic loads" International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 06 | June -2017.
- [2]. Prakash Paudel, "Effect of Infill Walls in Performance of Reinforced Concrete Building Structures", International Journal of Engineering Research and General Science Volume 5, Issue 4, July-August, 2017.
- [3]. Kiran Tidke¹, Sneha Jangave², "Seismic Analysis of Building with and Without Infill Wall", International Journal of Innovative Research in Science, Engineering and Technology Vol. 5, Issue 7, July 2016.
- [4]. Mohammed Nauman¹, Nazrul Islam, "Behavior of RCC Multistorey Structure With and Without Infill Walls", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 1, JANUARY 2014.
- [5]. Akshay Grover ¹ , Dr. S.K. Verma, "Effect of Infill Walls on RC Framed Structure", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 7, July 2016.
- [6]. Naveed .A.G¹, Chandradhara .G.P², "Seismic Performance of Infilled Frames with and without Opening", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 38-44.
- [7]. B Neha kumari¹, Tejas D Doshi, "linear analysis of infill walls with openings including shear wall at building core", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072.
- [8]. Kiran Tidke¹, Sneha Jangave², (2016), "Seismic Analysis of Building with and Without Infill Wall", International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 5, Issue 7, July 2016
- [9]. Hemchandra Chaulagaini , Hugo Rodrigues², et al., (2014), "Seismic assessment of RC structures with infill masonry panels in Nepal – sensitivity analysis", Second european conference of earth quack engineering and seismology, 2014.
- [10]. André Furtado¹ , Nelson Vila-Pouca², Humberto Varum³, et al (2019) , "Study of the Seismic Response on the Infill Masonry Walls of a 15-Storey Reinforced Concrete Structure in Nepal", <http://www.mdpi.com/journal/buildings>, Received: 14 December 2018; Accepted: 29 January 2019; Published: 4 February 2019.