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Seismic Damage Assessment of RC Frame with and without Infill Walls

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ABSTRACT: The research focuses on the seismic performance of RC (reinforced concrete) frame structures with and without masonry infill walls, using a 13-story residential building in Surat, Gujarat as a case study. The structures were modeled and analyzed in ETABS 2016, employing various seismic assessment methods such as Response Spectrum Analysis (RSA), Time History Analysis (THA), Eigenvalue Analysis, Pushover Analysis (PA), and Equivalent Static Analysis. The results indicated that infill walls significantly enhance the building's seismic resilience by improving strength, stiffness, and lateral load resistance. This study underscores the crucial role of masonry infills in the seismic design of RC structures.

KEYWORDS: Reinforced Concrete (RC), Infill walls, Seismic Performance, Response Spectrum Analysis (RSA), Time History Analysis (THA), Eigen value analysis , Pushover analysis (PA), ETABS 2016

I. INTRODUCTION

After an earthquake, the overall structure or parts of a building suffer various degrees of damage, which must be quantitatively or qualitatively specified to evaluate the residual seismic capacity of the building to withstand further earthquakes. Reinforced Concrete (RC) frames with infill walls represent a common structural system employed in building construction. This combination integrates the strength and ductility of reinforced concrete with the stiffness and mass provided by infill walls, typically made of masonry or other materials. The interaction between the RC frame and infill wall influences the overall structural behavior, especially in the context of seismic performance. Incorporating infill walls in reinforced concrete (RC) structures is a strategic design approach aimed at mitigating seismic damages. The presence of infill walls offers several advantages in enhancing the overall seismic performance of the structure. Infill walls contribute significantly to the lateral stiffness of the structure. This increased stiffness reduces the building's lateral sway during an earthquake, thereby minimizing potential damage. Infills are generally used as partition separators in RC structures by different types of material. They have significant impacts on both the earthquake performance of the structure and the structural damages after seismic events. Seismic forces pose a silent menace to structures, and understanding their impact is crucial for constructing resilient buildings. In this exploration, we unravel the intricacies of seismic damage assessment in reinforced concrete frames with and without infill walls. Earthquakes, a natural phenomenon, can wreak havoc (create damages and confusion) on buildings, making seismic damage assessment a critical aspect of construction. The evaluation of reinforced concrete (RC) frames with infill walls becomes paramount to ensure structural integrity and safety. The response reduction factor (R) is one of the seismic design parameters used in the earthquake performance of buildings. This factor is an indicator of the extent to which energy is dissipated by inelastic deformation during a seismic event. It differs according to the countries although this parameter is included in the seismic design codes. It generally specifies different 'R' values according to the over strength, redundancy, and ductility of the buildings stated that the response reduction factor is the most important parameter specified using the methodology the nonlinear type static pushover analysis and dynamic analysis for different types of frames using ETABS software.

Need for provision of Infill wall

1. Infill walls are key to improving the seismic behavior of buildings, reducing their susceptibility to earthquake damage.
2. Adding infill walls strengthens the earthquake resilience of structures, ensuring their safety and maintaining their integrity.
3. Infill walls are essential for absorbing and dissipating seismic forces through their capacity for inelastic deformation.
4. In regions susceptible to earthquakes, infill walls significantly enhance the seismic resistance of reinforced concrete (RC) frames.

5. Integrating infill walls into RC buildings is a strategic approach to enhance the durability of constructions in earthquake-prone areas.
6. It is crucial to comprehend how infill walls affect the seismic resilience of buildings to optimize damage assessments and structural designs in earthquake zones.

II. RELATED WORK

This study investigates the earthquake vulnerability of different reinforced concrete building models, considering the impact of infill walls. Using the Quadrants assessment method and Seismo Struct software, they analyze five models with varying levels of infill, finding that the width of infills according to ASCE-41-06 is underestimated compared to field tests. The results suggest a need for retrofitting bare and open ground story frames, highlighting the positive effect of infills on seismic performance[1]. This study explores using masonry infill walls to strengthen slightly damaged reinforced concrete frames, finding that such infills enhance stiffness, strength, and damping, resembling the performance of undamaged frames. The improvements depend on the masonry units' robustness and the chosen reinforcement method. In this paper, an RC frame model with infilled walls was built and tested, including by a modal test, percussion test and shaking table test.[2]. This study extensively examines the placement of shear walls in a 10-story building to enhance seismic resistance. Using STAAD PRO V8i software and Response Spectrum Analysis, three models with varying shear wall positions are assessed in terms of factors like lateral displacement and bending moment, offering valuable insights for engineers in seismic optimization.[3]. The study examines how buildings respond to earthquakes using Non-linear Static analysis, focusing on structures with shear walls, which are preferred for earthquake-prone areas. It aims to identify the optimal shear wall location in G+13 & G+5 RCC buildings, assess the effectiveness of the chosen shear wall, and analyze seismic behavior under different zones using ETABS software. The shear wall is required to be continuous from the foundation throughout the building.[4]. This study suggests a simplified method, based on Japanese seismic standards, to estimate the earthquake resistance of reinforced concrete buildings with masonry walls. By analyzing 370 buildings in earthquake-affected areas like Taiwan, Ecuador, and Nepal, the study found a correlation between the seismic capacity index and observed damage. Applying this method to 103 buildings in Bangladesh underscores the need for prompt seismic evaluation and retrofitting due to potential earthquake risks.[5]. The seismic performance of reinforced concrete buildings with masonry infill walls is crucial, especially in areas prone to earthquakes. This study focuses on evaluating an older RC building in Southern Italy originally designed for gravity loads in the 1960s, now in a high-seismic zone. The research involves assessing the impact of infill walls on the building's flexibility and seismic capacity, considering a strengthening solution involving cutting masonry infill panels from RC columns and reinforcing them with composite grids in a mortar matrix (FRCM).[6]

III. METHODOLOGY

Methods use for structural analysis on etabs:

1. Prepare autocad centreline plan
2. Import in etabs
3. Find the sizes of infill wall and columns
4. Add load and then analysed the structure by using different seismic condition
5. By using static and dynamic analysis
 1. equivalent static analysis
 2. time history analysis
 3. response spectrum analysis
 4. non linear static analysis
6. And check seismic result.

In this project we have taken quadrants assessment method. By using following methods.

1. Pushover analysis (response reduction factor)
2. Time history analysis
3. Response spectrum analysis
4. Equivalent static analysis
5. Eigen value analysis

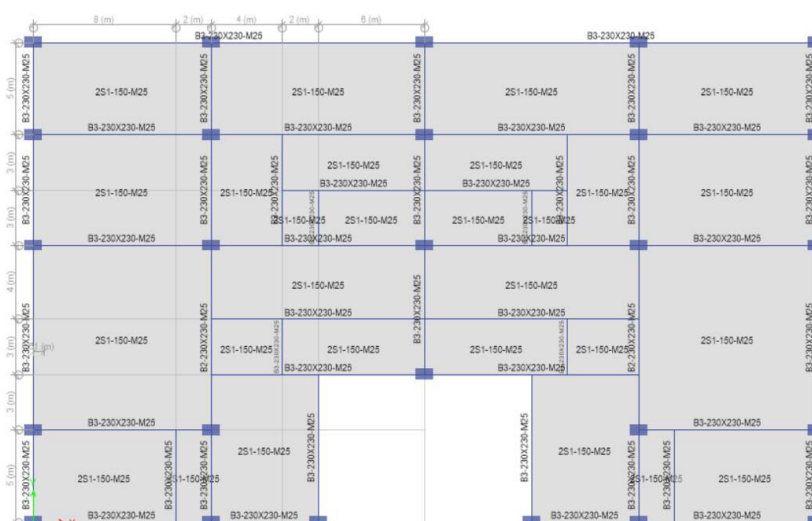
Infills are generally used as partition separators in RC structures by different types of material. They have significant impacts on both the earthquake performance of the structure and the structural damages after seismic events.

In this method we have taken two main structural parameters namely: the threshold damage limit state (i.e., the global yield point of the RC structure obtained from the reduced stiffness method. and the design base shear. These two values are used to indicate the horizontal and vertical axes in the capacity curve. The horizontal axis specifies the design base shear forces, while the vertical axis defines the threshold damage limit conditions. This created capacity curve is divided into four quadrants

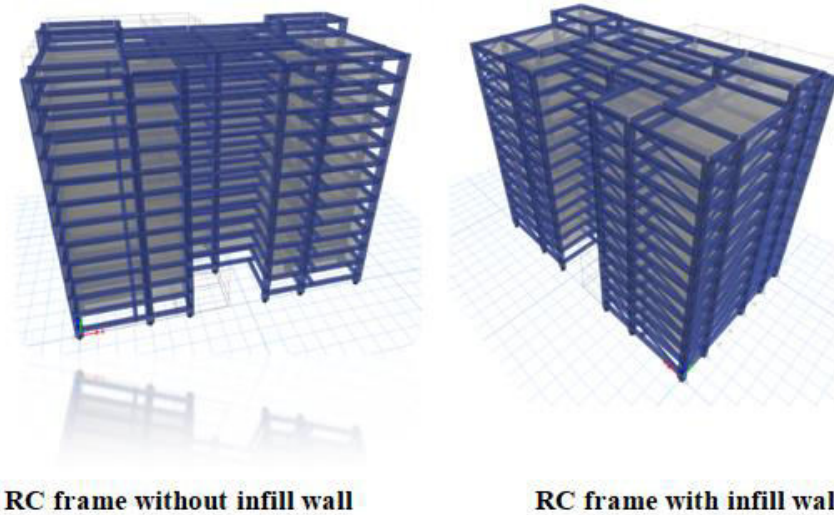
Design data

In this project we consider the following data from IS-1893-2016.

- 1. Type of Structure : Multi Storied G+11
(Special RC Framed Structure)
- 2. Seismic Zone : III (Table 2. IS 1893 Part 1: 2016)
- 3. Town : Surat
- 4. zone factor : 0.16
- 3. Number of Stories : (G +11)
- 4. Floor Height : 3.m
- 5. Imposed Load : 3 KN/m² (Typical Floor)
- 6. Imposed Load : 1.5 KN/m (Roof Floor)
- 7. Materials : Concrete (M 30) and Reinforcement
(Fe 500)
- 8. Size of Columns : (450 x 600) mm
- 9. Size of Beams : (300 x 600) mm
- 10. Depth of Slab : 150 mm thick
- 11. Specific Wt. of RC Slab : 25 KN/m
- 12. Specific Wt. of RC bricks : 20 KN/m
- 13. Type of Soil : STIFF SOIL
- 14. Response Spectra : As per IS 1893 (Part I: 2016)
- 15. Time History : Compatible to IS 1893 (Part I - 2016)
Spectra at Medium Site as per 5% Damping
- 16. Height of structure : 39.6m



Grid plan of typical floor



IV. ANALYTICAL RESULTS

Table1. Comparison table for with infill wall RC frame by static and dynamic analysis using etabs

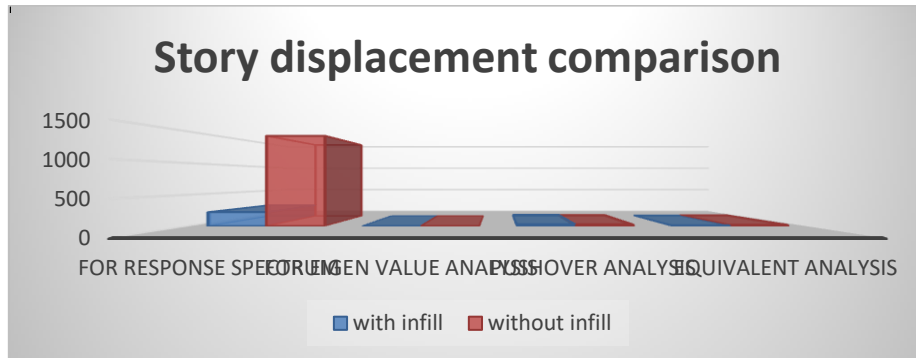
	For response spectrum method	For time history analysis Method	Eigen method	Pushover analysis	Equivalent static analysis
Story Displacement (mm)	1433.511426	0.001	0.013502	26.183698	21.938635
Story drift(mm)	0.054334	0.000021	0.000001	0.001015	0.000772
story Shear(KN)	103982	0.00931	0.961206	2366.306306	2.763
Overturning (KN.m)	2700832	6.00	25.33065	1733354	7.969
Base v/s time(sec)		9.8			
Base v/s monitored displacement				15655.386	

Table2. Comparison table for without infill wall RC frame by static and dynamic analysis using etabs

	For response spectrum method	For time history analysis Method	Eigen method	Pushover analysis	Equivalent static analysis
Story Displacement (mm)	223.000973	0.001	0.012929	29.080774	14.190839
Story drift(mm)	0.008329	0.000021	4.769	0.001152	0.000478
story Shear(KN)	41508.9035	0.00931	0.05114	6440.22098	8.263
Overturning (KN.m)	1018165	6.00	0	1764126	0.000002
Base v/s time(sec)		10			
Base v/s monitored displacement				18917.816	

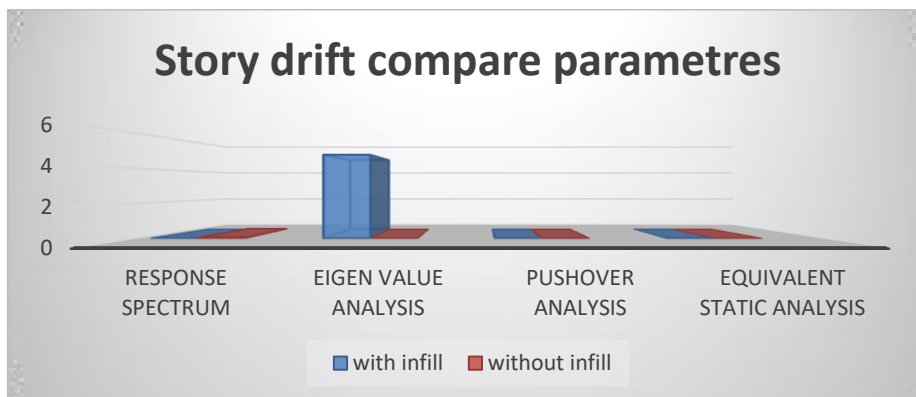
1. Storey displacement comparison

The maximum storey displacement was significantly lower in the RC frame with infill walls (223.000973 mm) compared to the bare RC frame (1433.511 mm), due to the increased stiffness provided by the infill walls.



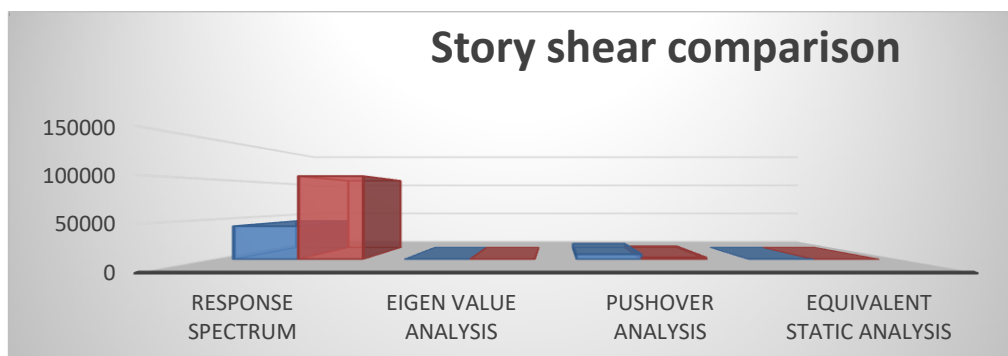
2. Story drift comparison

In an Eigen value analysis, the maximum storey drift ratio was found to be significantly higher at 4.769mm in reinforced concrete (RC) frames with infill walls, compared to just 0.001mm in bare RC frames. This notable decrease in the storey drift ratio in bare RC frames can be attributed to their increased stiffness relative to RC frames that include infill walls.



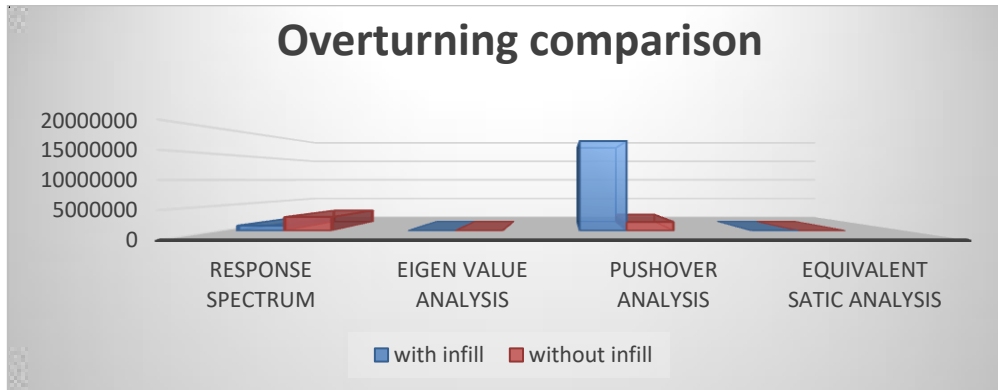
3. Story shear comparison

From the results obtained by Response spectrum analysis, maximum storey shear was observed (41508.90 kN) in case of RC frame having infill walls whereas (103982kN) in case of bare RC frame. This greater reduction of storey shear in case of bare RC frame was observed due to its greater stiffness as compared to that of infill walls having RC frame.



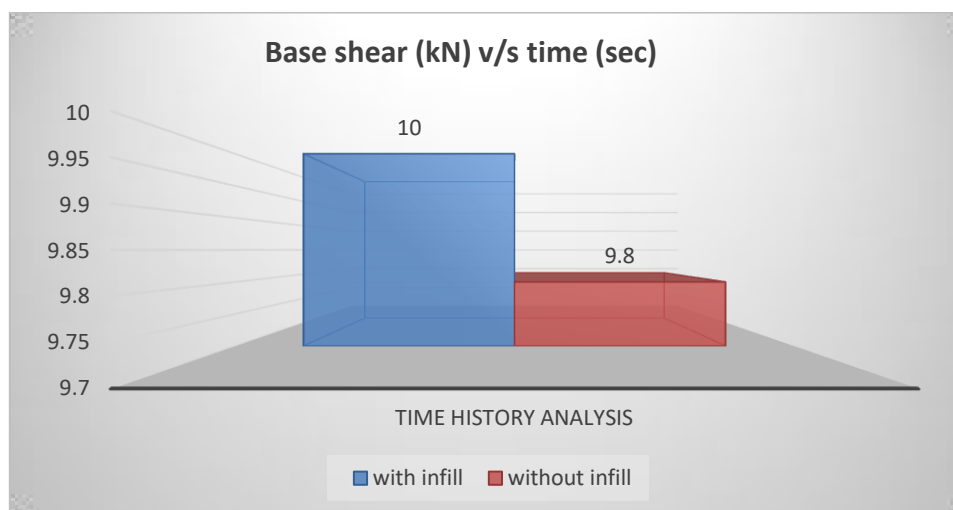
4. Story overturning comparison

From the results obtained by Pushover analysis, maximum storey overturning was observed (1018165 kN.m) in case of RC frame having infill walls whereas (2700832 kN.m) in case of bare RC frame. This greater reduction of storey overturning in case of bare RC frame was observed due to its greater stiffness as compared to that of infill walls having RC frame.



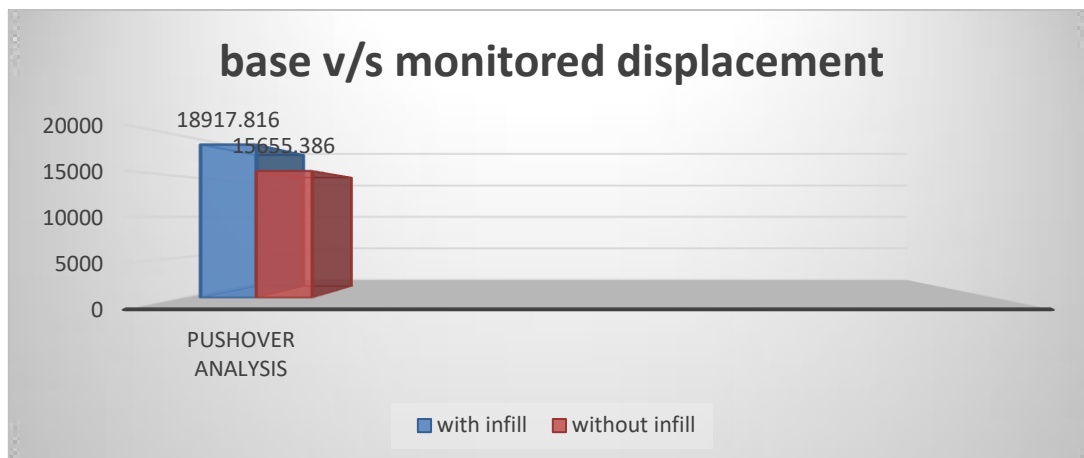
5. Base shear v/s time comparison for time history analysis

From the results obtained by Time history analysis, time period of the structure was observed to be (10 sec) in case of of RC frame having infll walls whereas (9.8sec) in case of bare RC frame. This reduction of time period in case of RC frame having infll walls was observed due to its greater stiffness as compared to that of bare RC frame.



6 .Base shear v/s monitored displacement comparison for pushover analysis

From the results obtained by pushover analysis, base shear was observed to be (18917 KN) in case of RC frame having infll walls whereas (15655.386KN) in case of bare RC frame. This greater increase of base shear in case of RC frame having infll walls was observed due to its greater stiffness as compared to that of bare RC frame.



V. CONCLUSION

Based on the seismic damage assessment results, the following conclusions can be drawn:

1. Incorporating infill walls significantly reduces maximum storey displacement, indicating enhanced lateral stiffness.
2. Bare RC frames exhibit minimal storey drift ratio, reflecting their inherent stiffness.
3. Base shear increases with infill walls due to greater stiffness, emphasizing the importance of structural rigidity.
4. The time period of the structure decreases with infill walls, indicating their higher stiffness.
5. Storey shear is notably lower in bare RC frames, suggesting reduced lateral forces and potential structural stress.
6. Bare RC frames exhibit lower storey overturning moments, showcasing their inherent stability against seismic events.
7. Overall, infill walls effectively boost lateral stiffness, minimize displacements, and distribute seismic forces uniformly.
8. Incorporating infill walls strengthens vulnerable corners, reduces shear forces, and enhances the ductility and overall resilience of the structure.

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