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| RESEARCH ARTICLE

Seismic Response History Analysis of RC Frame Building with Different Position of Shear Walls by using ETABS

Ahmad Zia Ayar[1] ✉ and Abdul Ahad Fizan[2]
[1] *Ahmad Zia Ayar, Construction Faculty, Kabul Polytechnic University, Afghanistan*
[2] *Civil Engineering, Sakarya University, Turkiye*
Corresponding Author: Ahmad Zia Ayar, **E-mail**: ahmadzia.ayar@kpu.edu.af

| ABSTRACT
When building frames are subjected to lateral deflections due to earthquake loads, the resulting oscillatory movement can induce a wide range of responses in building occupants. Hence, lateral stiffness is a major consideration in the design of multi-story structures. Fortifying reinforced concrete frame structures against lateral forces can be achieved by strategically positioning shear walls. Shear walls are structural members used to resist lateral forces and gravity loads. The position and type of shear wall have a significant effect on the overall behaviour of the building structure. For effective application of the building frame, it is necessary to locate the shear wall in an ideal place and select the most suitable type. This article examines the response of buildings with different types of shear walls. Four different models are subjected to earthquake loads. In this study, a G+20 story RC Frame building was analysed using different positions of shear walls. The analysis was conducted according to the ASCE-07 2010 code using the time history analysis method in the ETABS software. The main parameters compared in this study are story displacement, base shear, story drift, and fundamental period.

| KEYWORDS

Earthquake loads, shear wall, RC structures, Story displacement, Time-history analysis, ASCE-07 2010 code.

| ARTICLE INFORMATION

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1. Introduction

In recent times, earthquakes have emerged as a significant concern for human safety. Numerous countries worldwide, particularly in Asia and other continents, have suffered extensive damage due to earthquakes (Hosseini & Ramana Rao, 2018). A shear wall serves as a structural member designed to withstand lateral forces and gravity loads within each structure. Given the pivotal role of shear walls in building structures, they are commonly utilized elements in frame structures (Husain & Mahmood, 2017). Identifying the optimal position for shear walls necessitates familiarity with two primary methods of analysis: static and dynamic analysis (Afzal & Mishra, 2019), (Hosseini & Nezhadasad, 2019). Therefore, having a comprehensive understanding of these methods is crucial, as outlined below:

Static analysis, also referred to as the equivalent static force method, involves calculating seismic forces in a normalized manner. The total base shear is determined based on the dead load, which accounts for the weight of the building or frame. In some cases, various building or frame codes may also incorporate a portion of the live load, distributing it across each story and direction as per the requirements (Afzal & Mishra, 2019).

Dynamic analysis becomes necessary when equivalent static force analysis proves inadequate for structural analysis, especially under lateral and dynamic loads such as wind and earthquake loads. Instead of relying solely on static analysis, dynamic analysis methods are employed to achieve a more accurate response for structures. Two common dynamic analysis techniques are

Response Spectrum Analysis and Time History Analysis (also known as response history analysis) (Dharanya, Gayathri, & Deepika, 2017).

2. Literature Review

Various studies have investigated the impact of shear wall locations and types in buildings exposed to seismic loads, employing diverse methodologies. One notable research conducted by Mohammed Abbas Hussain and Osamah Ibrahim Mahmood entails a comparative study on different types of shear walls in buildings subjected to earthquake loading. Their analysis utilized the response spectrum method and was conducted using the SAP2000 program (Husain & Mahmood, 2017).

Another significant study was conducted by Ashish S. Agrawal et al., focusing on the effect of changes in shear wall location on the story drift of multistory buildings subjected to lateral loads. Their investigation involved a 25-story building located in zone V, with a thorough analysis carried out by varying the positions of shear walls to assess parameters such as story drift, axial load, and displacement. This comprehensive analysis was performed using ETABS software. The findings revealed that placing shear walls away from the center of gravity led to an increase in most member forces. Additionally, the study observed that drift increased with the height of the building but decreased for the top floor (Agrawal & Charkha, 2012).

Dr. Mahdi Hosseini and Zahra Nezhadasad conducted a research study titled "Analysis of High-Rise Structures Under Different Types of Shear Walls," aiming to estimate structural responses such as story displacement, time period, and frequency for earthquake-resistant buildings. The study emphasizes the necessity of dynamic analysis to derive the design seismic force and its distribution across different levels and lateral load-resisting elements of the building (Hosseini & Nezhadasad, 2019).

P. Siva Sankar and Dr. P. Kodanda Rama Rao conducted a study titled "Static and Dynamic Analysis of a Multi-Storied Building with Shear Walls at Different Locations." Their research involved analyzing five models using ETABS software, employing two methods of analysis: response spectrum and equivalent static analysis. The study compared results such as base shear, displacements, and drifts to assess the effects of shear wall placement on structural behavior (Sankar & Roma Rao, 2017).

Limited literature reviews by Anil Baral and Dr. SK.Yajdani have examined the positioning of shear walls. However, there is a need for more comprehensive research to determine the ideal location of shear walls in structures (Baral & Yajdani , 2015). Therefore, this study focuses on analyzing a G+20 story building. It introduces a novel approach aimed at achieving optimal building behavior under earthquake loading through linear time history analysis, considering various ground motion records and shear wall positions.

3. Methodology

In this study, four models of RC frame buildings with different shear wall locations and two ground motion records are utilized. These models are subjected to analysis using time history methods in ETABS software.

Modal analysis is employed to determine the fundamental time periods of each model using the Ritz vector mode type. In accordance with design codes, the modal participation ratio is considered to be greater than 90%.

To assess the story displacement, story drift, and base shear in four models of RC frame building structures with varying types of shear walls and two distinct ground motion records, the following structures are considered for seismic behavior analysis in this study:

Model 1: RCC Frame with RC shear wall and IMP VAL ground motion record of earthquake.
Model 2: RCC Frame with RC shear wall at corners and Kobe Japan ground motion record of earthquake.
Model 3: RCC Frame with RC shear wall at inner section and IMP VAL ground motion record of earthquake.
Model 4: RCC Frame with RC shear wall at inner section, and Kobe Japan ground motion record of earthquake.

3.1 Time History Analysis

Dynamic analysis involves a step-by-step examination of dynamic structures to determine their response under varying loads that change with time (Azad & Abd Gani, 2016). This analysis can be either linear or nonlinear. In this paper, linear time history analysis is employed to evaluate the response of structures to earthquake loads. Dynamic equations can be solved using various methods for each time step, including direct integration and modal analysis.

In this study, linear modal time history analysis is employed, following the American code ASCE 7-10 (Agrawal & Charkha, 2012). For dynamic analysis of steel and concrete frame buildings, the damping ratio is typically taken as 2% to 5% of the critical damping. In this study, a damping ratio of 5% is utilized (Dharanya, Gayathri, & Deepika, 2017).

3.2 Shear wall system

Multistory buildings are required to withstand higher seismic forces, necessitating the incorporation of a lateral load resisting systems such as shear walls or bracing. Shear walls are commonly referred to as a combination of braced panels (Afzal & Mishra, 2019). They offer superior resistance against lateral forces and are recognized for their efficiency in mitigating such loads. Generally, shear walls comprise reinforced concrete walls or large dimensioned columns. Their significance in structural engineering extends to enhancing the lateral stiffness of structural frames. Shear walls can be categorized based on materials, construction processes, and positions (Hosseini & Ramana Rao, 2018).

Concrete shear walls are extensively utilized in tall buildings, often positioned as lift cores or in the corners of the building frame. They play a crucial role in providing lateral stability and resisting seismic forces. Depending on the construction process, shear walls are typically classified into two types: precast and cast-in-situ (also known as monolithic).

The positioning of shear walls is a critical aspect of structural design. Shear walls have a significant impact on both the center of mass (CoM) and the center of rigidity (CoR) of a building. Minimizing the distance between the center of mass and the center of rigidity is essential to reduce eccentricity and the corresponding torsional moments in the structure. Shear walls are typically constructed from the foundation level and are designed to extend to maximum heights of buildings while maintaining a minimum thickness. Generally, shear walls have a thickness of approximately 150-200mm or more. In heavy-loaded structures, shear walls may also serve as load-bearing walls, carrying vertical loads in addition to resisting lateral forces.

3.3 Modeling in ETABS:

The paper focuses on the study of a G+20 story RC frame building. Four different structural models are analyzed, each with different shear wall locations, and subjected to various earthquake load records. All models feature a structural layout of 6 bays at 6m intervals in the x-direction and 4 bays at 5m intervals in the y-direction. The analysis is conducted in accordance with the ASCE-07 2010 code, utilizing the ETABS software. The main parameters compared in this study include story displacement, base shear, and story drift. Below are the properties of the building frame and its elements:

Table 1
Properties of building frame and seismic analysis parameters

Application of buildings	Residential building
Number of stories	G+20
shear wall thickness	30 cm
Ground floor story height	4 meters
Height of other stories	3 meters
Slab thickness	25 cm
Beam Size	40X50 cm
Concrete grade	M30 (columns and beams)
Rebar grade	T 400
Column size	60X90
Damping	5%
Site Class	D
S1	1.13
Ss	0.53

In this research, ground motion records have been obtained from a peer ground motion database. Specifically, the IMP VALL and Kobe Japan earthquake records have been selected for analysis. These records are utilized to determine the optimal location of shear walls for RC frame building structures. By studying the response of the structures to these ground motion records, insights can be gained into the effectiveness of different shear wall placements in enhancing the seismic performance of the buildings.

Figure 1 Modal 1&2 ,3D View

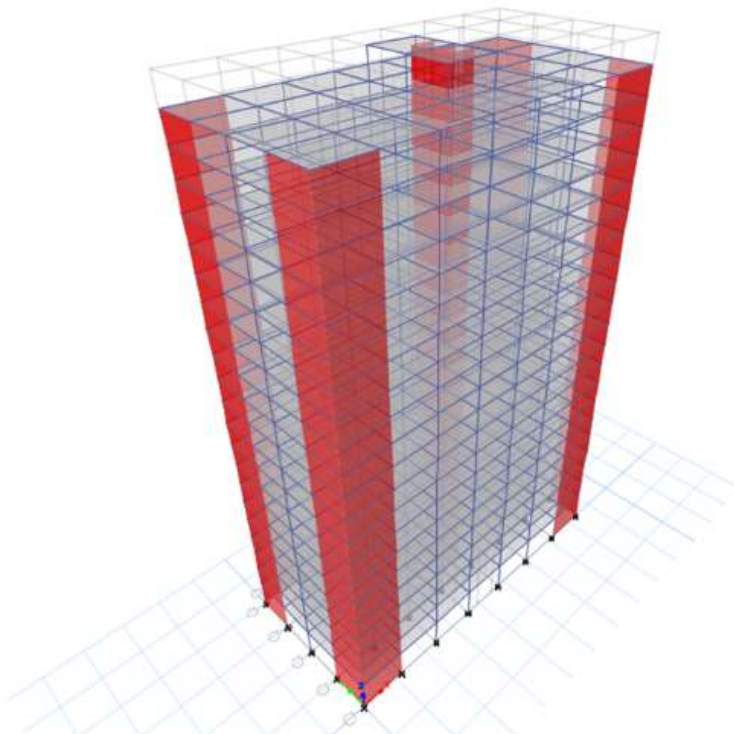


Figure 2 Modal 1&2 Plan

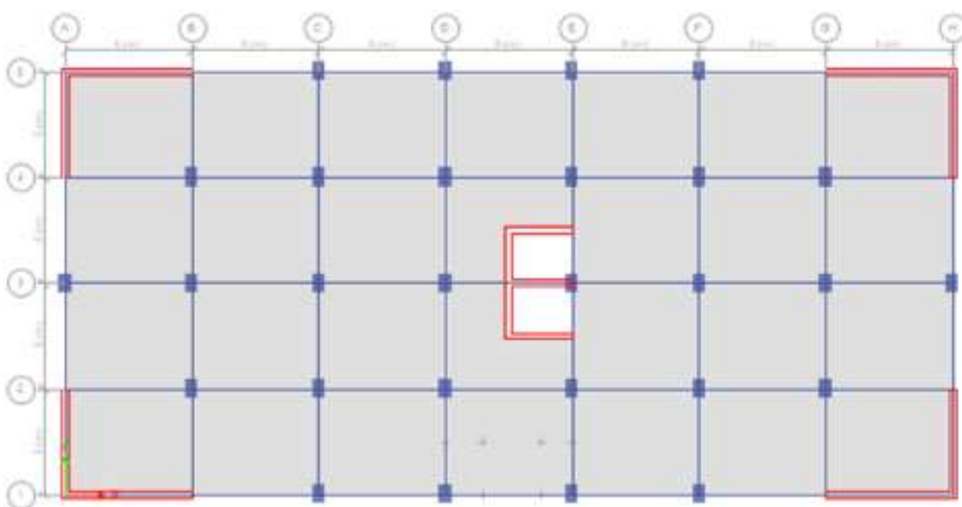


Figure 3 Modal 3&4 3D view

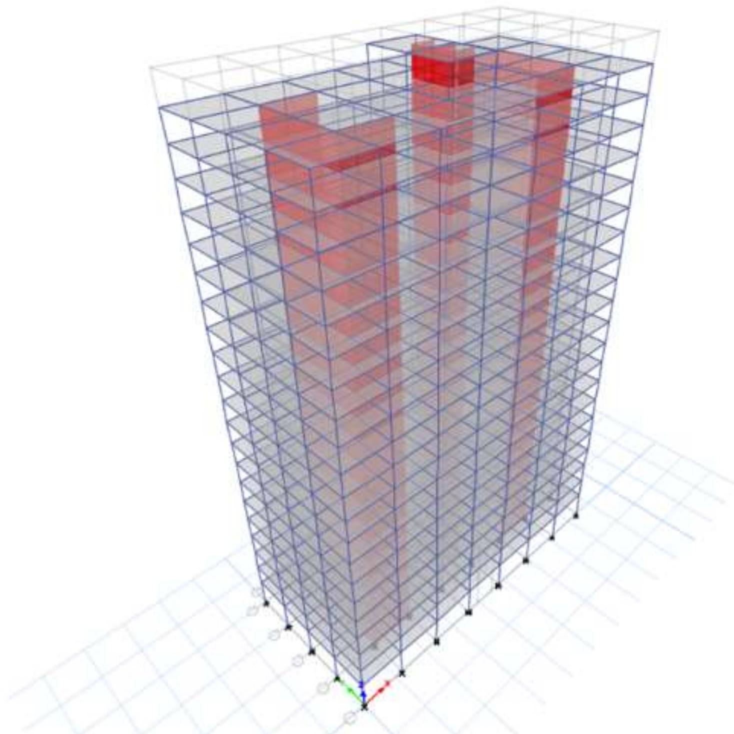
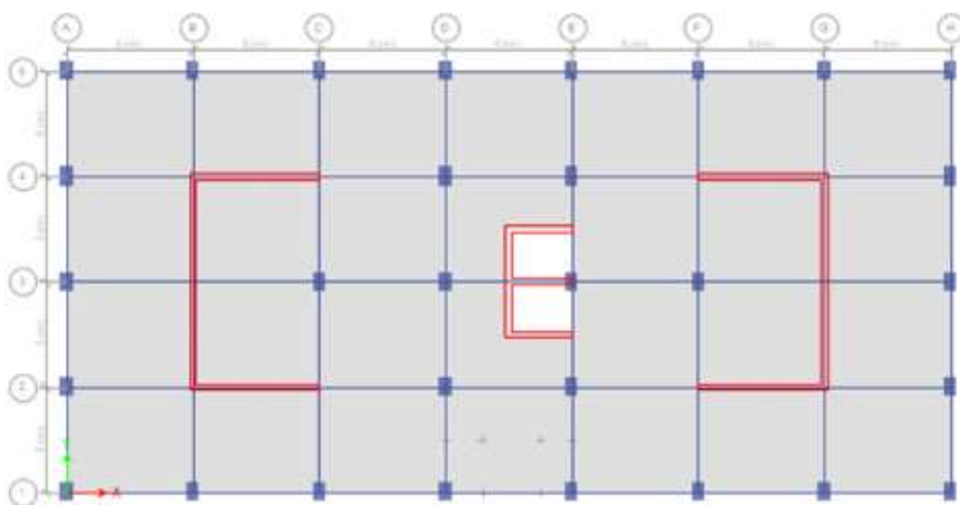


Figure 4 Modal 3&4, Plan



4. Results and Discussion

4.1 Fundamental time period

The fundamental time period of each model is as follows:

Table 2
Fundamental time periods of each model

Fundamental time period			
model 1	model 2	model 3	model 4
2.272	2.272	2.099	2.099

4.2 Base shear

The total lateral force at the base for the design of the structure. As shown in these charts for the x and y direction of the assumed building below:

Figure 5 Base reaction in x-dir

Figure 6 Base reaction in y-dir

4.3 Story drift :

Story drift, which is defined here as the relative horizontal displacement of the two adjacent floors, can form the starting point for assessment of damage to nonstructural components such as facades and interior partitions. Story drift is the displacement of one level relative to other levels above or below (Hosseini & Ramana Rao, 2018). The story drifts of all Four models in X and Y directions using time history analysis are shown in the figure below:

Figure 7 Story Drift in x-dir

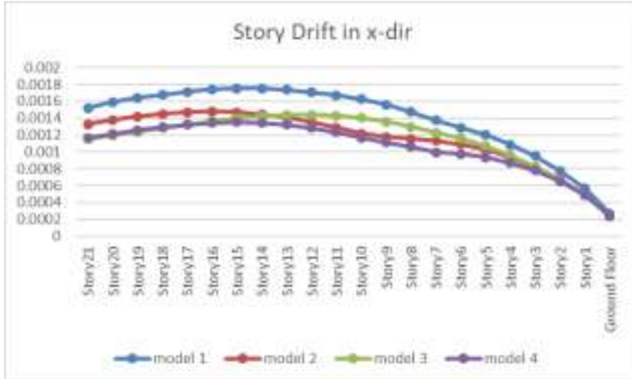
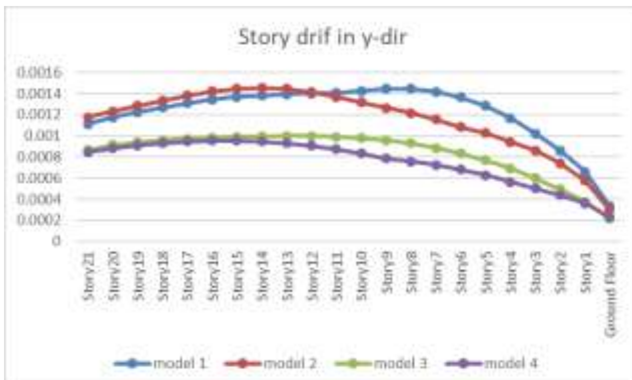


Figure 8 Story Drift in y-dir



4.4 Story Displacements

It is the story drift of one story with respect to the base of the building.
Story displacement of the assumed structures in the x and y directions are shown in the charts below.

Figure 9 Displacement in x-dir

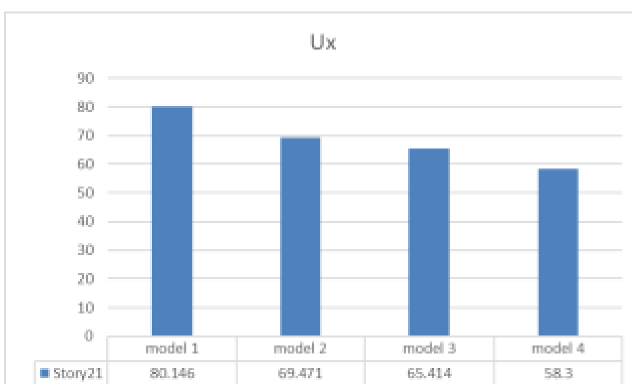
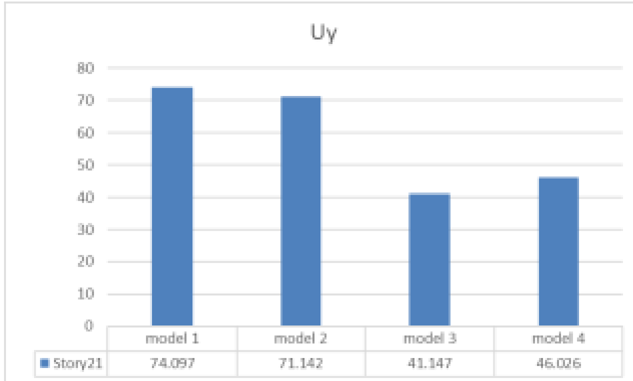


Figure 10 Displacement in y-dir



5. Conclusion

The conclusion of this study is as follows:

1. Models one and two exhibit the same fundamental period, as do models three and four. Consequently, models one and two have a greater period than models three and four, suggesting that shear walls positioned closer to the center of the structure have shorter periods than those positioned at the outer sides.
2. Base shear in the x-direction surpasses that in the y-direction for each model, indicating an increasing amount of base shear along the longitudinal direction of the frames.
3. Story displacement in model one exceeds that in the remaining models, in both the x and y directions, implying that shear wall positioning on the inner side is more favorable than on the outer side for the studied models.
4. Models one and two exhibit greater story drift than the remaining models, indicating that shear wall positioning on the outer side results in maximum story drift for both earthquake records.
5. Story displacement is greater in models where shear walls are located on the outer side, irrespective of direction (x or y).
6. Model one experiences greater displacement than model two, suggesting that the IMP VAL ground motion record induces more displacement than the KOBE Japan ground motion record in the x-direction, but the opposite holds true for the y-direction.
7. The maximum displacement occurs in model one subjected to the IMP VAL ground motion record, with shear walls positioned on the outer side.

6. Study Limitations and Future Research

In general, there are many limitations in the field of research and data collection in Afghanistan; few studies have been done in the field of earthquake engineering. Very little data is available for earthquakes. The results of the studies conducted by USGS are used by researchers in Afghanistan. Financial restrictions also add to researchers' problems because there are no funds available for research in the country's universities.

The next research can be in the comparison of different types of shear walls according to the materials; a comparison can be made to obtain the most suitable materials for shearwalls and compare the different shapes of shear walls under lateral loads by using different types of analysis.

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