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Effect of Shear Wall Location on Reinforced Concrete Building having Flat Slab in Erbil-Iraq

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Abstract - *Due to rapid increase in population leading to a rising number of multi-storey reinforced concrete (RC) buildings in the commercial districts of the country. It is important to investigate the seismic behavior of these multi-storey buildings especially those situated in high seismic regions. The effect of seismic forces on a structure vary depending on the selected load bearing system. Layout of the shear walls in the plan, selected floor system and structural irregularities affect the seismic performance of the structure Flat slab systems are commonly adopted for many buildings in Erbil city due to economic advantages over conventional slab. They also present some disadvantages as lack of resistance to lateral loads. Adding shear walls in flat slab buildings leads to improve their seismic performance especially in higher seismic zones. The main aim of this study is to investigate the seismic performance of purely flat slab, and flat slab with shear walls at five different locations. A five-storey residential building is analysed by using Equivalent Lateral Force Method (ELFM) using Extend Three Dimension Analysis of Building System (ETABS) software package as per Iraqi Seismic Code (ISC-2017) in Erbil city. The results achieved from static analysis is presented in the form of horizontal displacement, base shear, time period and storey drift. Based on the analysis, the results show that the position of shear wall close to the center of the building gives the best performance.*

Key Words: **Iraqi Seismic Code (ISC-2017), flat slab, shear wall, seismic force.**

1. INTRODUCTION

Currently, with the increasing population, the number of RC buildings are increasing and becoming more slender which makes the building seismic design important. Buildings should be designed to resist both lateral and vertical forces especially those situated in high seismic zones. Selecting an appropriate floor system for buildings needs to be considered as it has a main role in resisting lateral forces [1]-[3].

Flat slab is the common building floor system used in the world and particularly in Erbil as it requires a simple formwork, lower cost, free design of space, and a shorter construction period. Therefore, flat slab offers an economical alternative to the maximum use of interior space. For areas of high seismicity, ISC-2017 does not permit flat slab construction without any lateral load resisting system. Due to the absence of beams and/or shear walls in the flat slab systems excessive lateral deformations can be seen. Thus, It is not preferable to use flat slab in high seismic zones but with the application of shear wall, flat slab building shows better performance [4]-[6].

Shear wall is a common lateral load resisting member which gives lateral stiffness to the buildings. But the stiffness depends on the locations the shear wall which is placed within the building [7]-[11].

Studies conducted by [9] and [12] found out that adding shear walls to the interior part of a building increases its seismic performance. On the other hand, [11], [13] and [14] observed that adding shear walls to the exterior part of the building also increases its seismic performance. Due to these contradictions observed in previous studies about the best location of shear wall, compels us to investigate the effect of the location of shear walls on seismic performance of buildings.

Erbil city is regarded as the oldest city in the world [15]. The population of Erbil is more than one million and has an area of 130 Km^2. Erbil lies in northern part of Iraq close to the border of Iraq-Turkey and Iraq-Iran which is in the active seismic zone (zone1) as shown in Fig-1. This area has been known as a vulnerable area to earthquake and the main sources are the four plates shown in Fig-2. This has led to casualties and lot of damaged buildings over the years due to poor seismic design [16]-[19].

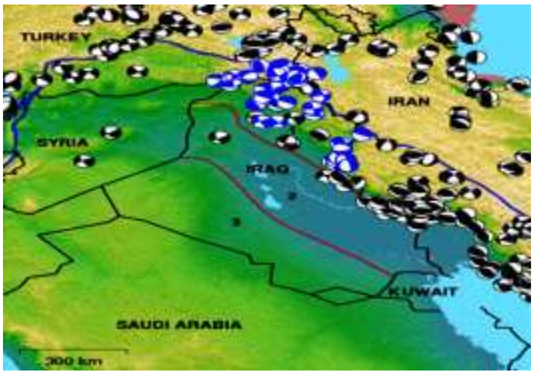

Fig- 1: Seismic zones in Iraq [18]

Fig- 2: Iraqi map among four plates [18]

2. OBJECTIVE AND SCOPE OF THE STUDY

In Erbil, very few buildings are properly designed to resist seismic forces. Proper seismic design of the building that is imposed by gravity and lateral forces is very important. The main objective of this study is to analyze flat slab buildings having different shear wall location. The seismic parameters which include horizontal displacement, storey drift, time period and base shear are compared.

3. MATERIALS AND METHODS

In the present study, the behavior of RC multi-storey building combined with flat slab and shear wall is studied for different models. A regular G +4 structures modelling is carried out in ETABS software package. The building is assumed for seismic analysis which is located in Erbil city, north Iraq. The analysis is carried out for six models by using equivalent lateral force method (ELFM) as per ISC-2017. The loads used are dead load, live load and seismic load.
General information and structural details of building models are given in Table 1 and 2. The seismic data used are shown in Table 3. Two different configurations are modelled in this building i.e. flat slab and flat slab with shear walls at five different locations. The plan and 3D view of six different models are given in Fig. 3 – 8 respectively.

Table 1: General information of residential building in Erbil

Specifications	Values
Building dimension, length and width	20.4 m x 20.4 m
Building height	15m
Floor height	3m
Intended purpose	Residential
Grade of concrete	30 MPa
Grade of steel	420 MPa
Supports condition	Fixed
Dead load	Automatically calculated
Superdead load (finishing materials)	3 KN/m²
Live load	3 KN/m²

Table2: Layout of slab, beams, columns and shear walls for residential RC building

Specifications	Values
Thickness of slab	0.24 m
Dimension of beams, depth and width	0.5 m x 0.25 m
Cross-section of columns	0.4 m x 0.4 m
Length of shear wall	2m
Thickness of shear wall	0.25 m

Table 3: Seismic data according to ISC-2017

Parameters	Values
Spectral response acceleration in the 0.2 Sec., S_s	0.6 g
Spectral response acceleration in the 1 Sec., S_1	0.2 g
Site coefficient F_a	1
Site coefficient F_v	1
Risk category	II
Importance factor	1
Fundamental period T_a,	0.5 sec.
Response reduction factor, R	4.5
Over strength factor, Ω	2.5
Deflection amplification factor, C_d	4.5
Soil site class	B

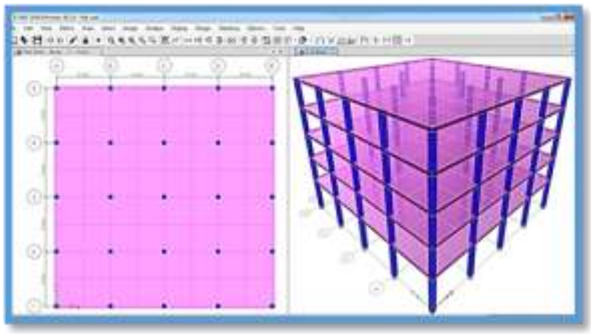

Fig- 3: Flat slab without shear wall (model 1)

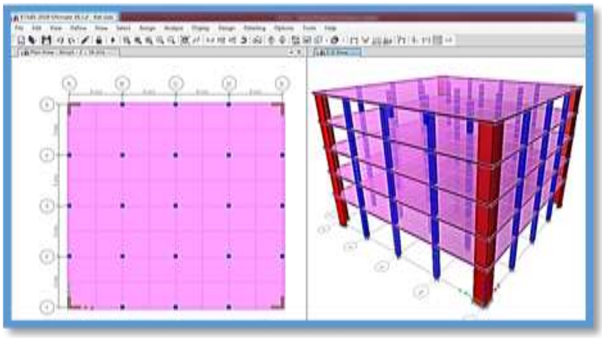

Fig- 4: Flat slab with shear wall at exterior corners (model 2)

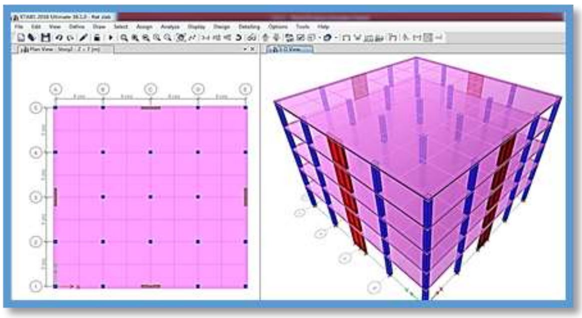

Fig- 5: Flat slab with shear wall at exterior edges (model 3)

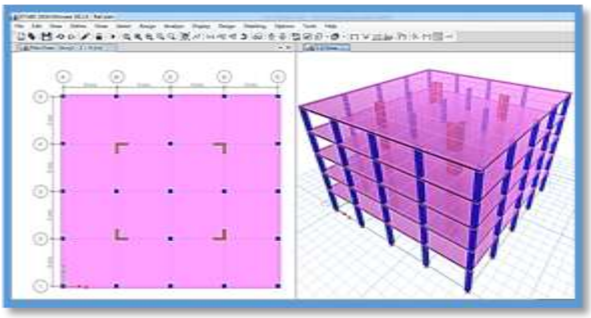

Fig- 6: Flat slab with shear wall at interior corners (model 4)

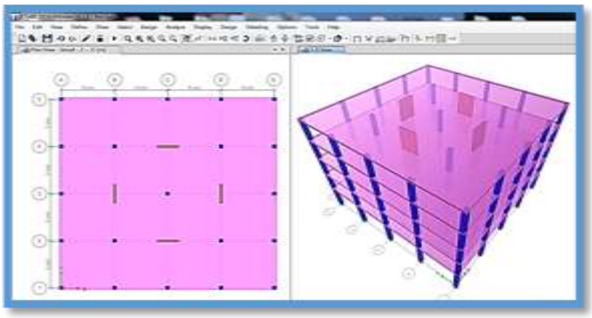

Fig- 7: Flat slab with shear wall at interior edges (model 5)

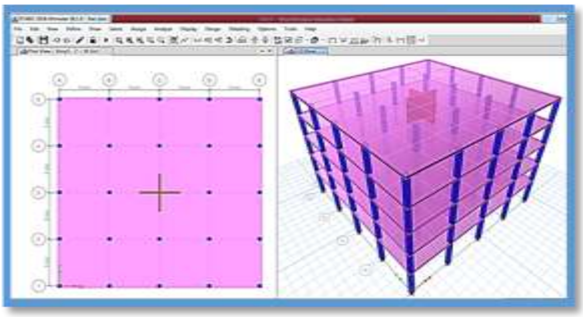

Fig- 8: Flat slab with shear wall at the center (model 6)

4. RESULTS AND DISCUSSIONS

This study investigates the behavior of a structure, flat slab with and without shear wall by using ELFM for earthquake zone 1 as per ISC-2017. The effect of location of shear wall on these building system is evaluated. The seismic parameters such as horizontal displacement, storey drift, time period and base shear is discussed below.

4.1 Horizontal Displacement

For all the models, horizontal displacement is maximum at the upper storeys and minimum at the bottom as shown in Fig- 9.

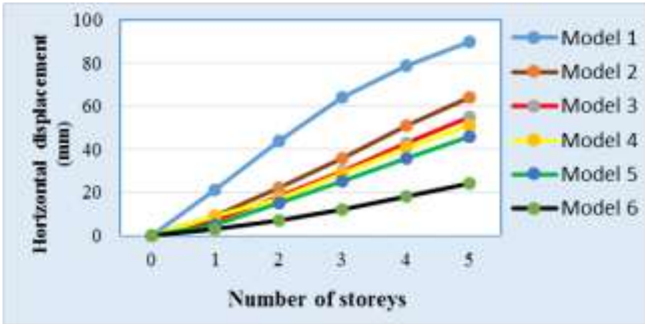

Fig- 9: Horizontal displacement relative to the number of storeys

The maximum value of horizontal displacement of the models are shown in Fig-10

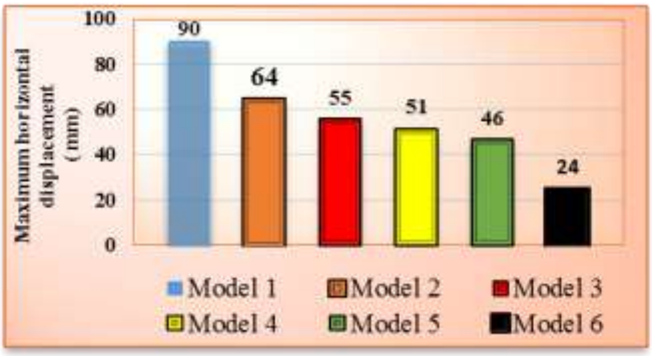

Fig- 10: Maximum horizontal displacement

Moreover, Fig-10 shows that the horizontal displacement of the model 1 having flat slab is 28.88% higher when compared to model 2, 38.88% higher when compared to model 3, 43.33% higher when compared to model 4, 48.88% higher when compared to model 5 and 73.33% higher when compared to model 6.

4.2 Storey Drift

For all the models, the storey drift is highest at the mid-storey of the building and is lowest at the bottom storey as shown in Fig-11.

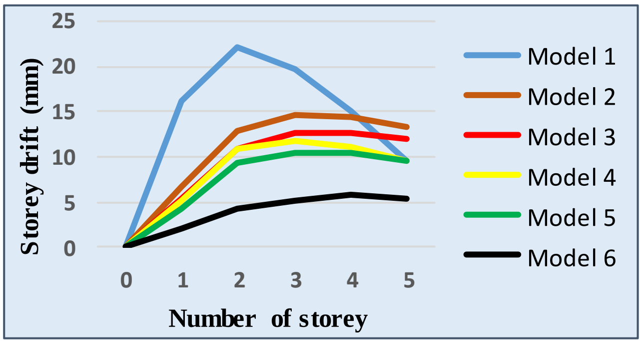

Fig- 11: Storey drift relative to the number of storeys

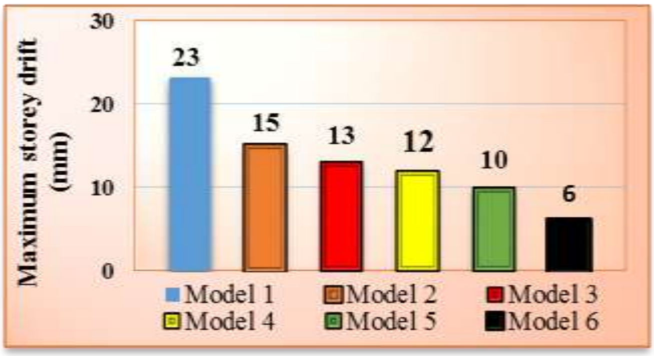

Fig-12: Maximum storey drift

Furthermore, Fig-12 shows that the storey drift of the model 1 having flat slab is 34.78% higher when compared to the model 2, 43.47% higher when compared to the model 3, 47.28% higher when compared to model 4, 56.52% higher when compared to model 5 and 73.91% higher when compared to model 6.

4.3 Time Period

Time period decreases by adding shear wall and it also depends on the location of the shear wall as shown in Fig-13.

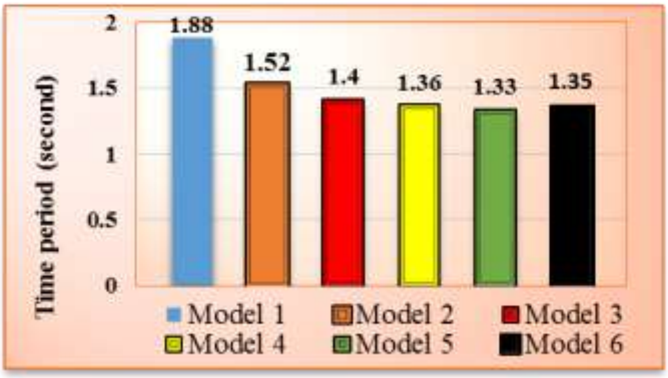

Fig- 13: Time period

Fig.10, 12, and 13 show that, Flat slab has higher horizontal displacement, storey drift, and time period due to the absence of beam. Therefore, using shear wall decreases the horizontal displacement, storey drift, and time period but approaching the shear walls to the center of the building gives the minimum value of horizontal displacement, storey drift, and time period

4.4 Base Shear

Base shear increases by adding the shear wall because of increasing stiffness and it also depends on the location of the shear wall. Figure 14 shows that base shear is highest in model 6, when the shear walls are situated at the center of the building.

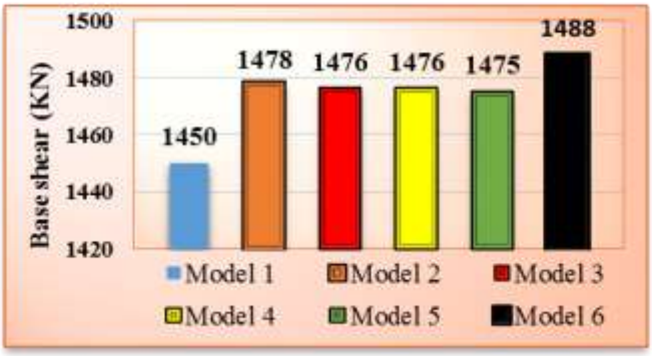

Fig- 14: Base shear

5. CONCLUSION

In this study, it is concluded that the flat slab without shear wall behaves poorly in resisting seismic forces. The behavior of flat slab increases by the addition of shear wall and it also depends on the location it is situated. Adding shear walls decrease the horizontal displacement, storey drift and also time period but decrease further if the shear walls are approached into the center of the building. Shear walls increase the base shear and it is higher when the shear walls are situated in the center of the building. Flat slab structure is more flexible than conventional frame structure and because of that does not reveal good peformance in high seismic zones. The application of shear wall in flat slab structures expose better properties. Therefore, position of shear wall needs to be considered carefully as it makes different in resisting lateral loads.

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BIOGRAPHIES

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