Kurdistan Engineering Union

**یەکێتی ئەندازیارانی کوردستان**

Term Engineering Paper:

# The Effect of Stair Open Around Core Walls Under Seismic Load on Building


## Prepared By:

Ali Muhammad Shekha


**Sulaymaniyah/Rania**

**March/2024**

## Contents:



## List of figures:



## List of tables:

# The Effect of Stair Open Around Core Walls Under Seismic Load on Building


## Abstract

Core walls have many engineering applications in structural analysis, especially in building resistance combination for shear, moment, axial and lateral loads such as seismic and wind load. It is great significance and purpose part in high-rise building and all the buildings that have more height. It uses to locate elevators. Elevator and stair location need to open in slab. Shear wall is very necessary to determine resistant effective on building. The purpose of this research was to study the effects of open around core wall which is made by stairs especially on the slabs or any location in building and effect shear wall or core wall with their locations under seismic load on building. All the literatures showed the effect of opens and shear walls with their locations and sizes, but many building stairs constructed around elevators. The constructions of stair around core wall cause to collect double open in one location, how many effects when separate them, or effect of stair open created far from core walls on the building under seismic load when core wall stay in place. This literature reviews gave minimum displacement and story drift by parameter shear wall. Stiffness of shear wall with openings decreases. Some literatures presented more open in building lead to decrease stiffness of building. Location of the stair is reason for creating open in diaphragm, it is the reason for the failure. And minimum displacement, minimum drift ratio and minimum story displacement for model open far from core wall occurred, if stairs are built around the elevator, the stair's open will cause the elevator to disappear integrity with the building models.



**Keywords**: Stair, Core wall, Seismic, Elevator, Open, and Slab

## 1.Introduction

Tall buildings have grown rapidly worldwide, and tall buildings have become signs of civilized buildings because all the element building must be investigated. In high-rise buildings, shear wall is of great significance and function to support resist lateral loads such as wind and seismic, a braced wall line called a shear wall sometimes. Building without shear wall is poor structure to resist lateral load.

All the literatures show the effect of opens and shear walls with their locations and sizes, but many building stairs constructed around elevators, this construction lead to collect double opens in one location, how many effects when separate them, or effect of stair open created far from core walls on the building under seismic load when core wall stay in place.

This literature reviews give minimum displacement and story drift by parameter shear wall, stiffness of shear wall with openings decreases. Some literatures presented more open in building cause to decrease stiffness of building. Location of the stair is reason for creating open in diaphragm. It is very important for the earthquake to look at the stairs, maybe it causes to problem in buildings. All the stairs need to open, because they are the reason for the failure in the slabs or structures by having plastic hinges to form around the opening corners. In all the literatures he said should be avoided large open in slab, but large open or small did not have more effect on out of plane slab.

For this review was take some building models as experimental study, Three models with different open location (open around core wall, open adjacent core wall and open far from core wall), by method liner static analysis in ETABS computer program. The number of stories is 7 stories and the column with a flat slab plate has a story height equal to 3.6 m. The effect of topic showed especially for the model high-rise building and more force went to the core wall. And Effect open around core wall or far from core wall, and minimum displacement, minimum drift ratio and minimum story displacement for model open far from core wall occurred. Core wall has very good stair support for the open around core wall, but the core wall can not be used as a shear wall because more partial walls do not have integrity with the building. The stair structures around the core wall allow double opening to be collected in one place, how many effects are generated under seismic load when they are separated, or the effect of stair opening far from the core walls of the building models.

## 2. Literature Reviews

In multistory buildings shear walls are used and located in every side of elevator cores. The staircase may be created adjacent building structure. In certain cases, though, the staircase is combined with the construction structure and is placed next to the center of the elevator. Staircase is primarily failure to story drift, building frame has core wall, in reinforced concrete frame, Core wall building stiffness more than stair model (Rao Botsa and Dasgupta, 2017).

Shear wall is a great significance and purpose part in high-rise building to support part of dead loads and resist lateral loads such as wind and seismic (Taheri Fard et al., 2017). Shear wall the International Building Code called a braced wall line (Govalkar et al., 2014). Shear walls have to be positioned in the building in favorable places, by minimizing lateral displacements with drift under wind load and earthquake loads, they can form an impact lateral force resisting system. It is therefore very important to decide the efficient, effective and optimal shear wall position (Rokanuzzaman et al., 2017).

The primary goal of a shear wall is to improve the rigidity of lateral load resistance, such as wind load and seismic load. Shear walls are widely used as a vertical structural element feature in contemporary tall buildings to withstand the lateral loads that can be caused by the effects of wind and earth quakes. The strength and rigidity of the shear wall reduces based on the sizes and shapes of the opening shear walls (Kankuntla et al., 2016).

Large earthquake can take down building and cause death and injury to the human. It is the natural phenomena and no one have control on it. In the past several major earthquakes cause impact on the buildings. The failure in the structures causes due to low stiffness, these weakness result in the failure of the building. Those causes due to the irregularity in the building which could be in vertical and plane irregularity, As per IS 1983-2016 the opening in the plan should not be more than 50 % of total slab area in the building(Choubey et al., 2020). The horizontal deflection and displacement of the column for shear wall or core wall construction is decreased, he said that building with shear wall as angle in corners of building  is more efficient (Harne, 2014).

At the middle of the structure, the core wall must be given because it offers optimum stiffness, minimum displacement and minimum story drift and produces no torsional irregularities. Building must be checked for torsional irregularities if

core wall is to be provided at different location other than the center of the building cause to torsional irregularities. The overall demand for force and moment on the frame members around the stair and elevator core is lower than for models without an elevator core, since more forces go to the core wall (Khan et al., 2019). Shear wall for reinforced concrete building is the best tool to control deformation during earthquake, but it interferes with architecture and feasibility, optimum location of shear wall or lift core wall that will help in achieving the earthquake performance aim (Varna K R, 2017).

In terms of acceleration, acceleration, or displacement, the motion of the ground may be expressed. The action of ground acceleration with time, reported during an earthquake at a point on the ground, is called an accelerogram, which simultaneously measures velocity and displacement by integration (Ajit and Rajesh, 2016). The existence of the openings contributes to failure, where the yield of the bars around the opening corners seems to have a major effect on the slabs' actions by allowing plastic hinges to form around the opening corners. Must be placed bars at opening corners for positive inclined reinforcing, is effectively demonstrated by using of the finite element model (Khajehdehi and Panahshahi, 2016). Broad awareness targeted the modelling and construction elements of structural walls. Using either a fine mesh model or the corresponding frame form, walls were usually modeled (Sahu et al., 2014).

For multiple purpose, the opening in the slabs is usually required. For Slabs newly constructed, locations and sizes of the openings required are usually pre-defined in the early stages of design. However, when a large opening is created in the slabs or any object of an existing building, it surely has a significant effect on its structural behavior (Mahmoud Ahmed et al., 2017).

Stair changes the behavior of structures under seismic load but it is often neglected in design and it is effect on mode shape, shear and moment for column near stair are increase, the stairs must be isolated from main structure for decreasing from these effects (Noorifard and Tabeshpour, 2018).

It is very important to look at the stairs in earthquake, because it may cause problems in building, and the stair effect on all elements around itself, and the support of stair is very important (Sun et al., 2013).

Shear wall size and location cause economical on building, As the length of the shear wall in the plan increases, the opening effect is decreased and the opening

shape does not influence structure responses, but the height and width of the openings affect the opening effect (Kankuntla et al., 2016).

The structural engineer must have a detailed understanding of the irregular structures' seismic response. It is recognized that building codes have requirements for the definition of vertically irregular structures and allow dynamic analysis for lateral forces to be constructed(Soni and Mistry, 2006).

Nonlinear finite element techniques can be safely used in models of reinforced concrete flat slabs to analyses the influence of punching on these construction elements (Marques et al., 2020).

It is necessary to carefully select the right design and size of the openings. In addition, square openings have less effect on rectangular slab load capacity, although rectangular openings have a big effect on the square slab area load capacity. An hole in an existing slab has a major effect on the concrete slab's area load capacity, which decreases its strength (Hadi and Muttashar, 2020). Although deflection and toughness decreased, two way slabs with openings increased (Series and Science, 2020). For several reasons such as stair cases, now a days openings in the floors are normal, lighting architectural these openings in diaphragms cause stresses at discontinuing joints with building elements (Mable Vas et al., 2021). It is easy to apply the proposed equivalent opening for multiperforated walls and promising for a rapid evaluation of the average elastic lateral movement profiles of such complex walls (Tena-Colunga and Liga-Paredes, 2020).

For opened in shear wall noticed from the above analysis that the stiffness of the structure will be lower and the structural components will fail when there will be excess usage of opening beyond the 20 percent limit (Thakre et al., 2020).

## 3. Materials and Methods

### A. Methodology:

A residential building of G+15(16 Story) , 8, 10, 12, 14 and 16 storied buildings were studied by software (Figure 1) (Rokanuzzaman et al., 2017). Location of LCW (lift core wall) (Khan et al., 2019).

Reinforced concrete frame (RCF) used (Rao Botsa and Dasgupta, 2017). These models was used without shear wall Model, Building on the corners of each side with shear wall, building in the center with shear wall, building on each side with shear wall in the center (Figure 2) and they analyzed by ETABS program (Taheri Fard et al., 2017).

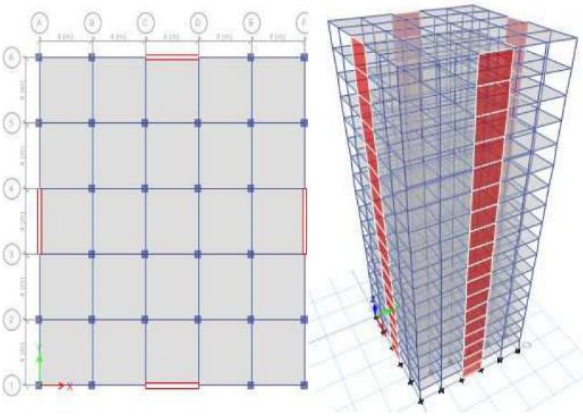


Figure 1 wall on each side on middle (Khan et al., 2019)

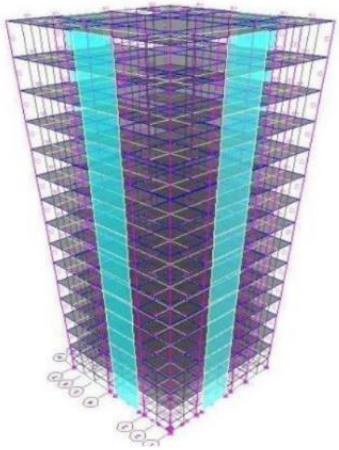


Figure 2 Shear wall at the center of Four external sides (Taheri Fard et al., 2017)

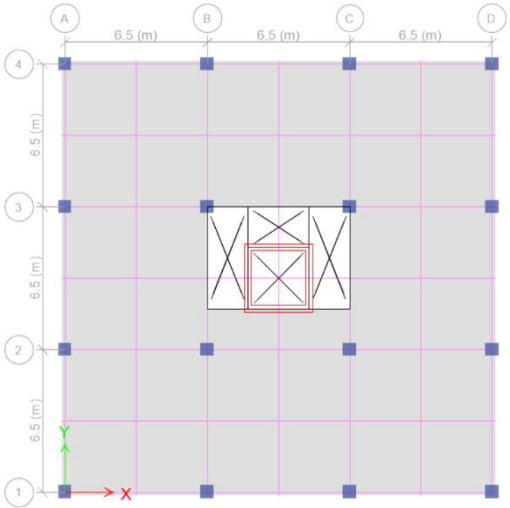
### B. Experimental Study:

This literature review was taken some models to study this topic as shown in below picture (3), but for different models such as frame building or (rebid slab, flat slab and flat slab plate), and must be study for high-rise building, because the effect of core wall appears more. And modal must be studied under special codes that contain seismic load such as UBC Code or ASCE- Code or so. can you use parameter Code UBC such as (All seismic direction with eccentricity ratio (0.05%), Time period under method A or B as per UBC code, force distribution on all story, over strength ratio as per model type, Soil profile, seismic zone factor and important factor), these parameters are selected by the model and will remain in all the models, And such as literature reviews must be check mode to(story drift, maximum story drift, story Shear, maximum displacement structure, base shear, max displacement diaphragm, over terming moment And story

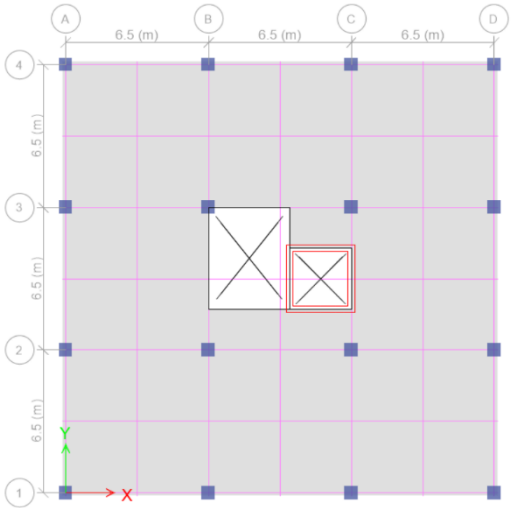
stiffness).and liner or nonlinear analysis must be considered for analyzing the building.

**Case study:**

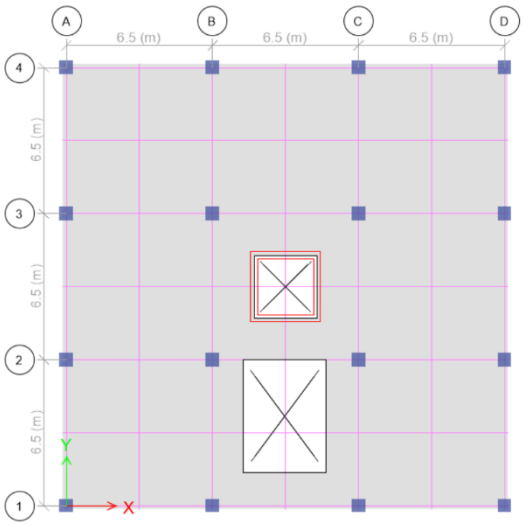
- Method liner static analysis and by ETABS (Extended 3D analysis of building Systems) program. It is an engineering software product that solves the study and design of multi-story buildings.
- Three models with different location stair open.
- 7 stories (story Hight = 3.6m) column with flat slab plate.
- Seismic load acted in all direction by UBC Code. Over strength ratio (R= 4.5) Important factor =1, Soil profile Sc, seismic zone = 3



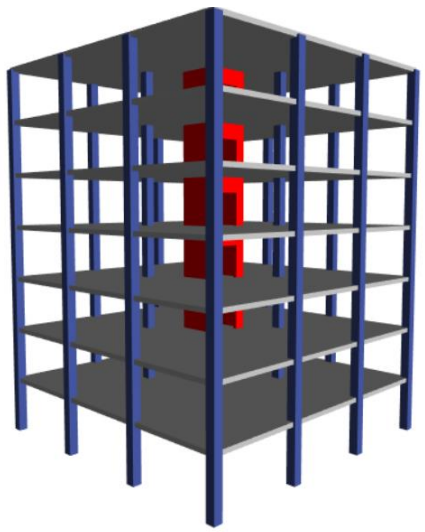

A. Open around Core Wall




B. Open Adjacent Core Wall




C. Open Far from Core Wall



D .3D model

Figure 3 Opened Staired around Core Wall and 3D Model

## 4.Results and Discussions

If opening increases more than 45 % of the plan area at that floor level top story displacement, story drift increases (Figure 4) (Choubey et al., 2020).

When the shear wall was located at the middle of periphery top displacement of the structure is low (Figure 5). In medium high-rise buildings (greater than 10 stories) provision of shear walls is found to be effective in enhancing the overall seismic capacity of the structure (Khan et al., 2019).

It can be shown that the existence of a wide opening size of 25% of the floor panel area has greatly influenced the FE slab's in-plane behavior. It can also be seen that even the existence of smaller opening sizes (6.25% and 14% of the floor panel area) influenced the slabs' in-plane behavior (figure 6) (Khajehdehi and Panahshahi, 2016).

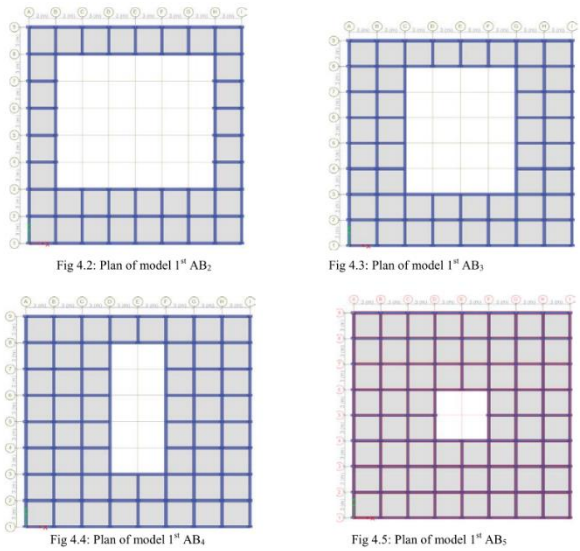



Figure 4 open at floors

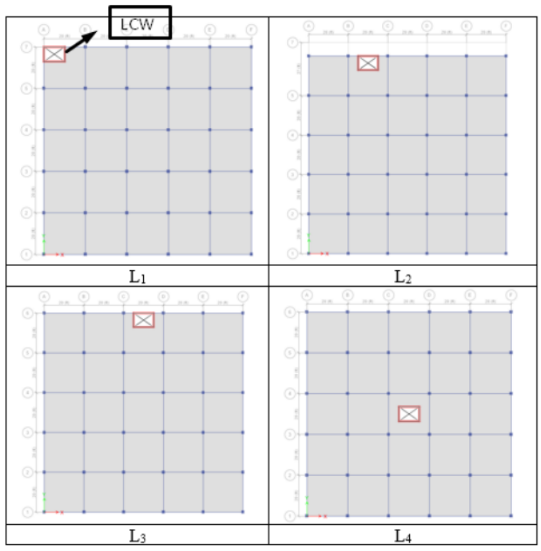



Figure 5 location lift core wall

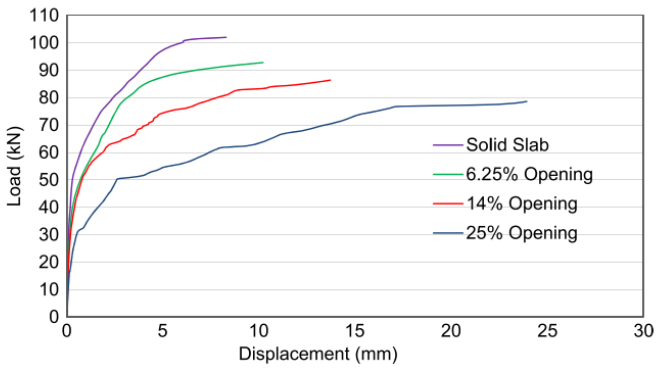



Figure 6 Load displacement curves with different opening sizes for the FE solid slab and the FE slabs.

The results in the table (1) for all the models in the case studies (open around core wall, open adjacent core wall and open far from core wall), Showed that minimum displacement and minimum drift ratio for model open far from core wall, because the open is not more effect on building and core wall for this model all edge connect with building and integrity is very good.

The model opens far from core wall if compared with other models (open around core wall and open adjacent core wall) was better than them, cause core wall takes the slab in all the sides, the many lateral forces go to the core wall. All these above decrees stiffness model as soon as the model open far from maximum story stiffness is more when compared with other models.

The minimum support reaction in model far from core wall this is useful to distribution load to foundation. another important result is story maximum displacement to average displacement, the minimum result in model open fare from core it is useful to torsional irregularity, the meager torsional irregularity sees in the model open around core wall. The result to opened adjacent core wall displacement and story maximum displacement/ average displacement it is not good.

Table 1 The result models for case study.

| All Items Under Seismic Load/Models | Open Around Core Wall | Open Adjacent Core Wall | Open Far from Core Wall |
|---|---|---|---|
| Maximum Displacement (Mm) | 154 | 156 | 141 |
| Maximum Center Mass Displacement (Mm) | 144 | 131 | 131 |
| Maximum Diaphragm Drift | 0.007868, story 6 | 0.007555, story 5 | 0.007155 story 6 |
| Maximum Story Drift Ratio | 0.007868, story 6 | 0.007555, story 5 | 0.007155 story 6 |
| Maximum Story Shear (Ton) | 351.16 | 355.28 | 354.24 |
| Maximum Over Turning Moment (Ton.M) | 6397 | 6472 | 6454 |
| Minimum Over Turning Moment (Ton.M) | 5133 | 5193 | 5178 |
| Maximum Story Stiffens (Ton/Mm) | 70.37 | 71.53 | 75.3 |
| Maximum Support Reaction Direction X (Ton) | 158 | 130 | 151 |
| Maximum Support Reaction Direction Y (Ton) | 107 | 133 | 110 |
| Story Maximum Displacement/Average | 1.33 | 1.48 | 1.29 |
| Maximum Mode Time (Sec) | 1.487 | 1.448 | 1.42 |

## 5.Conclusion

By literature reviews and experimental study, some conclusions were achieved:

1. In review literatures the minimum story drift and minimum displacement occurred in building with shear wall on each side on middle.
2. In order to resist lateral load, building without shear wall is weak structure. Building with shear wall positioned at the middle of 4 peripheral sides indicates the minimum value of top displacement and building without shear wall and large open causes for large displacement.
3. It is very important to look at the stairs in earthquake, because it may cause problem in building. The improvement in protection can only be influenced by adjusting the position of the core wall in the structure.
4. more attention should be done on the opens, because they are the reason for the failure in the slabs or structures by inducing the formation around the opening corners of plastic hinges.
5. The all literatures confirm that avoided large open should be considered in slab, but large open or small did not have more effect on out of plane slab. And Decreasing effects on building lead to economical. square openings have less effect on rectangular slab, if compared with rectangular openings.
6. The conclude for model open around core wall, open adjacent core wall and open far from core wall are minimum displacement, minimum drift ratio and minimum story displacement for model open far from core wall occurred. But for opened far from core wall that used to stair location may need another additional support to it. And opened adjacent core wall displacement and story maximum displacement/ average displacement is not good if compared to another model.
7. The open around core wall that used to satire location it has very good support to stair, but the core wall cannot be use as a shear wall because more partial walls don not have integrity with the building.

## References:


Ajit, G., Rajesh, P., 2016. The effect of earthquake frequency content on the seismic behavior of regular r.c.c. Buildings. Ijirst-international j. Innov. Res. Sci. Technol. 2.

Choubey, A., Rawat, A., Indiap, M.P., 2020. Analysis of earthquake resistant open story building on etabs acc to is:1893-2016, ijiset-international journal of innovative science, engineering & technology.

Govalkar, V., Salunke, P.J., Gore, N.G., 2014. Analysis of bare frame and infilled frame with different position of shear wall, international journal of recent technology and engineering.

Hadi, W.K., Muttashar, M., 2020. Effects of opening on load carrying capacity of reinforced concrete slabs: analytical study. Iop conf. Ser. Mater. Sci. Eng. 881.

Harne, V.R., 2014. Comparative study of strength of rc shear wall at different location on multi-storied residential building, international journal of civil engineering research.

Kankuntla, A., Sangave, P., Chavan, R., 2016. Effects of openings in shear wall. Iosr j. Mech. Civ. Eng. (iosr-jmce 13, pp.

Khajehdehi, R., Panahshahi, N., 2016. Effect of openings on in-plane structural behavior of reinforced concrete floor slabs. J. Build. Eng. 7, 1–11.

Khan, A., Shahzad, Asif, Shahzad, Adil, Hanif, U., Israr, D., 2019. Effect of lift core wall location in high rise buildings.

Mable Vas, V., Nagaraja, P., Venkataramana, K., 2021. Effect of diaphragm discontinuity on the seismic response of an rc building. Lect. Notes civ. Eng. 99, 157–170.

Mahmoud Ahmed, M., Gamal Abdel Al-Shafy, A., Abd Rb Al-Nabi Mohamed, A., 2017. The effect of creating symmetrical openings in the slabs of high buildings on their structural behavior.

Marques, M.G., Liberati, E.A.P., Pimentel, M.J., De Souza, R.A., Trautwein, L.M., 2020. Nonlinear finite element analysis (nlfea) of reinforced concrete flat slabs with holes. Structures 27, 1–11.

Noorifard, A., Tabeshpour, M.R., 2018. Effects of staircase on the seismic behavior of rc moment frame buildings. Archit. Civ. Eng. Environ. 11.

Rao Botsa, S., Dasgupta, K., 2017. Influence of staircase and elevator core location on the seismic capacity of an rc frame building. J. Archit. Eng. 23, 05017007.

Rokanuzzaman, M.D., Khanam, F., Das, A., Chowdhury, S.R., 2017. Effective location of shear wall on performance of building frame subjected to lateral loading, international journal of advances in mechanical and civil engineering.

Sahu, S.K., Sharma, N., Dasgupta, K., Sahu, S., 2014. Influence of modeling of rc structural walls on dynamic analysis of wall-frame buildings.

Series, I.O.P.C., Science, M., 2020. Strengthening of self-compacted concrete two way slabs with opening using near surface mounted ( nsm ) fiber reinforced polymers ( frp ) technique strengthening self-compacted concrete two way slabs with opening using near surface mounted ( nsm ) fiber re.

Soni, D.P., Mistry, B.B., 2006. Qualitative review of seismic response of vertically irregular building frames. Iset j. Earthq. Technol. 43, 121–132.

Sun, H., Zhang, A., Cao, J., 2013. Earthquake response analysis for stairs about frame structure. Eng. Fail. Anal. 33, 490–496.

Taheri Fard, A.R., Taha, M.I., Hidayat, A., 2017. Строительство уникальных зданий и сооружений. Evaluation of seismic analysis in diverse effect position of shear wall for reinforced concrete frame building article history.

Tena-Colunga, A., Liga-Paredes, A.E., 2020. Approximation of lateral stiffness for walls with two bands of openings considering slab stiffness effects. J. Build. Eng. 30, 101310.

Thakre, P., Jamle, S., Meshram, K., 2020. Opening area effect of shear wall in multistorey building under seismic loading 6495, 122–129.

Varna K R, B.B., 2017. Optimum location of lift core wall for flat slab and conventional beam system using generated response spectra. Int. J. Adv. Sci. Res. Eng.