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Study of Moment and Shear in Optimum Location of Lift Core Shear Wall in Multi-Storied Building Using Response Spectra Method

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***Abstract:** Increased frequency and intensity of earthquake fetching a need of more earthquake resistance in building. Shear wall is the best way to control deflection during earthquake. But the providing shear wall is sometimes not feasible and hence avoided. Lift core, which are the mandatory to be used in multi-storey building and are frequently used as core type shear wall can be best option. In general, lift cores are provided with convenience of users. In this paper, various positions of lift core are modelled and were analysed under dynamic earthquake loading in IV earthquake zone of India. The results were compared with bare frame.*
***Key words:** Earthquake loading, Shear wall, Lift core, Dynamic Aanalysis, Moment and Shear.*

I. INTRODUCTION

The design of a multi-storey building is governed by lateral loads and it should be prime concern of the designer to provide adequately safe structure against lateral loads. The modern buildings are heaving light curtain walls, lightweight flexible partitions along with high strength concrete and steel reinforcement. This reduces the safety margins provided by non-structural components. Shear wall system is one of the most commonly used lateral load resisting system in high rise buildings. A shear wall is a structural system providing stability against wind, earthquake and blast deriving its stiffness from inherent structural forms. The shear wall can be either planar, open sections, or closed sections around elevators and stair cores.

II. OBJECTIVE OF STUDY

Shear walls must provide the necessary lateral strength to resist horizontal earthquake forces. When shear walls are strong enough, they will transfer these horizontal forces to the next element in the load path below them. These other components in the load path may be other shear walls, floors, foundation walls, slabs or footings. Shear walls also provide lateral stiffness to prevent the roof or floor above from excessive side-sway.

The objectives of the study are:

A. Structural analysis of multi-storeyed building with and without shear wall using Staad pro and determine lateral displacement, and storey drift.

B. Study of behaviour of structure (Moment, Shear and Axial) with different location of shear wall and with different earthquake zone.

C. Study of optimum location of lift core shear wall for multistoried frame keeping other parameters same.

III. METHODOLOGY

In linear dynamic method, modes of vibration and their contribution in base shear is considered. The dynamic analysis provides more robust data of response of structure under dynamic loading. The equivalent static method is on the basis that the whole system can be approximated as single degree of freedom system, which is in case of high magnitude earthquake zone can't be reliable. To effectively compare the effect of presence of shear wall at various location, dynamic analysis needs to be consider. The dynamic analysis can be done in two way: Response Spectrum method and linear time history method. The advantage of time history method is highly dominated in earthquake analysis but due to consideration of actual earthquake forces, the need of analysis to be in non-linear range increases. Hence, in this thesis, Response spectrum method as per Indian Standard Code IS 1892-2016 is considered.

Procedure for performing dynamic analysis:

A. Calculation of modes of vibrations.

B. Find out mode shape

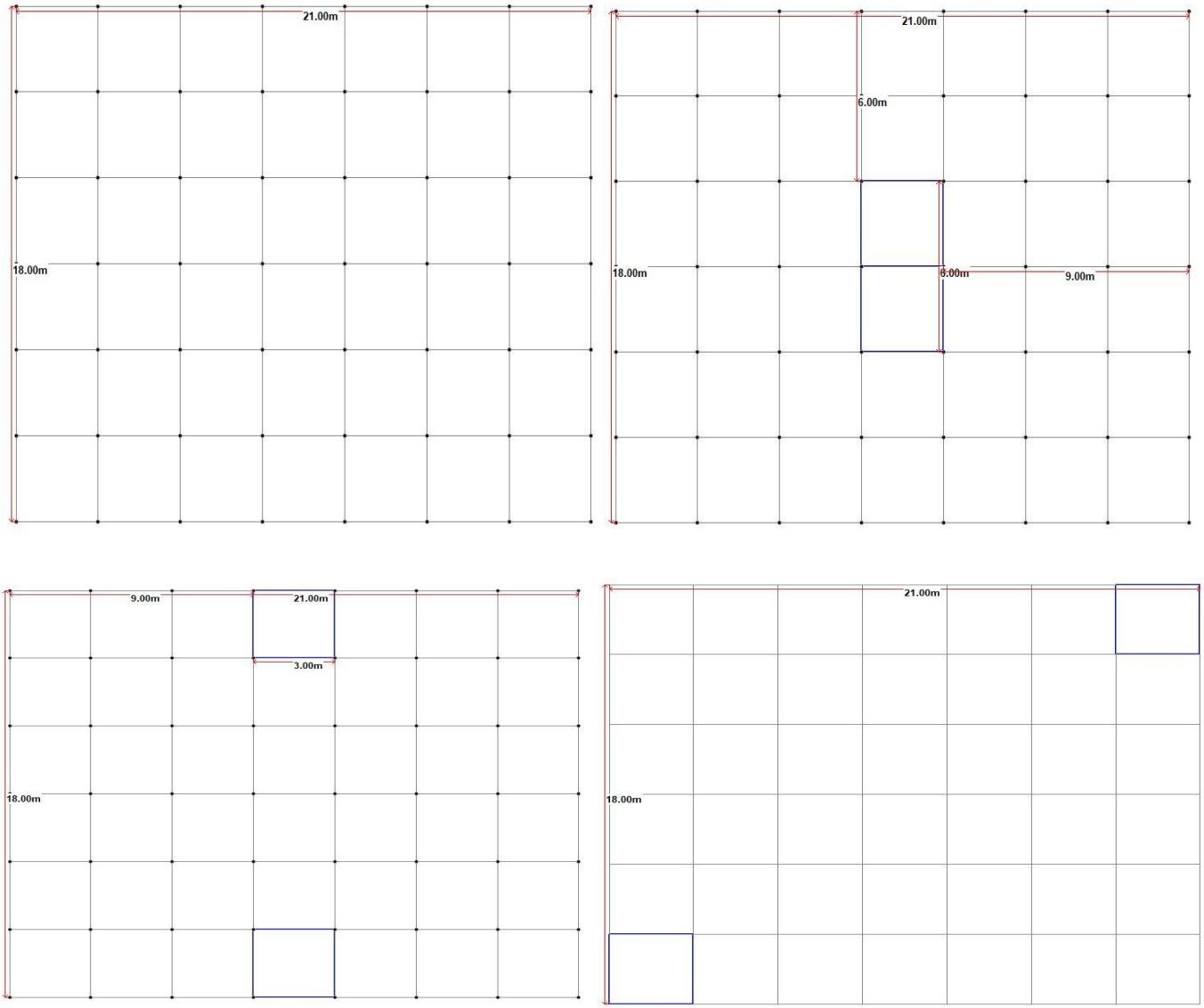
C. Determination of modal participate factor
D. Determination of modal mass
E. Calculate design lateral force at each floor in each mode
F. Calculate storey shear in each mode
G. Calculate total response from modal response

H. Details of Model

For the study, three models were considered:

1) Simple bare frame without any shear wall
2) Simple frame with Lift core shear wall at centre of building plan (Shear wall configuration 1)
3) Simple frame with lift core shear wall at the edge of building (Shear wall configuration 2
4) Simple frame with lift core shear wall at the corner of building (Shear wall configuration 3)

Figure 1. Top view of Staad Models



Nomenclature:
SF= Simple Frame
SWC1= shear wall configuration 1 (Lift core at centre)

SWC2= Shear wall configuration 2(Lift core at edge of building)
SWC3= Shear wall configuration 3(Lift core at alternate corners of building)

All models are of 10 storey each having standard height of 3m and hence height of building will be 30m.
Plan of all building is 35m X 30m.
Section properties:

Element	Thickness/ width (mm)	Depth (mm)
Beam section	300	450
Column Section	500	500
Shear wall	300	--

All supports are taken as Fixed.

I. Loadings Considered

The static earthquake force is considered from X and Z direction for zone IV and V of IS1893:2002[1]
Following load combinations were used:

1) Live Load – 3 KN/m^2 on all the floors.
2) Dead load for floor = -4.5kN/m^2
3) Self weight of building
4) Dead load of curtain wall = -15kN/m of the peripheral wall only
5) Earthquake Load – As per IS 1893 (Part-I):2002

J. Load Combinations

Load Combinations considered for static analysis are as follows:

1) 1.5(DL + LL)
2) 1.2(DL + LL + EQX)
3) 1.2(DL + LL - EQZ)
4) 1.2(DL + LL + EQZ)
5) 1.2(DL + LL – EQZ)
6) 1.5(DL + EQX)
7) 1.5(DL – EQX)
8) 1.5(DL + EQZ)
9) 1.5(DL – EQZ)
10) 0.9DL + 1.5EQX
11) 0.9DL - 1.5EQX
12) 0.9DL + 1.5EQZ
13) 0.9DL – 1.5EQZ

K. Parameters and Different Aspects of Study

Section Displacement:
Net displacement of each floor with respect to fixed point at ground is studied.
Storey Drift Controlling storey sway or inter storey drift of a building is an important aspect because:

1) prevents pounding of adjacent buildings in urban areas.
2) It prevents shear (brittle) failure.
3) It restricts damage to fragile non-structural elements, which can be costlier than the building.
4) Drift limitation provides stability to individual column as well as the structure as a whole
5) Limited drift also provides comfort to occupants of such buildings.

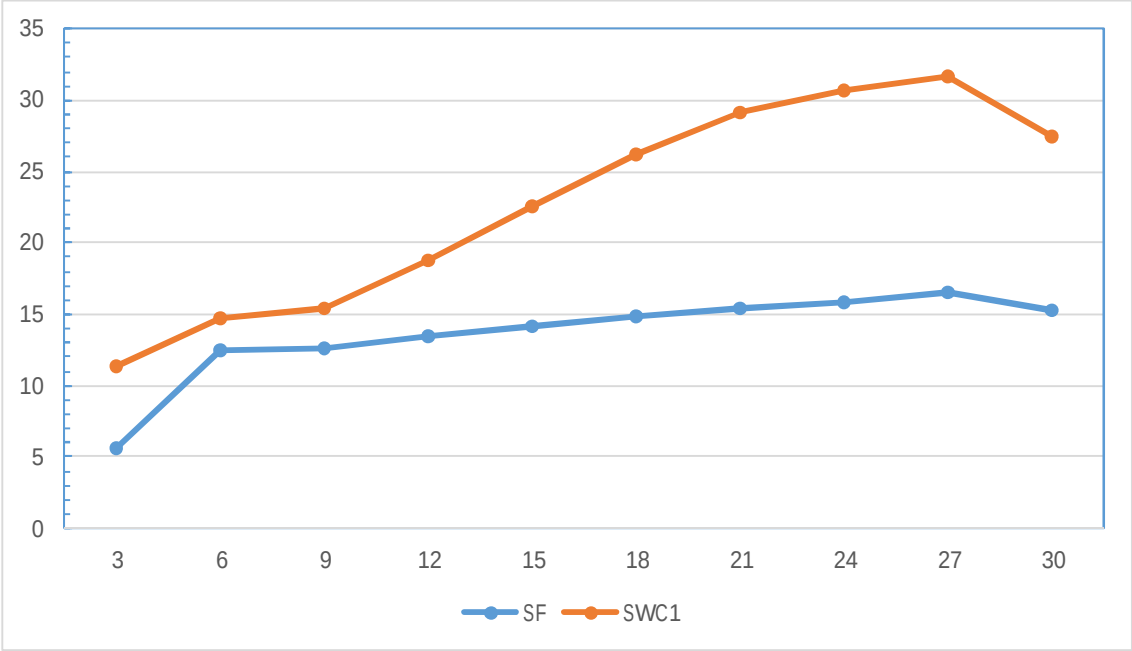
As per clause 7.11.1 of IS 1893 (Part I):2002, the storey drift in any storey due to specified design lateral force with partial load factor of 1 shall not exceed 0.004 times the storey height.

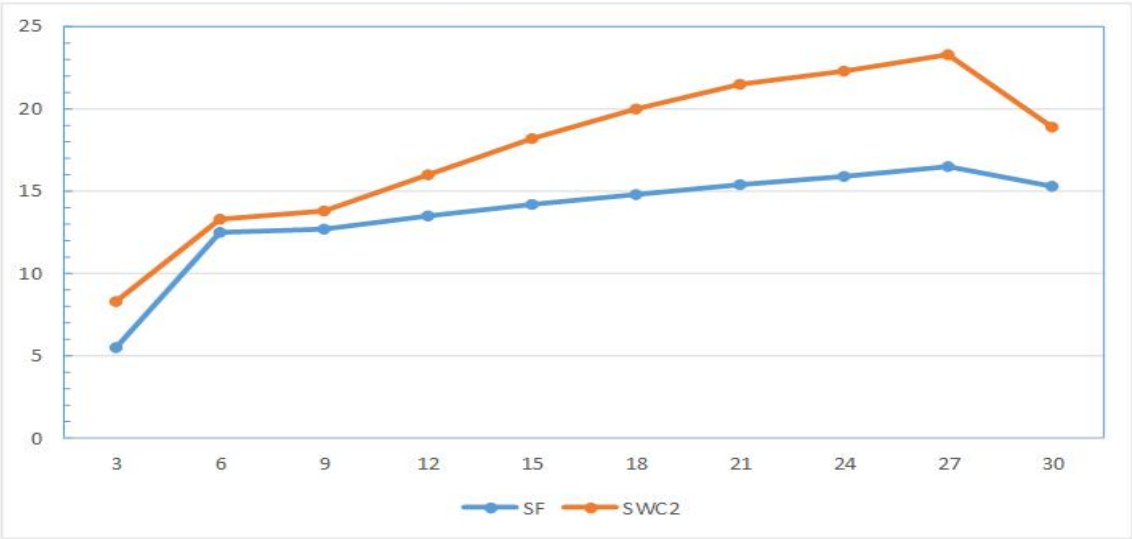
Drift Reduction Factor Use of shear walls with frame changes in the drift values. Therefore drift reduction is one parameter to be studied. It is equal to ratio of difference of Storey drift without shear wall and with shear wall to storey drift without shear wall. Parameters and different aspects of study Bending Moments in Column: A bending moment is the reaction induced in elements of structure when an external force is applied to the element causing the element to bend. Bending moment in the elements of a building is an important aspect for the design of the building elements Shear force in column: Shearing forces are unaligned forces pushing one part of a body in one direction, and another part of the body in the opposite direction. When the forces are aligned into each other, they are called compression forces.

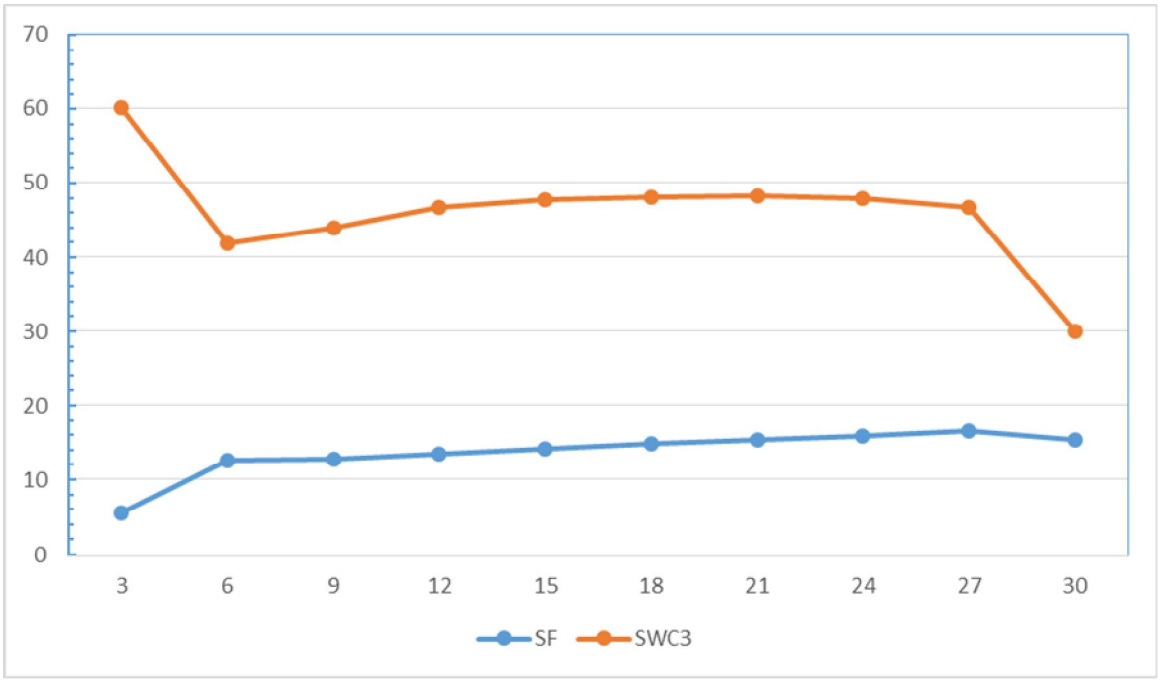
IV. RESULT AND DISCUSSION

The study examines the performance of shear walls in multi-storey buildings, cases studied are buildings without shear wall and with shear wall at centre, edge and centre location. In present study we have been compared bare frame with system having different cases of shear wall for moment and shear force in corner column. Corner column is most vulnerable during earthquake.

Figure 2. Maximum Moment M_y in Corner Column







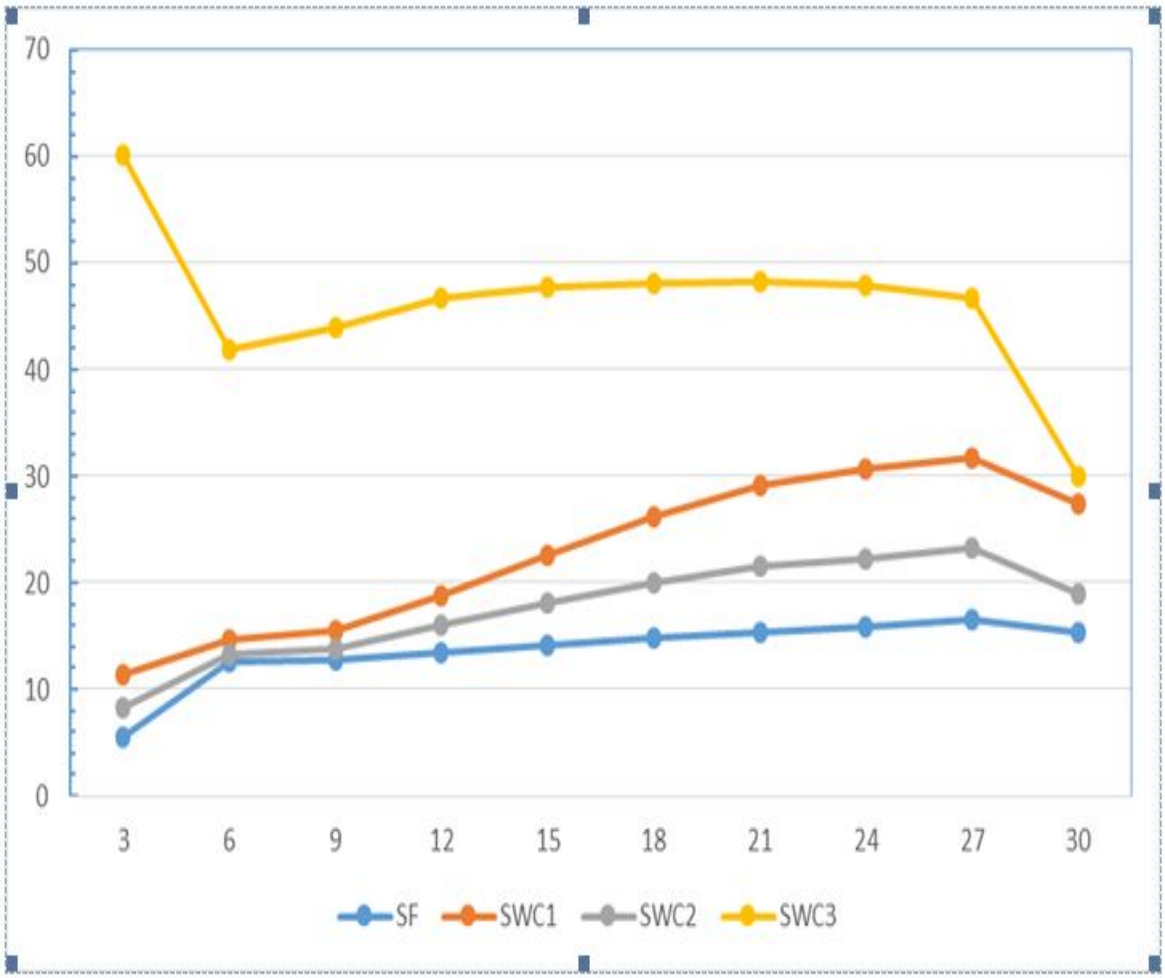
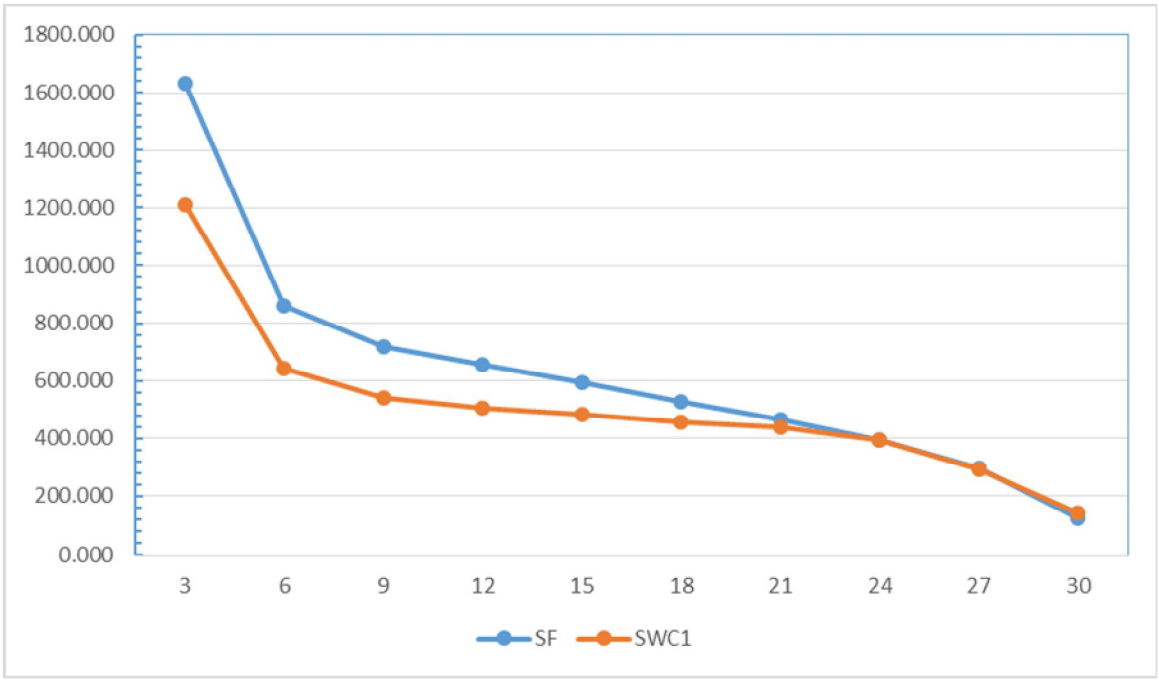
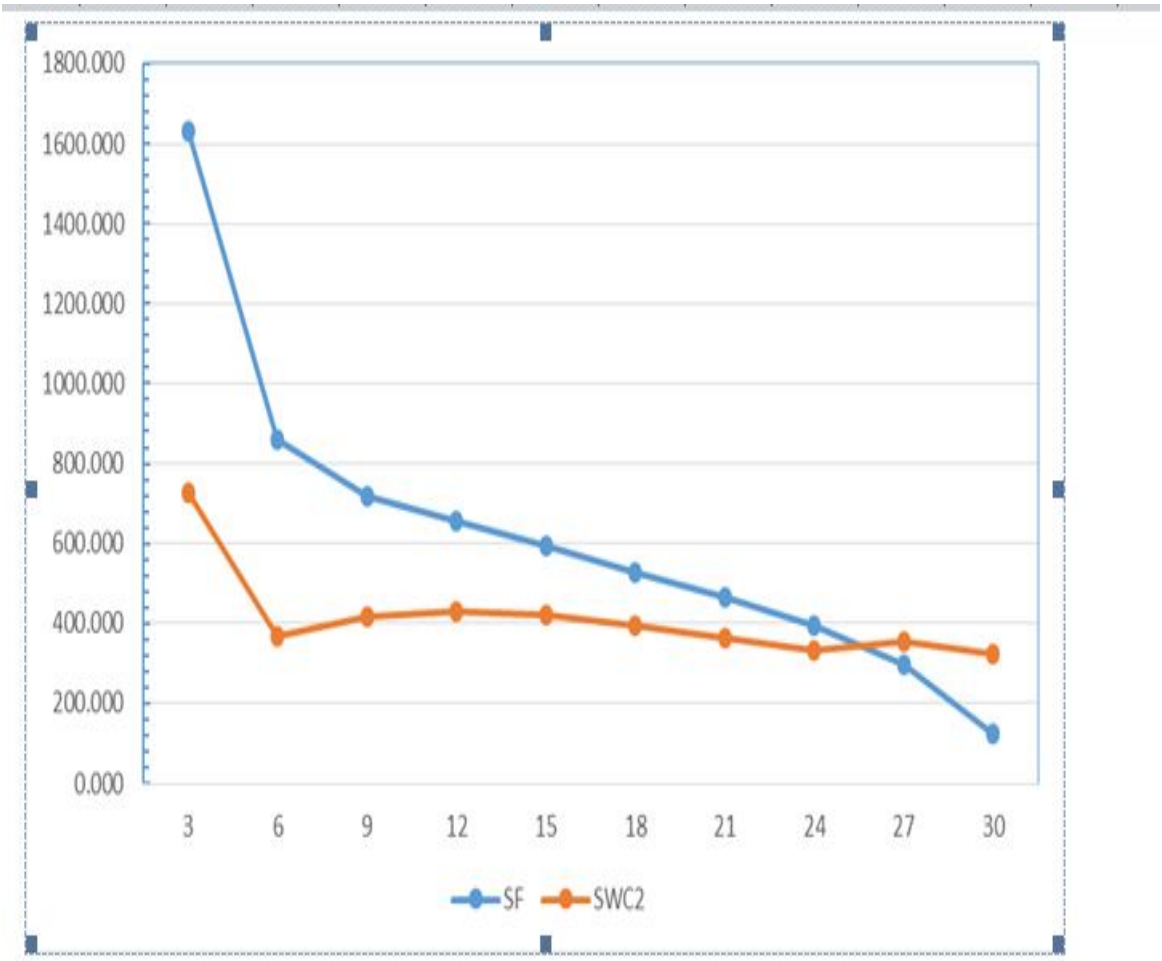
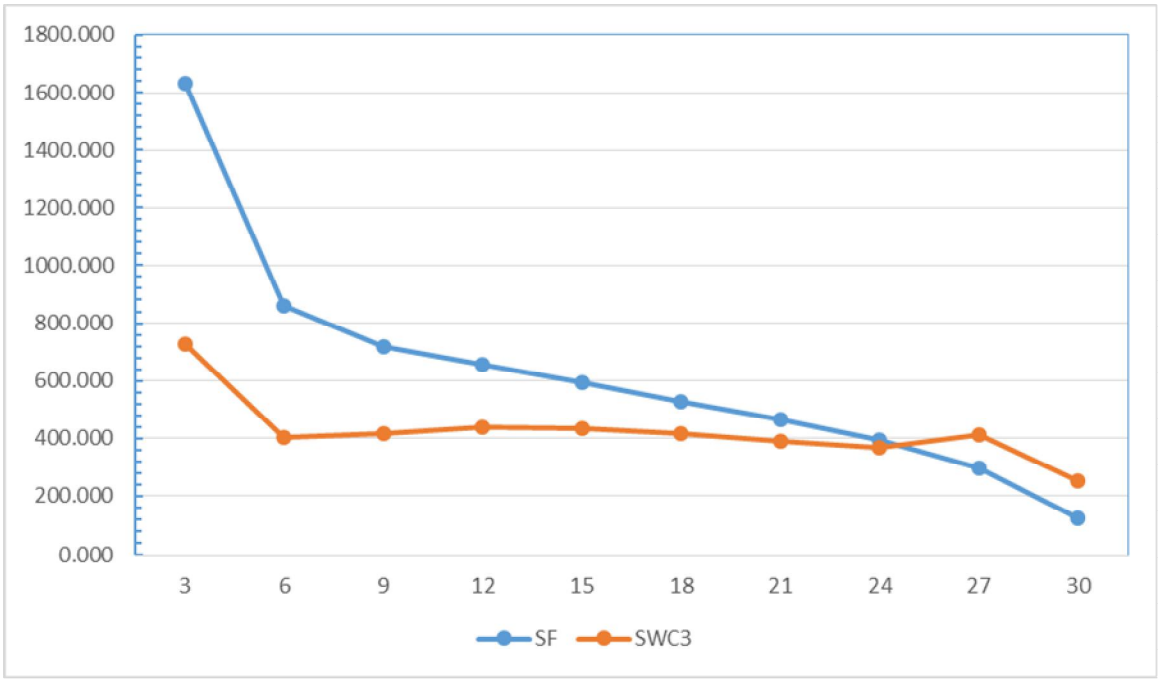


Figure 3. Maximum Moment Mz in Corner Column







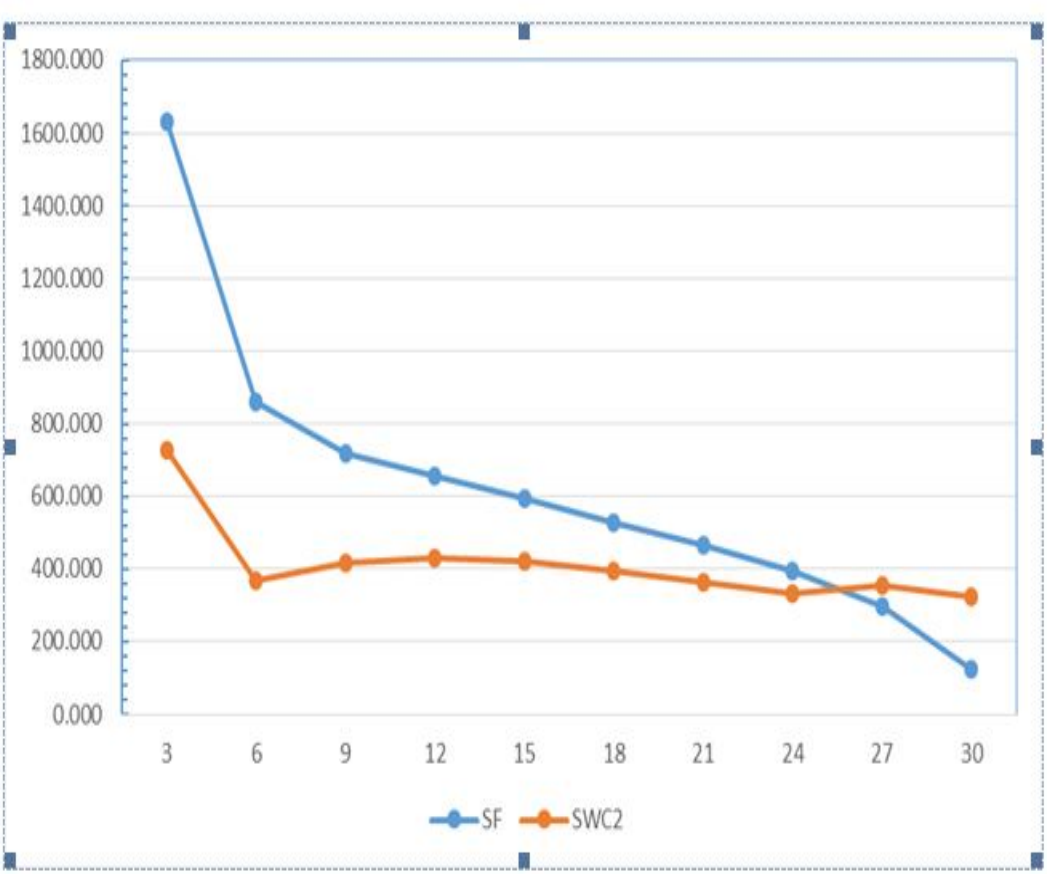
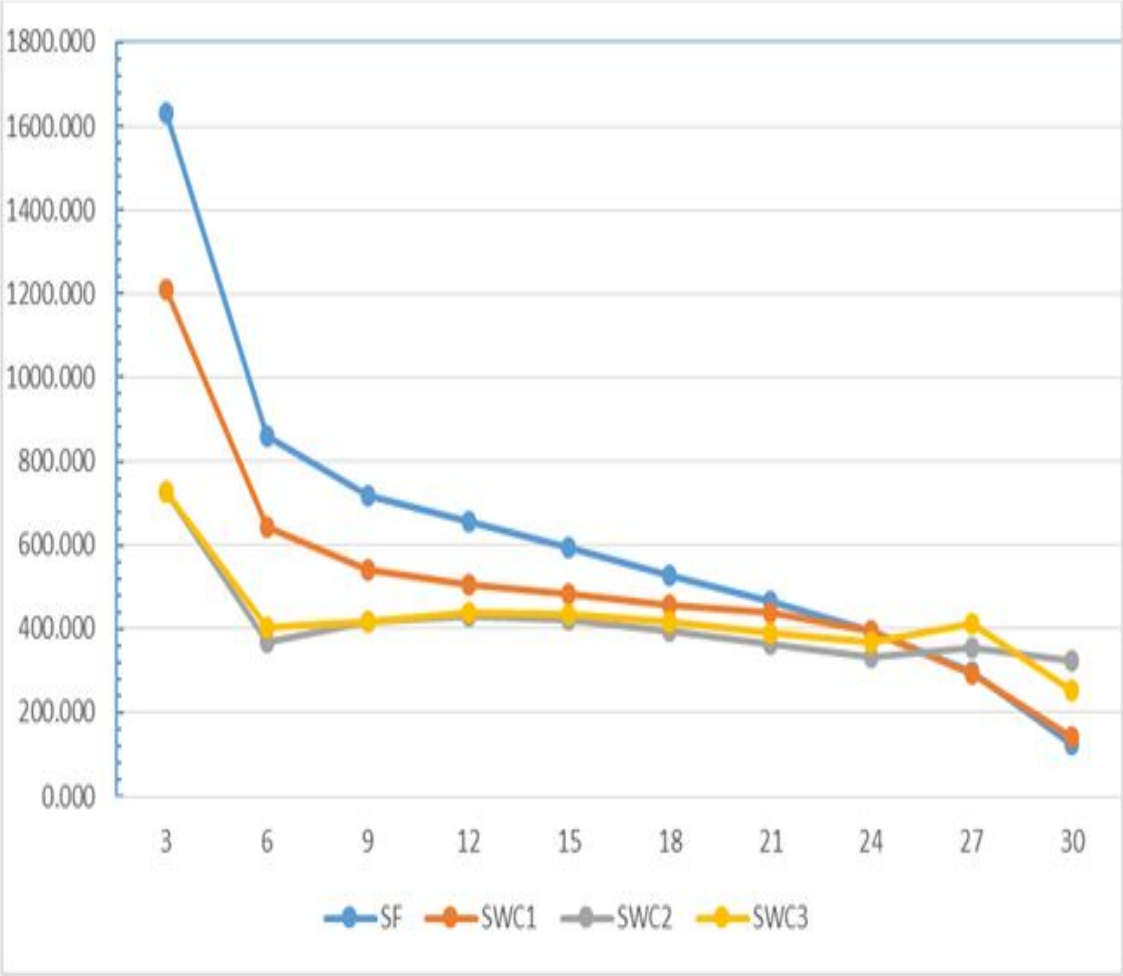
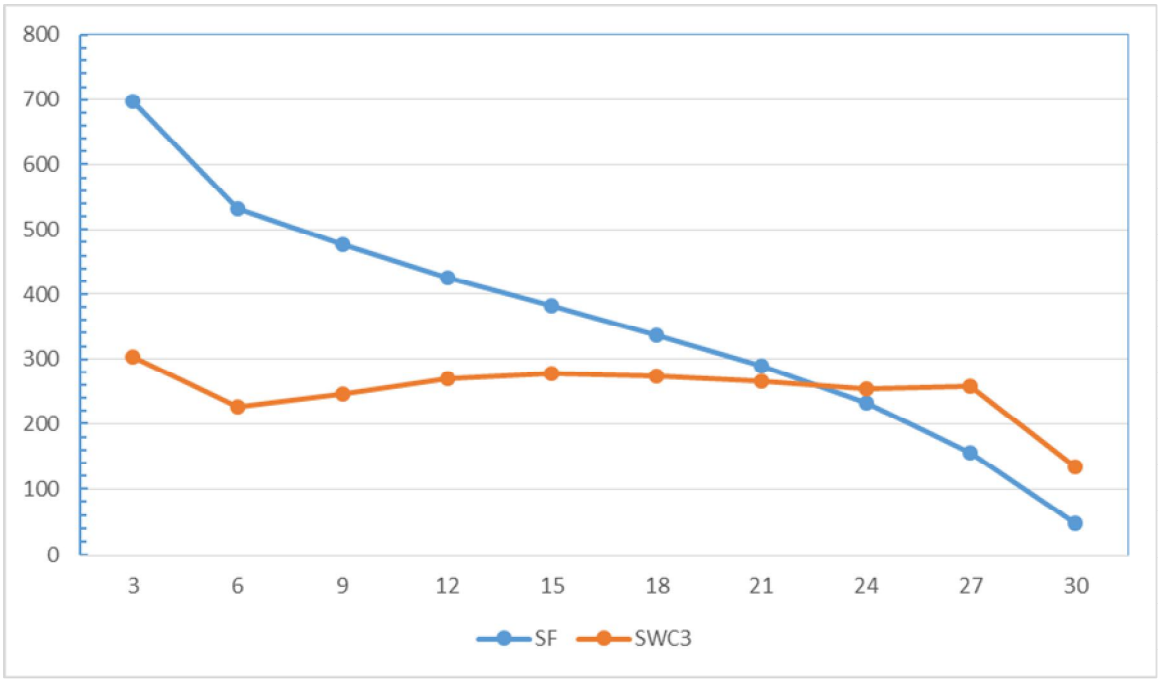


Figure 4. Maximum Shear M_y in Corner Column





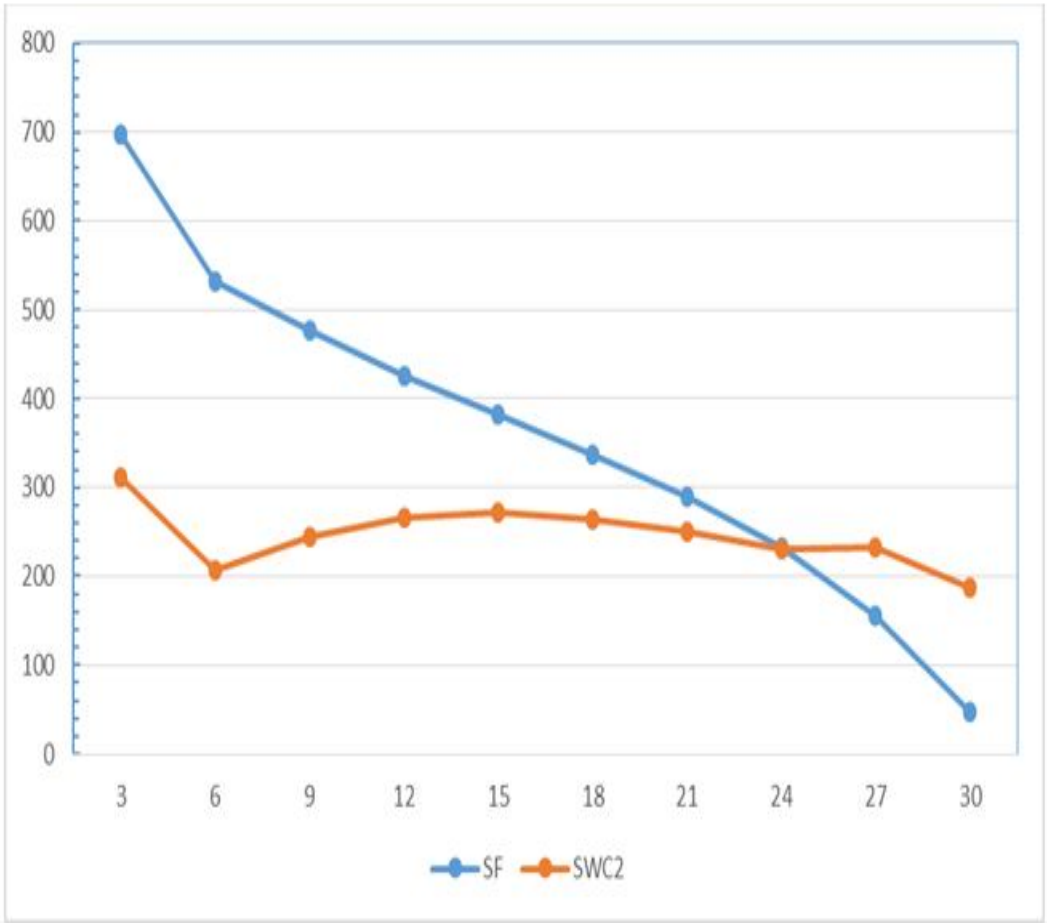
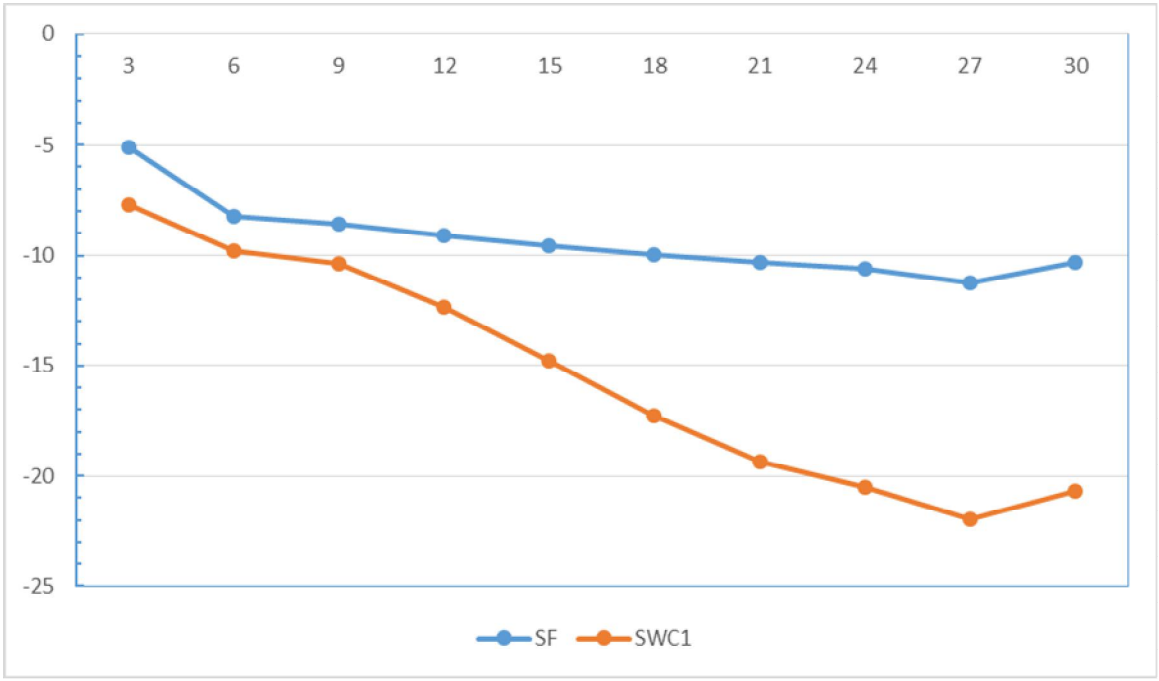
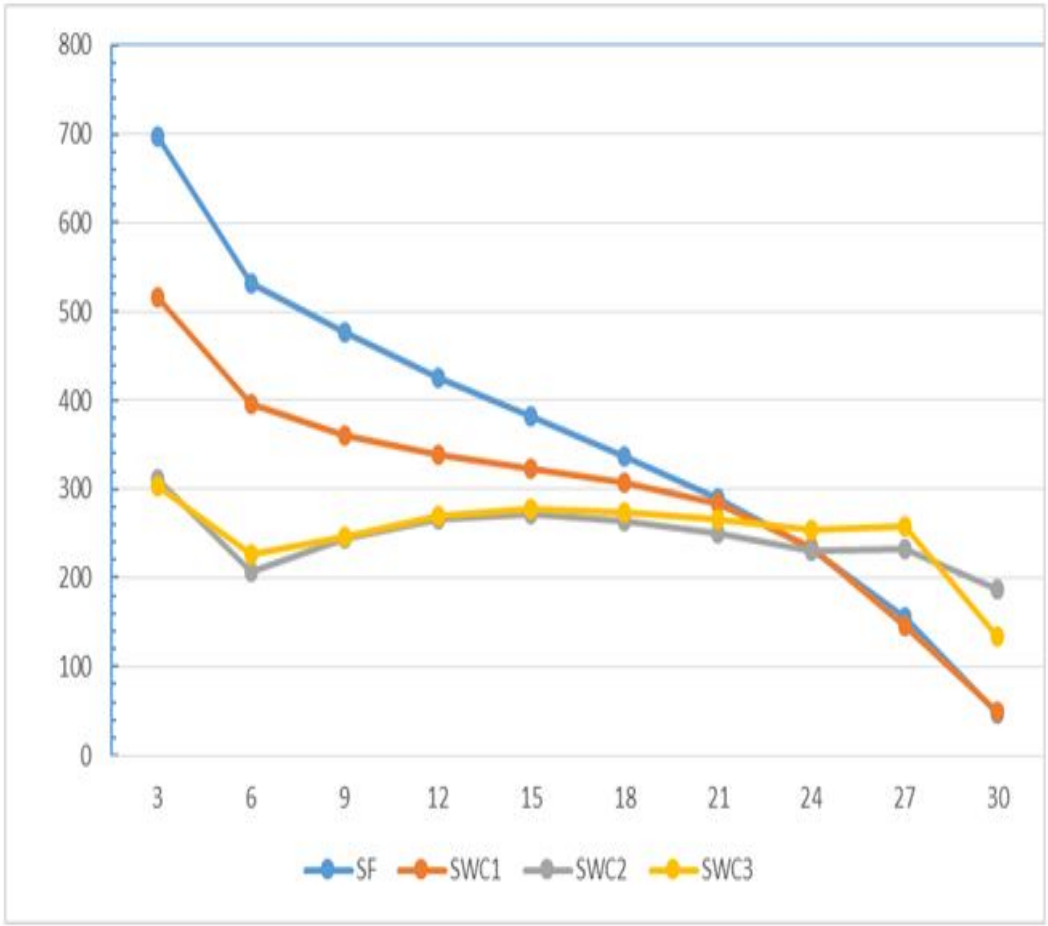
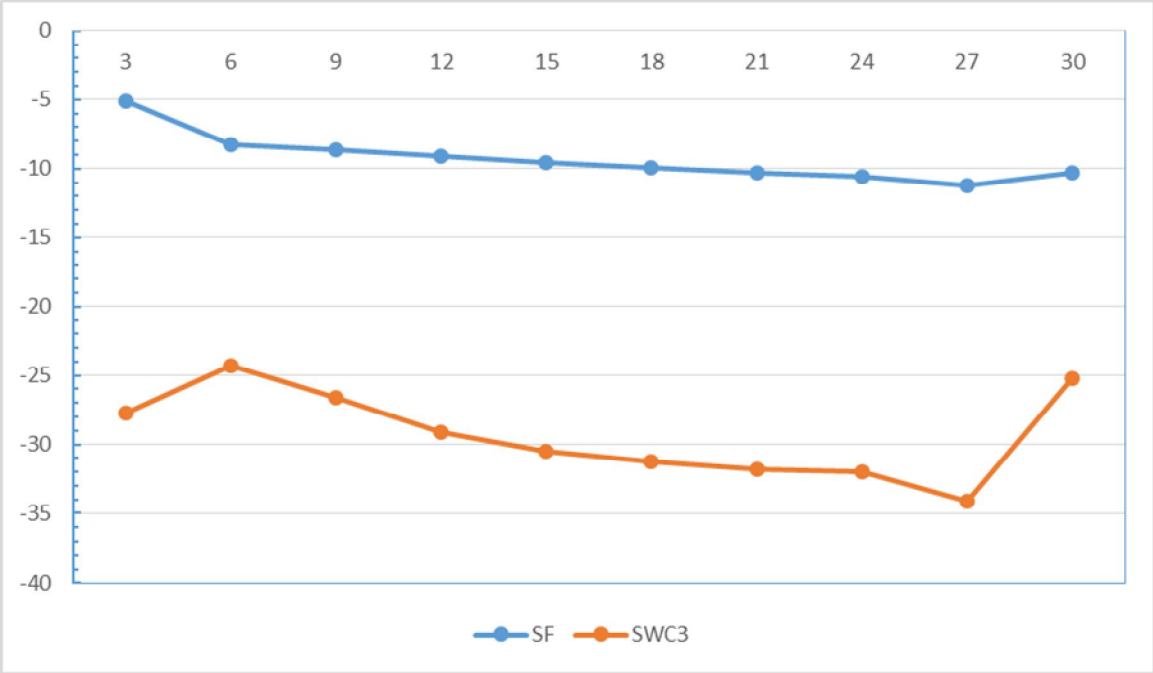
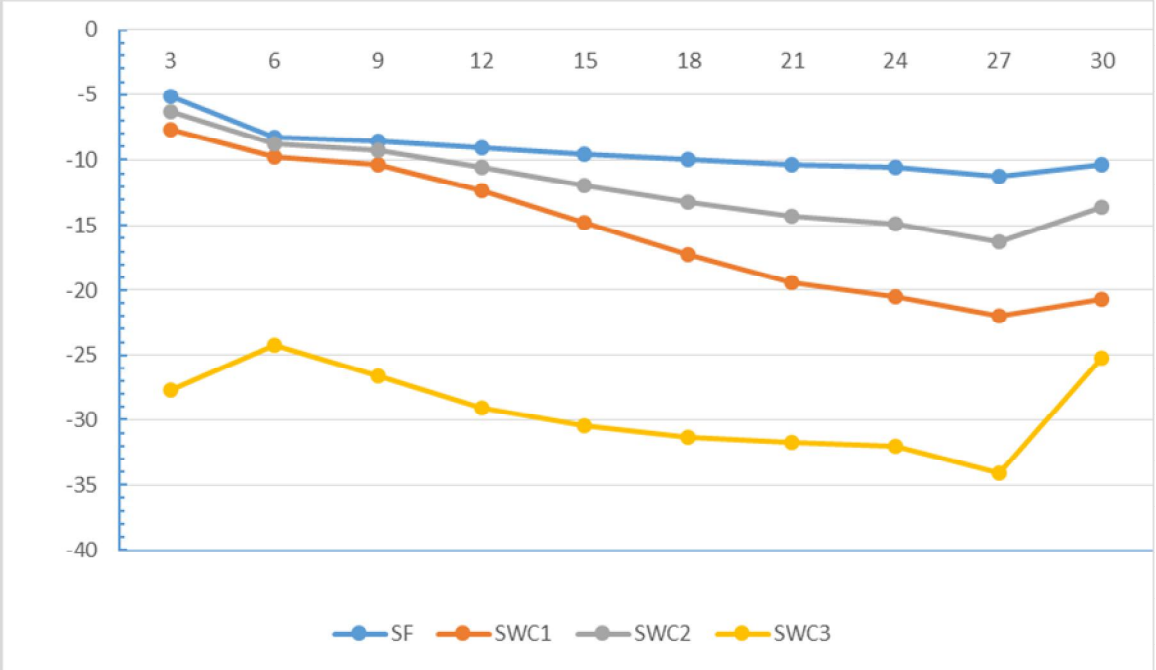


Figure 5. Maximum Shear M_z in Corner Column









V. CONCLUSION

Linear dynamic analysis of building situated in zone IV was studied. Results were obtained from STAAD Pro Models reflects various findings.

From above study following points can be concluded:

A. Providing lift core as shear wall is always beneficial in order to increase the lateral resistance of building with utilising the lift service of buildings. Location of lift core wall should be such that it can not only provides its intended function but effectively acts as structural system against seismic load.

B. On comparing, lift core at edge and corner have better control over storey displacement and inter-storey drift as compared to providing lift at centre. Although for upper storey centre lift core perform well.

C. The mode frequencies, mode shape and their participation was also studied. It was noticed that due to increase in stiffness and mass, the frequencies were altered, although very much same for all three configuration.

D. Although the base shear for shear wall building will be more, the moment in Y direction of shear wall building is lesser due to increase in lateral stiffness. Same observation can be made for moment in Z-direction of corner columns. On comparison edge and corner lift core shear wall shows relatively lesser moment.

E. Shear force in corner column is another parameter which increase during seismic event. So, shear force in Y and Z direction was also considered. Base shear increased with shear wall mass yet great reduction in shear force value can be observed.

F. Providing shear wall at corner may not be good option in view of its usability hence lift core shear wall at edge can be provided which will not only good for functionality but also provide lateral resistance.

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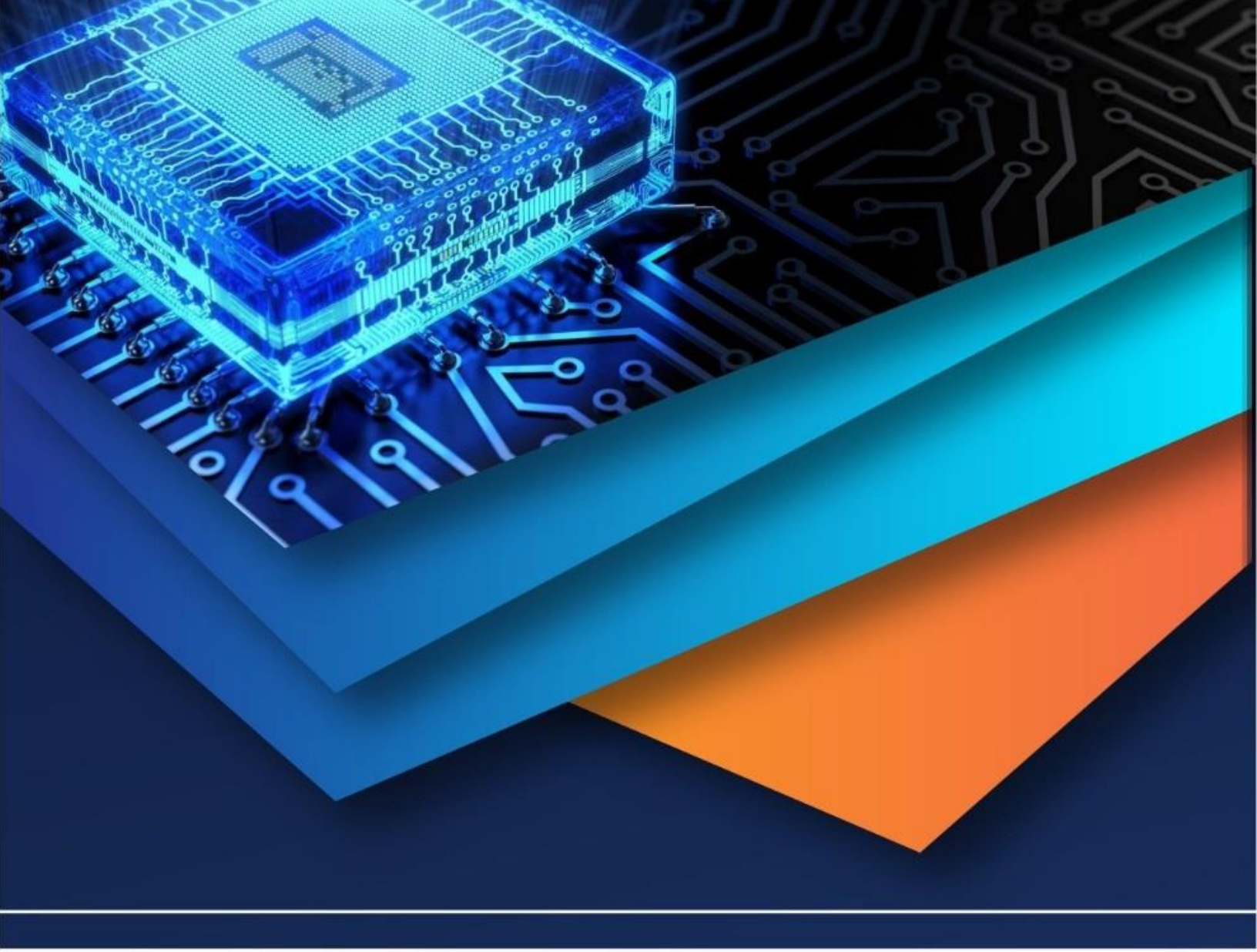

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