International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 05, May-2019

SEISMIC ANALYSIS OF BUILDINGS WITH AND WITHOUT SHEAR WALL ON DIFFERENT TYPES OF SOIL

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Abstract: Civil engineering is always deals with constructing different types of structures with ensuring safety, durability and serviceability. Now days "earthquake "is phenomena that affects the structures with their safety and serviceability. The amount of damage that earthquake can done to structures is depend on Type of building, Type of soil, Technology used for earthquake resistance, and last but not the least Location of building. Effects of earthquake is largely depend on type of soil in which foundation of building is done because earthquake changes the motion of ground that results the failure foundation. So it is important to study the behaviour of different soil at the time of construction of structures. Also earthquake can resisted by various technologies used in building, one of these are shear wall. It improves the structural performance of building subjected to lateral forces due to earthquake excitation. This paper aims to study, understand and analyse the critical behaviour of RCC frame structures with and without shear wall on hard, medium and soft soil strata subjected to seismic loading. Lateral displacement, base shear, storey displacement are the main parameters that are calculated and compared for all 5 models with different location of shear wall. This paper not only covers the behaviour of building with and without shear wall but it also helps to understand the behaviour of building for different locations of shear wall. All RCC frame models are modelled in ETABS software. Output from software consisting of Pushover curve and storey displacement results of all 5 models are presented, which helps to design the structures in order to reduce the effect of seismic forces.

Keywords- earthquake, shear wall, soil, ETABS, pushover curves, displacement.

I. INTRODUCTION

Earthquake is moving phenomenon of soil or we can say that vibrations which disturb the earth surface due to waves inside the surface of earth is termed as earthquake. Earthquake can damage the structures which are not constructed according the earthquake consideration. A large number of building designed in India according to static and permanent loads but earthquake is an occasional loads. Present time in India approximately more than 60% area is under earthquake prone zone. So it is important to design the structures according to seismic forces. Earthquake damages the substructure and superstructures. Substructures is the lower part of buildings i.e.; foundation of buildings and superstructures is the part of buildings that rests above the ground level. It is important to understand the behaviour of substructures due to seismic loads (soil-foundation interaction) and behaviour of superstructures due to seismic loads (beam, column, slab, beam-column joint etc.).

Shear wall is generally defined as vertical member of building that is able to resist shear, moment and axial load at the same time that is induced by all lateral loads and gravity loads. The main function of shear wall is to increase the rigidity for horizontal load resistance thus shear wall is a structurally efficient solution to strengthen and stiffen a building.

In recent days the number of earthquake is increased so it is important to design the building to resist lateral loads for betterment of performance of buildings and shear wall is one of the best lateral load resisting system. In this research the main aim is to analyse the effect of Lateral displacement and Base shear of different locations of shear walls in different types of soils (i.e. Hard, Medium, and Soft).

A G+8 storey structure with lift tower as its ninth storey is considered with five configuration of shear wall in three types of soil. A nonlinear static (Pushover Analysis) and Static analysis is carried out and from pushover curves lateral displacement and base shear is calculated and compared for different cases.

II. METHODOLOGY

Buildings that are constructed in seismic zones requires extra care to avoid the damages due to seismic occurrence. The performance of building for seismic loads can be checked by pushover method by applying the loads on building that are expected to come at the time of seismic occurrence and by increasing that loads up to collapse of building we can predict the behaviour of building that is why pushover analysis is most needed analysis of RC structures.

The static non-linear pushover analysis of a structure is an analysis under permanent vertical loads and gradually increasing lateral loads. The equivalent static lateral loads approximately represent earth quake induced forces. A plot of the base shear versus top displacement in a structure is plotted by this analysis that indicates any failure or weakness on structures. The analysis is done until failure point is obtained, thus it enables determination of collapse load and ductile behaviour of building. On a building frame, and plastic rotation is monitored, and lateral inelastic force versus displacement response for the complete structure is analytically computed. This analysis provide the necessary information of building weakness point. The decision to retrofit can be taken in such studies.

III. STRUCTURAL MODELLING

For this study, 9-story building with top storey as lift tower, 3-meters height for each story and 2.5m height of base (Foundation), regular in plan is modelled. These buildings were designed in according to the Indian Code of Practice for Seismic Resistant Design of Buildings. The buildings are assumed to be fixed at the base. The sections of structural elements are square and rectangular. The buildings are modelled using software ETABS. Five different models were studied with different positioning of shear wall in building. Models are studied in all three types of soils comparing lateral displacement and base shear for all models.

Pushover curve can be plotted for frame with and without shear wall. Different configuration of building with and without shear wall is given below:

- Multi-storey frame without shear wall.
- Multi-storey frame with shear wall at lift.
- Multi-storey frame with shear wall at internal frame. (Shear wall length 2m).
- Multi-storey frame with shear wall at external frame. (Shear wall length 2m).
- Multi-storey frame with shear wall at central frame. (Shear wall length 2m).

1. STRUCTURAL MATERIALS

- Concrete of M30 grade is used and the code for reinforced cement concrete is IS 4562000.
- High yield strength deformed bars (HYSD) having yield strength 415 N/mm 2 is widely used in design practice and is used for the present study.

2. FOUNDATION

Fixed supports are provided at the end of columns.

3. ELEMENT PROPERTIES

- Size of beams are 350mmX450mm.
- Size of columns are 350mmX750mm.
- Sizes of columns in lift shaft are 450mX450mm.
- Slab thickness for all floors are 120mm.
- Shear wall thickness is 200mm.
- Default M3 hinge is assigned in beams.
- Default P-M-M hinge is assigned in columns.

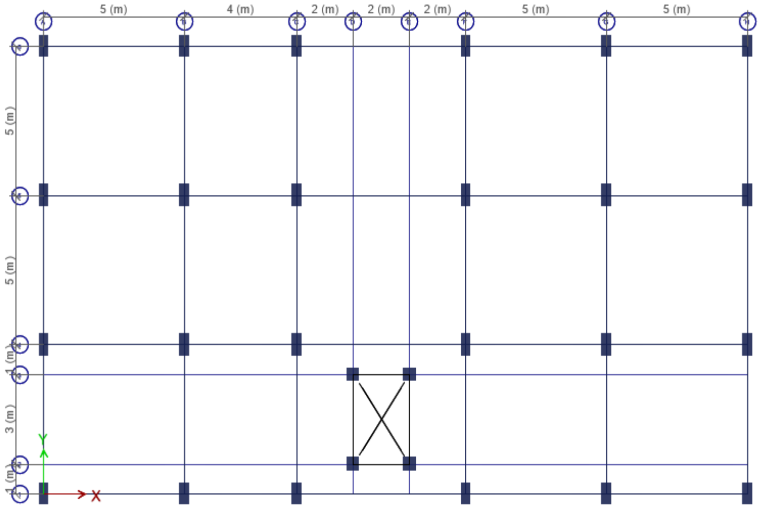
4. MEMBER LOADING

- Self-weight.
- External wall load is 6KN/m.
- Internal wall load is 5KN/m.
- Live load is 3KN/m.
- Floor finish load is 0.75KN/m.
- Earthquake loading as per IS 1893-2002.
- Wind force is not considered.
- Seismic zone III.

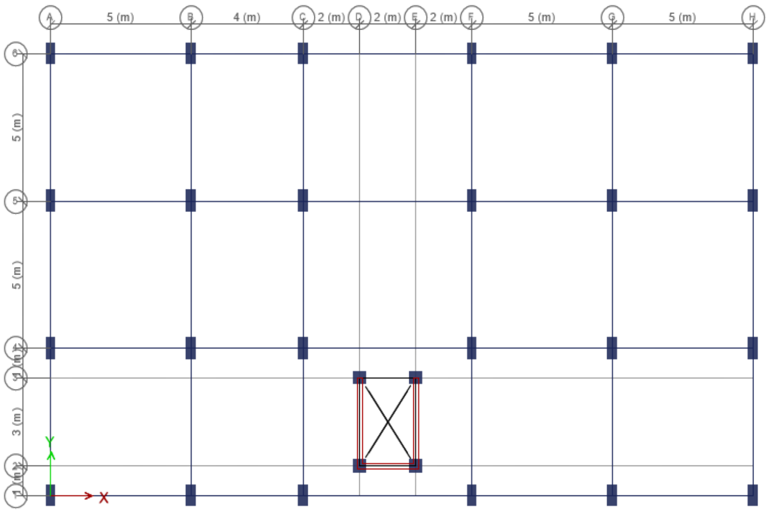
5. PUSHOVER CASES

- PUSH-1 for gravity loading.
- PUSH-X for lateral loading in X-direction.
- PUSH-Y for lateral loading in Y-direction.

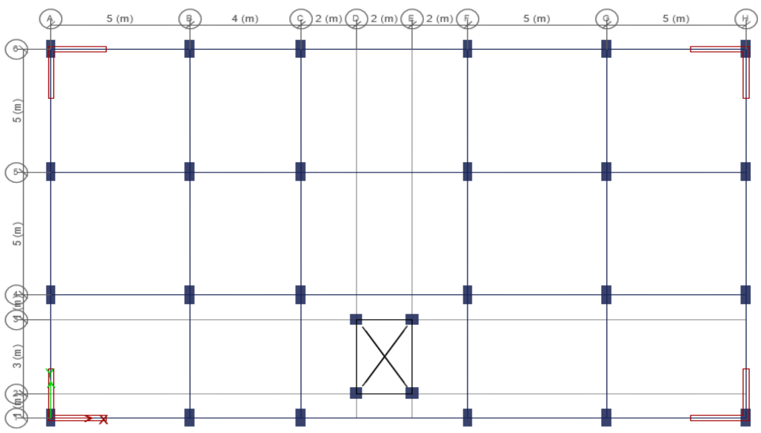
6. PLAN OF BUILDINGS



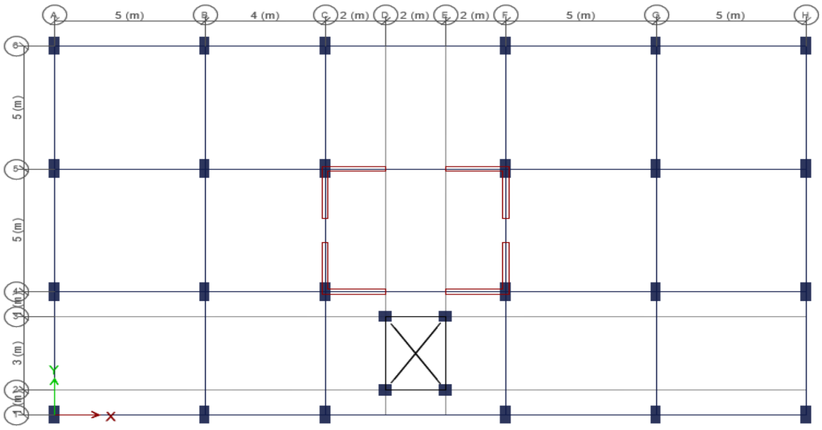
Plan without shear wall (MODEL-1)



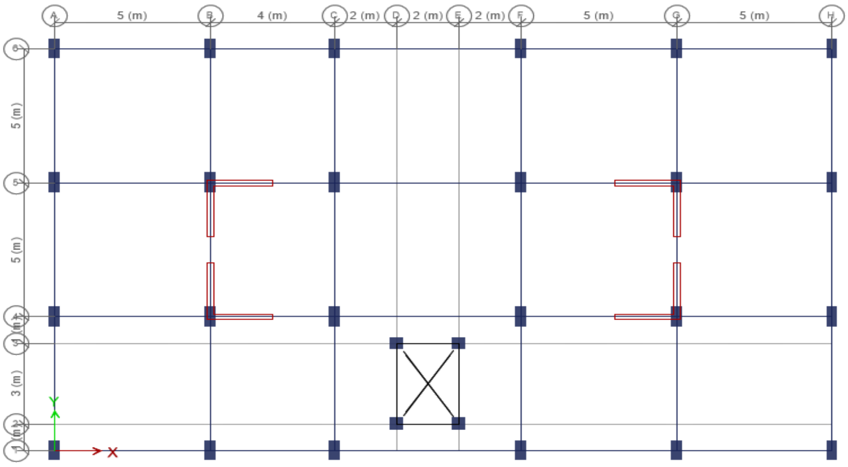
Plan with shear wall at lift (MODEL-2)



Plan with shear wall at external frame (MODEL-3)



Plan with shear wall at central frame (MODEL-4)



Plan with shear wall at internal frame (MODEL-5)

IV. RESULTS AND DISCUSSION

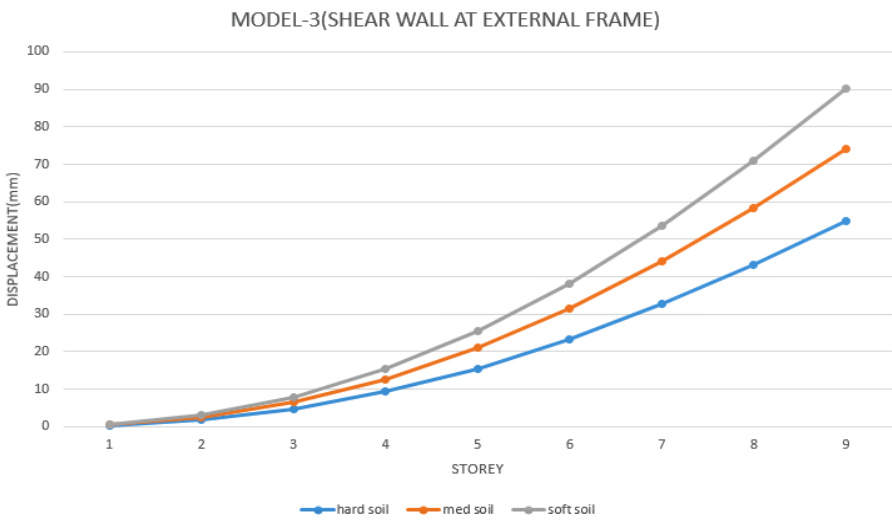
A.LINEAR STATIC ANALYSIS OF FRAMES:-

1. LATERAL DISPLACEMENT:-

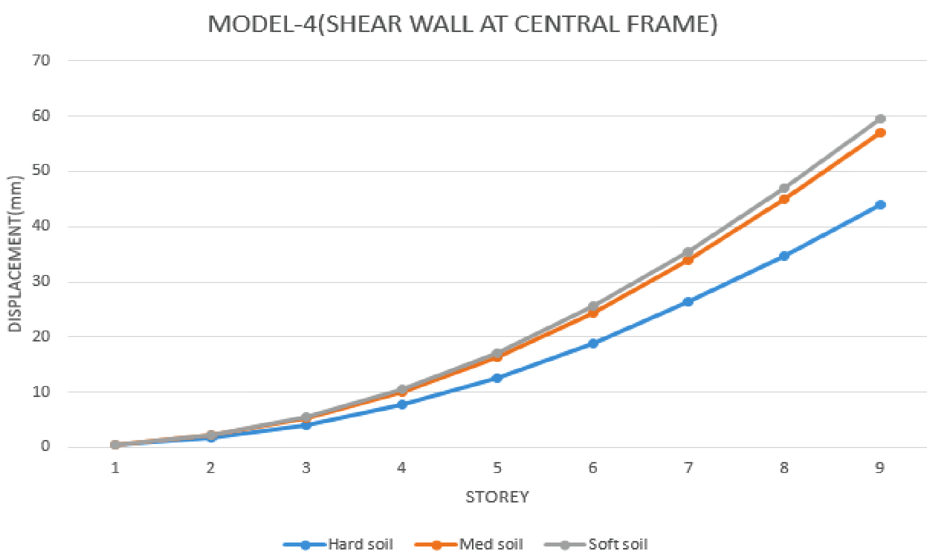
WITHOUT SHEAR WALL

WITH SHEAR WALL AT LIFT

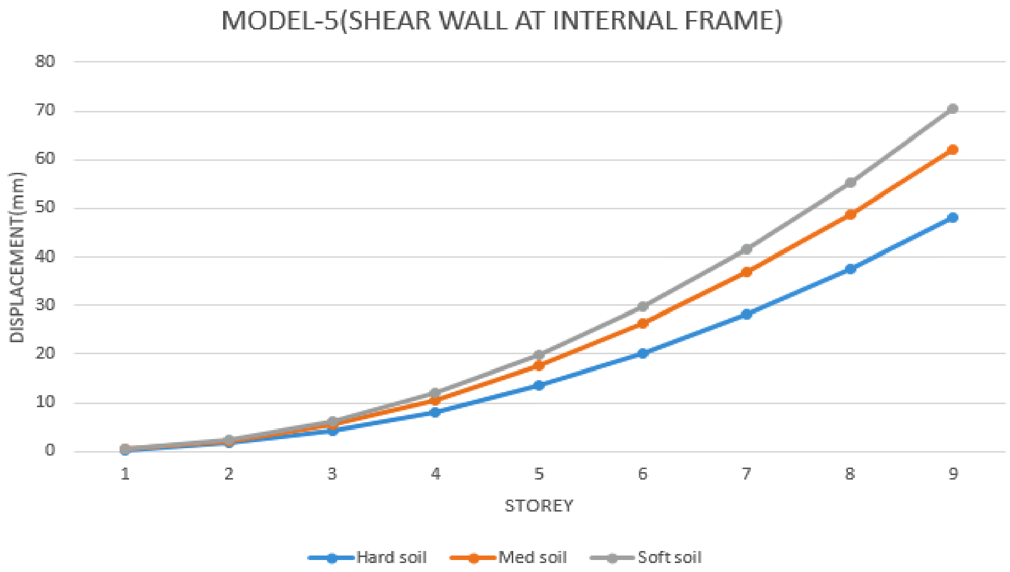
WITH SHEAR WALL AT EXTERNAL FRAME



WITH SHEAR WALL AT CENTRAL FRAME



WITH SHEAR WALL AT INTERNAL FRAME



2. COMPARISON OF DIPLACEMENT FOR DIFFERENT MODELS:-

9 STOREY	DISPLACEMENT(mm) MODEL-1	DISPLACEMENT(mm) MODEL-2(LIFT)	% REDUCTION IN DISPLACEMENT
HARD SOIL	71.310	60.142	15.66
MEDIUM SOIL	96.233	80.299	16.55
SOFT SOIL	117.700	96.843	17.72

Comparison of displacement between model-1 and model-2

9 STOREY	DISPLACEMENT(mm) MODEL-1	DISPLACEMENT(mm) MODEL-3(EF)	% REDUCTION IN DISPLACEMENT
HARD SOIL	71.310	54.972	22.91
MEDIUM SOIL	96.233	74.192	22.90
SOFT SOIL	117.700	90.049	23.49

Comparison of displacement between model-1 and model-3

9 STOREY	DISPLACEMENT(mm) MODEL-1	DISPLACEMENT(mm) MODEL-4(CF)	% REDUCTION IN DISPLACEMENT
HARD SOIL	71.310	44.045	38.23
MEDIUM SOIL	96.233	56.995	40.77
SOFT SOIL	117.700	59.507	49.44

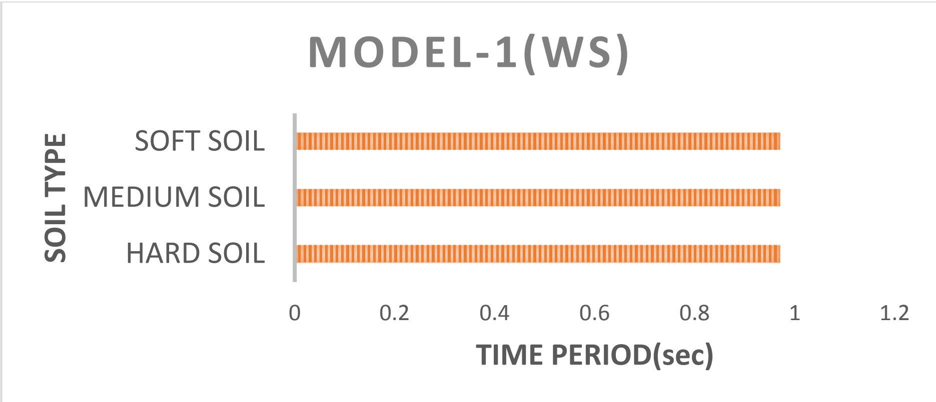
Comparison of displacement between model-1 and model-4

9 STOREY	DISPLACEMENT(mm) MODEL-1	DISPLACEMENT(mm) MODEL-5(IF)	% REDUCTION IN DISPLACEMENT
HARD SOIL	71.310	47.990	32.70
MEDIUM SOIL	96.233	62.230	35.33
SOFT SOIL	117.700	70.376	40.20

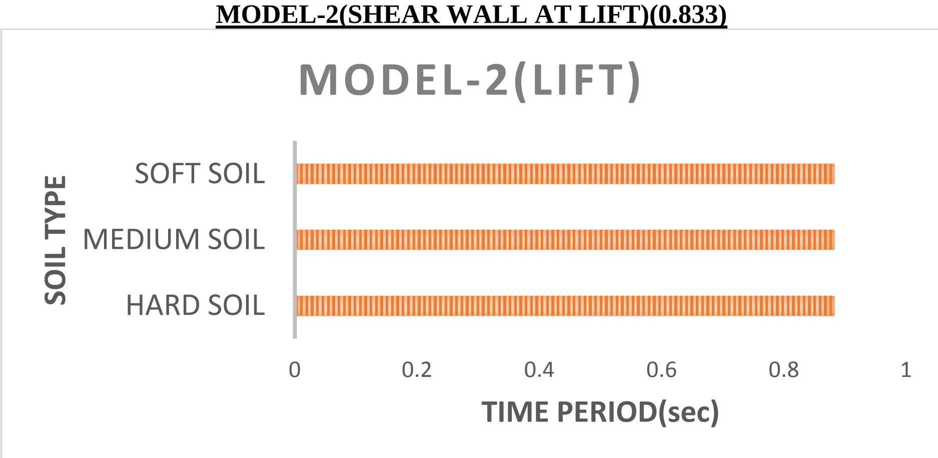
Comparison of displacement between model-1 and model-5

3. TIME PERIOD:-

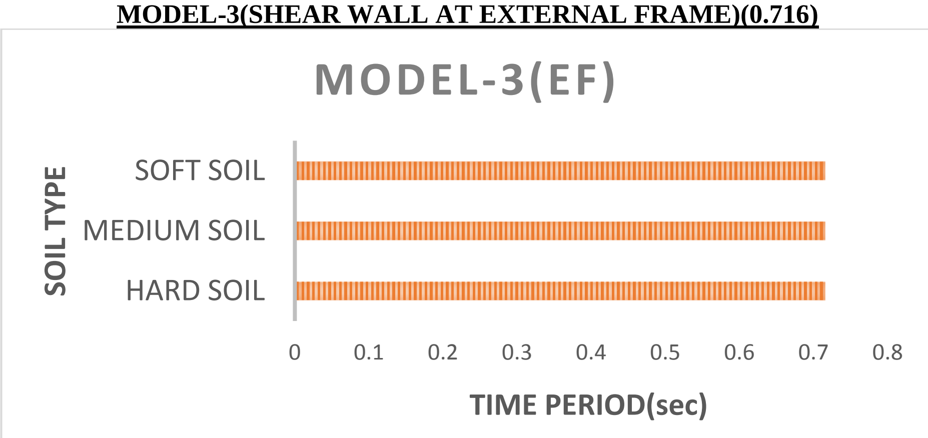
MODEL-1(WITHOUT SHEAR WALL)(0.97)



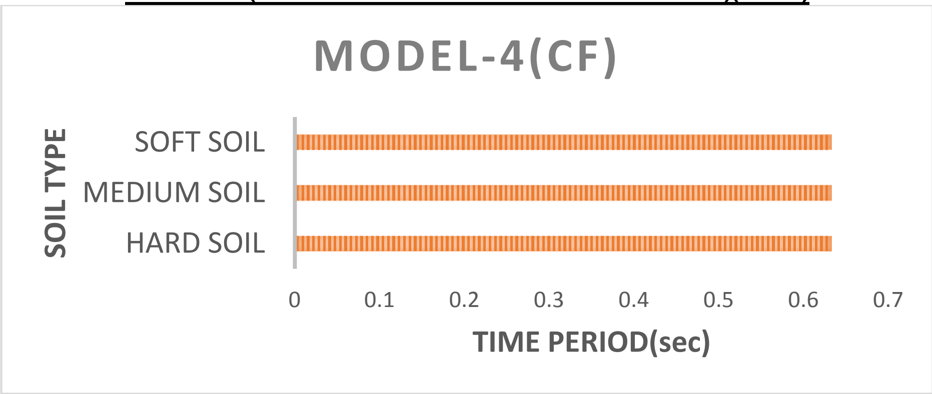
MODEL-2(SHEAR WALL AT LIFT)(0.833)



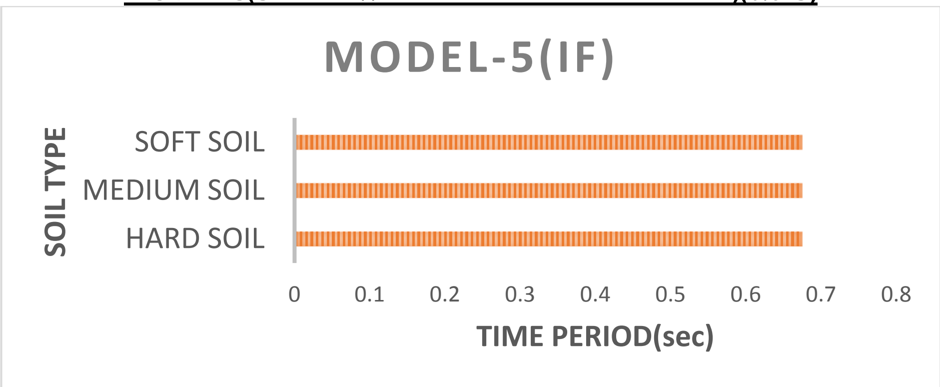
MODEL-3(SHEAR WALL AT EXTERNAL FRAME)(0.716)



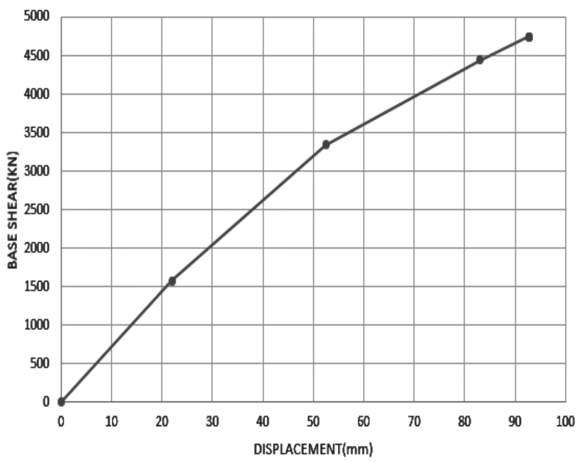
MODEL-4(SHEAR WALL AT CENTRAL FRAME)(0.633)



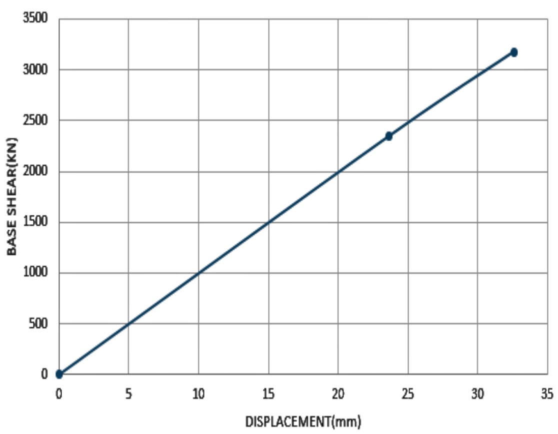
MODEL-5(SHEAR WALL AT INTERNAL FRAME)(0.675)



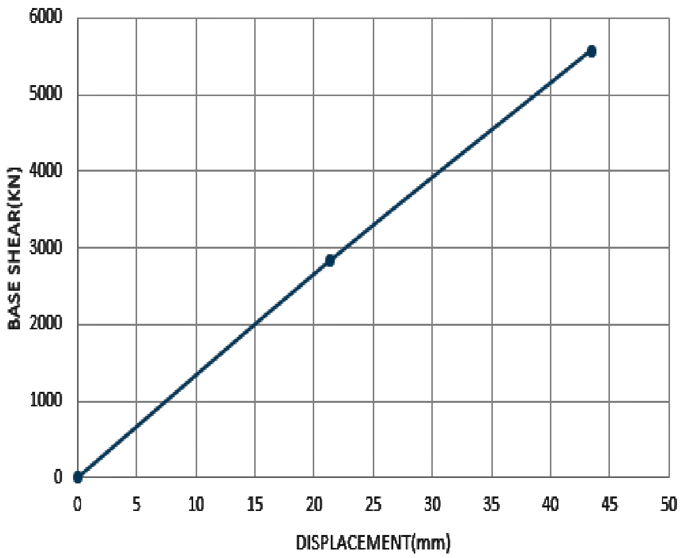
B.PUSHOVER CURVES RESULTS:-



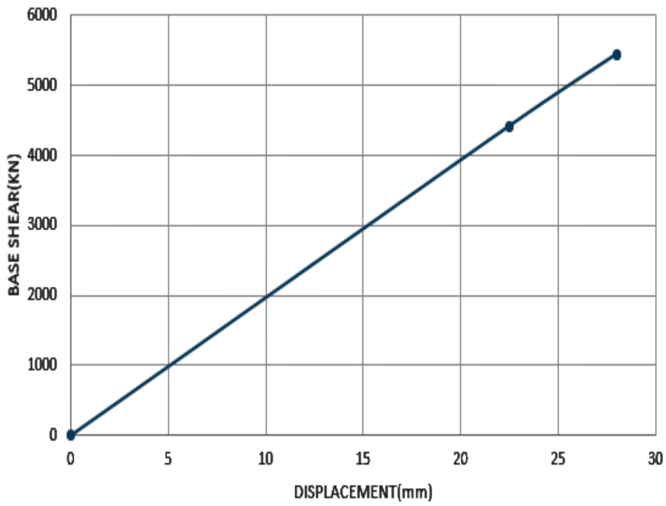
WITHOUT SHEAR WALL



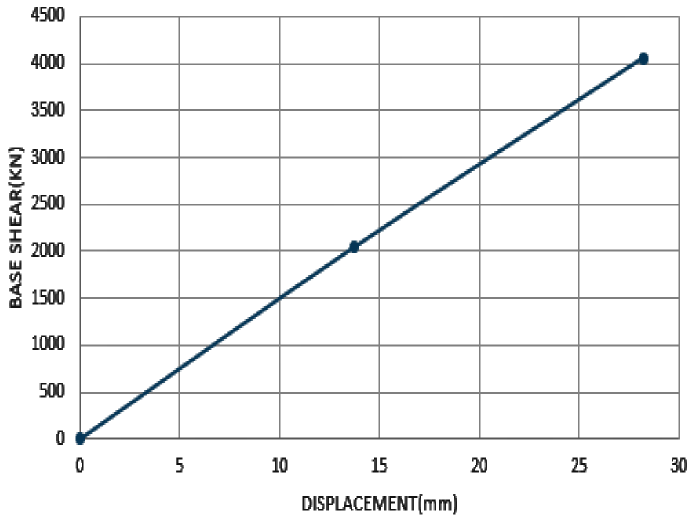
WITH SHEAR WALL AT LIFT



SHEAR WALL AT EXTERNAL FRAME



SHEAR WALL AT CENTRAL FRAME



SHEAR WALL AT INTERNAL FRAME

TYPE OF FRAME	DISPLACMEENT(mm)	% REDUCTION IN DISPLACEMENT FOR EACH FRAME
RCC FRAME WITHOUT SHEAR WALL (MODEL-1)	92.8	0
RCC FRAME WITH SHEAR WALL AT LIFT (MODEL-2)	32.6	64
RCC FRAME WITH SHEAR WALL AT EXTERNAL FRAME (MODEL-3)	43.4	53
RCC FRAME WITH SHEAR WALL AT CENTRAL FRAME (MODEL-4)	27.7	70
RCC FRAME WITH SHEAR WALL AT INTERNAL FRAME (MODEL-5)	28.5	68

V. DISCUSSIONS

1. From pushover curves table it can be seen that for **model-1** the maximum displacement is **92.8mm** and the corresponding base reaction is **4740KN.**
2. Also from pushover curve table it can be seen that for **model-2** the maximum displacement is **32.6mm** and the corresponding base reaction is **3174KN.** And reduction in displacement is **64%** from model-1.
3. Also from pushover curve table it can be seen that for **model-3** the maximum displacement is **43.4mm** and the corresponding base reaction is **5560KN.** And reduction in displacement is **53%** from model-1.
4. Also from pushover curve table it can be seen that for **model-4** the maximum displacement is **27.7mm** and the corresponding base reaction is **5442KN.** And reduction in displacement is **70%** from model-1.
5. Also from pushover curve table it can be seen that for **model-5** the maximum displacement is **28.5mm** and the corresponding base reaction is **4054KN.** And reduction in displacement is **68%** from model-1.
6. Because first mode depends on **Height** and the **Lateral dimension** so for different type of soil time period is not changing.

VI. CONCLUSIONS

From above results it can be seen that the displacement of all five models in Hard, Medium and Soft soil. If we compare the model without shear wall with model having different locations of shear wall we found that model with shear wall at central frame reduced more displacement than any other model. so it can concluded as shear wall in central frame (Model -4) is more effective than the other models and providing shear walls at adequate locations substantially reduce the displacements due to earthquake. Some important points of conclusion are:

- From result it can be concluded that RCC frame with shear wall are able to resist the displacements more than normal RCC frame.
- It can be concluded that placing of shear wall in proper location is more effective in case of base shear and displacement.
- Changing the location of shear wall affects the attraction of forces, so that wall must be in proper position.
- Providing shear wall at central location resist the displacements more than any location of shear wall.
- Time period is also for central frame is less as compared to other locations of shear wall.
- Displacements in hard soil are less than medium and soft soil.
- Type of soil influence the seismic performance of building.
- If shear wall is provided in building major amount of horizontal forces are taken by shear wall.
- Large dimension of shear wall can resist more horizontal forces.
- Time period is also for central frame is less as compared to other locations of shear wall.

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