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Seismic Analysis of Building Resting on Sloping Ground with Soil Structure Interaction

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Abstract - *RCC structures been used along with and without soil structure interaction on sloping ground to compare the displacement, story shear, story drift and base shear of buildings. RCC structures are commonly used on plain ground without SSI (soil structure interaction). The above parameters are evaluated for buildings with and without soil structure interaction in buildings on sloping ground. The performances of structures have been evaluated using response spectrum analysis. To achieve this objective; G+19 structures with and without soil structure interaction are carried out in ETABS 2016, and from the obtained results, the values of parameters such as displacement, story drift, story shear, base shear are compared .*

Key Words: **RCC, SSI, Response Spectrum Analysis, ETABS-2016**

1. INTRODUCTION

The main aim is to response spectrum analysis on RCC building on sloping ground with 20 stories. Seismic response of a building usually depends on the behaviour of the soil, on which the building is laid. The response of the building varies as the soil type changes and also this dynamic response, depends upon the state of one type of soil at a particular instant. The response values of the building subjected to seismic analysis, under the effect of soil structure interaction are greater than the response values obtained from seismic analysis of building, with fixed base. Therefore it very important to consider the effect of soil structure interaction, to get more appropriate values of response of the building subjected to seismic forces. Soil structure interaction is defined as a process, in which the response of soil for seismic force affects the motion of the structure and the motion of the structure, in turn affects the response of the soil.

1.1 Scope of Work

1) To study the seismic response of multi-storey building with Soil Structure Interaction resting on sloping ground.

2) To study the seismic response of multi-storey building with Soil Structure Interaction resting on sloping ground with varying angles.

3) To compare various parameters like Base shear, Storey drift, Storey displacements, story shear of structures.

1.2 Structural Modeling

For the purpose of this study, G+19 story RCC framed buildings with and without SSI are designed in order to determine the behavior of the structure during high seismic activity. The material properties are selected on the basis of displacement limitations and strength as per IS 1893. The models are designed as,

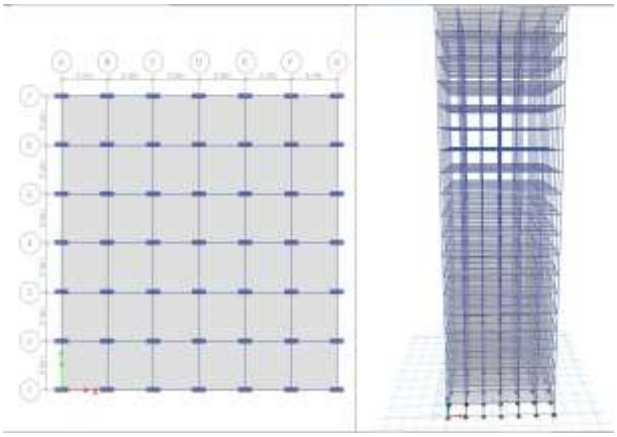

Fig. 1 Plan and Elevation of building on plane ground model.

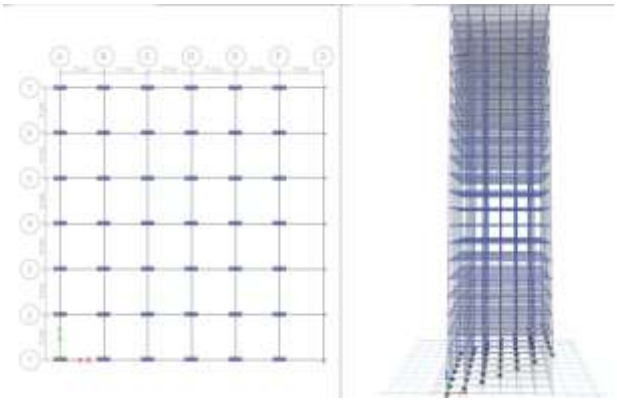

Fig. 2 Plan and Elevation of building having 10°slope model.

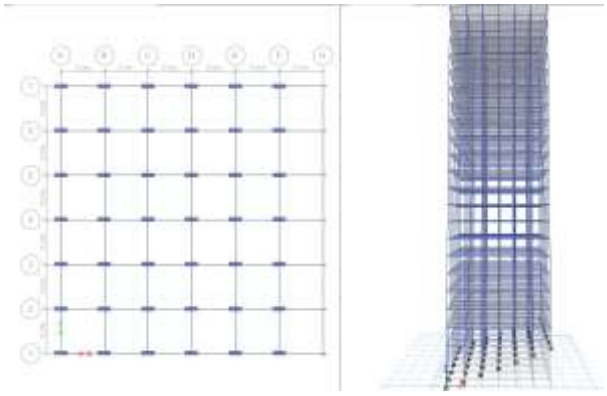

Fig. 3 Plan and Elevation of building having 20°slope.

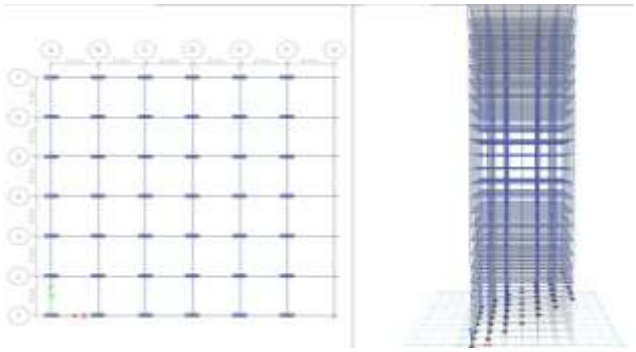

Fig. 4 Plan and Elevation of building having 30°slope model.

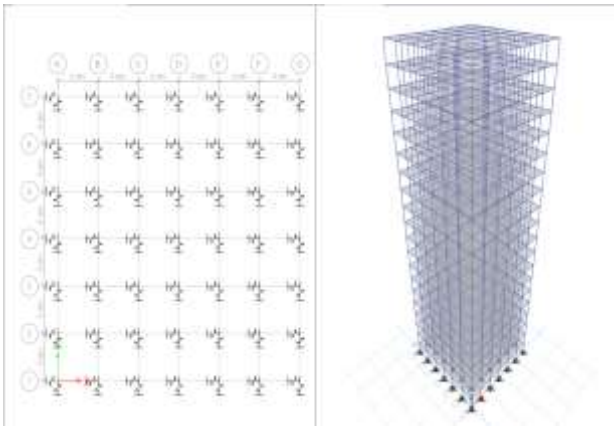

Fig. 4 Plan and Elevation of soil structure interaction model

2. Structures Considered For Analysis

Model 1:20 story structure on plane ground

Model 2:20 story structure on plane ground with soft soil, medium soil and hard soil.

Model 3: 20 story structure having 10°slope on ground

Model 4: 20 story structure having 10°slope on ground with soft soil, medium soil and hard soil.

Model 5: 20 story structure having 20°slope on ground

Model 6: 20 story structure having 20°slope on ground with soft soil, medium soil and hard soil.

Model 7: 20 story structure having 30°slope on ground

Model 8: 20 story structure having 30°slope on ground with soft soil, medium soil and hard soil.

3. METHODOLOGY

This research paper deals with comparative study of behaviour of structures building frames with three geometrical configurations and different slope of ground. This study is attempted in following steps:

1. Selection of building geometry, 6 bays of 3 meters in length and 20story of 2D frame.
2. Selection of sloping angle of ground (0°, 10°, 20°, 30°).
3. Modelling of building frames using ETABs-2016 software.
4. Response spectrum analysis is carried out in software and gives appropriate solution for each plan configuration.

$$Kz = \frac{2GL}{1-\vartheta}\left[0.73 + 1.54\left(\frac{B}{L}\right)^{0.75}\right] \quad \ldots\ldots (1)$$

$$Ky = \frac{2GL}{2-\vartheta}\left[2 + 2.5\left(\frac{B}{L}\right)^{0.85}\right] \quad \ldots\ldots (2)$$

$$Kx = Ky = \frac{0.2}{0.75-\vartheta} GL\left[1 - \left(\frac{B}{L}\right)\right] \quad \ldots\ldots (3)$$

such that L≥ B and size of the foundation is 2L x 2B.

Where $G = \frac{E}{2(1+\vartheta)}$ is Shear Modulus and $\vartheta$is poison's ratio of the soil.

Soil type	Shear Modulus (G) in kN/m²	Poisson's Ratio (μ)
Hard Soil	2700	0.25
Medium Soil	451.1	0.33
Soft Soil	84.5	0.48

SPRING CONSTANTS	TYPE OF SOIL		
	SOFT SOIL	MEDIUM SOIL	HARD SOIL
Kx	2763.5	5527.019	11054.138
Ky	2763.5	5527.019	11054.138
Kz	3474.68	6949.37	13898.84

Serial no.	Material properties	
1	Column size	300x900mm
2	Beam size	300x600mm
3	Height of ground floor	3 m
4	Thickness of slab	150mm
5	Grade of steel	HYSD415
6	Grade of concrete	M30
7	Live load	2 KN/m^2
8	Floor finish	1 KN/m^2
9	No. of stories	G+19
10	Floor to floor height	3 m
11	Type of soil	Soft Medium Hard Soil
12	Seismic zone	V
13	Importance factor	1.5

4. RESULT AND DISCUSSION

4.1 Displacement Comparison along with slope

Model Type	Angle	Maximum Displacement(mm)
On plane ground	0	92.19
Sloping ground	10	93.70
Sloping ground	20	94.99
Sloping ground	30	96.13

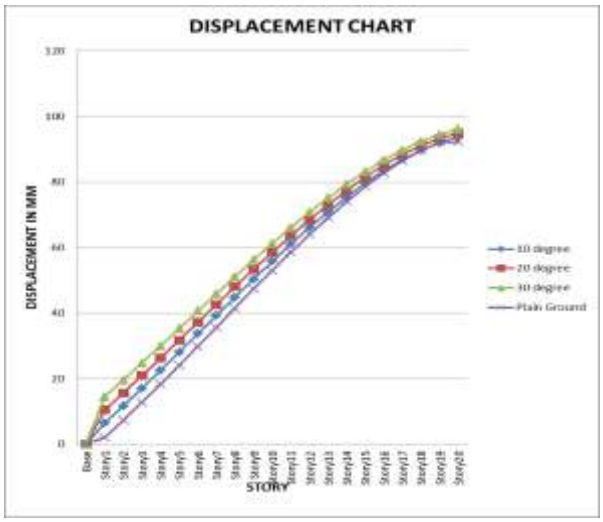

Chart -1: Displacement chart on slope

4.2 Displacement Comparison along with soil structure interaction.

Model Type	Angle	Soil Type	Maximum Displacement (mm)
On plane ground	0	Soft	849.17
On plane ground	10	Soft	860.17
On plane ground	20	Soft	893.96
On sloping ground	30	Soft	923.23
On plane ground	0	Medium	447.04
On sloping ground	10	Medium	452.04
On sloping ground	20	Medium	473.30
On sloping ground	30	Medium	493.30
On plane ground	0	Hard	246.12
On sloping ground	10	Hard	248.13
On sloping ground	20	Hard	252.30
On sloping ground	30	Hard	275.40

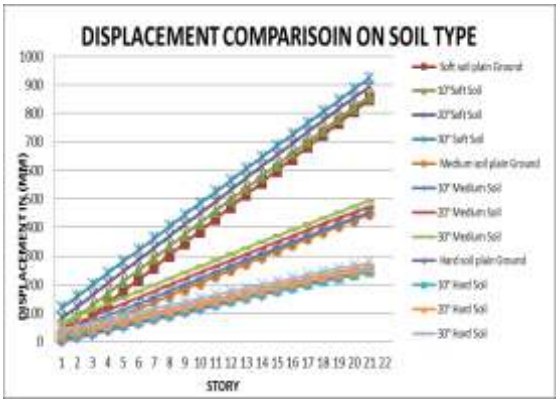

Chart -1: Displacement chart on soil type.

4.3 Drift Comparison along with slope

Model Type	Angle	Story Drift
On plane ground	0	0.001943
Sloping ground	10	0.001843
Sloping ground	20	0.002549
Sloping ground	30	0.003381

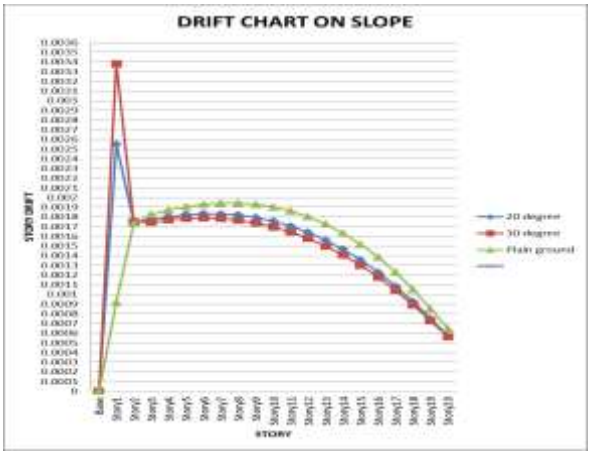

Chart -3: Drift chart on slope

4.4 Drift Comparison along with soil structure interaction.

Model Type	Angle	Soil Type	Story Drift
On plane ground	0	Soft	0.01546
On plane ground	0	Medium	0.008682
On plane ground	0	Hard	0.005213
On sloping ground	10	Soft	0.014159
On sloping ground	10	Medium	0.007702
On sloping ground	10	Hard	0.004449
On sloping ground	20	Soft	0.01465
On sloping ground	20	Medium	0.008214
On sloping ground	20	Hard	0.004972
On sloping ground	30	Soft	0.015209
On sloping ground	30	Medium	0.008673
On sloping ground	30	Hard	0.00549

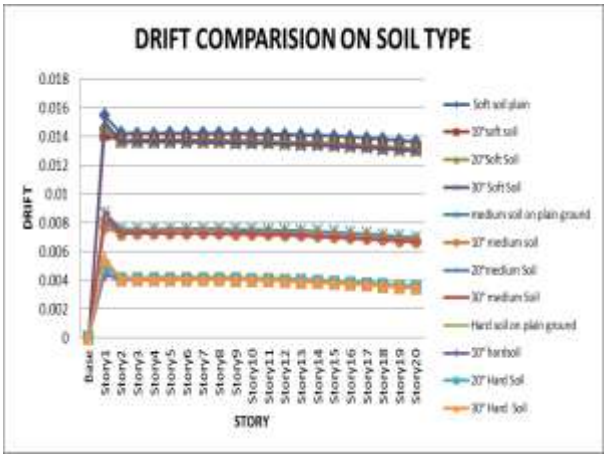

Chart -4: Drift chart on soil type

4.5 Base Shear Comparison along with slope

Model Type	Angle	Base Shear (KN)
On plane ground	0	4149.25
Sloping ground	10	3938.52
Sloping ground	20	3902.59
Sloping ground	30	3880.30

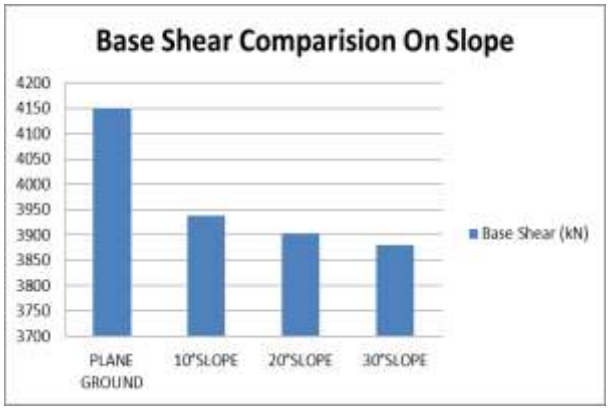

Chart -5: Base Shear on Slope chart

4.2 Base Shear Comparison along with soil structure interaction.

Model Type	Angle	Soil Type	Base Shear(KN)
On plane ground	0	Soft	1206.24
On plane ground	0	Medium	1206.24
On plane ground	0	Hard	1240.24
On sloping ground	10	Soft	1154.41
On sloping ground	10	Medium	1154.41
On sloping ground	10	Hard	1192.75
On sloping ground	20	soft	1164.52
On sloping ground	20	Medium	1164.52
On sloping ground	20	Hard	1190.29
On sloping ground	30	soft	1175.90
On sloping ground	30	Medium	1175.90
On sloping ground	30	Hard	1193.18

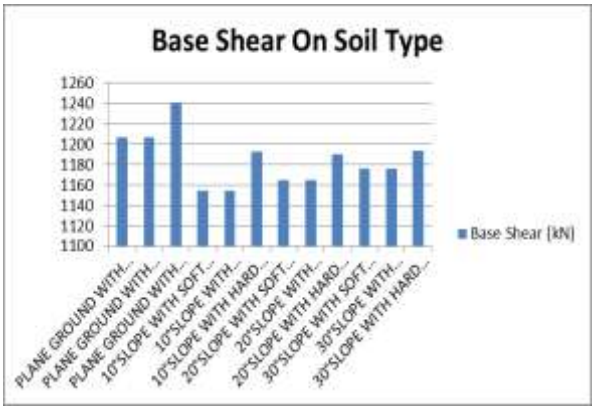

Chart -6: Base Shear on soil type

5. CONCLUSIONS

In this study the G+19 building models analysed for different angles and including soil structure interaction. The results lead to following conclusions.

1. Story displacement of the building models with SSI is more when compared to conventional fixed base (NSSI) models. It also increases with the soft soil.

2. Story displacement is maximum in 30°slope type of building model in soft, medium and hard soil with and without SSI.

3. It is observed that in conventional fixed base the base shear value was increasing with increase in models having fixed base whereas it is decreasing in case of SSI models.

4. Story displacement and story drifts are maximum in case of building with soil structure interaction than fixed base buildings (NSSI).

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