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Study of Soil-Structure Interaction and Vertical Irregularity on Open Ground Storey Building

Shilpa Sara Davidson
PG scholar, Department of Civil Engineering ,
Sree Buddha College of Engineering,
Alappuzha/Pathanamthitta cluster of APJ Abdul Kalam Technological University, Ayathil, Elavumthitta P.O,
Pathanamthitta-689625

Archana Sukumaran
Assistant Professor, Department of Civil Engineering,
Sree Buddha College of Engineering,
Alappuzha/Pathanamthitta cluster of APJ Abdul Kalam Technological University, Ayathil, Elavumthitta P.O,
Pathanamthitta-689625

Abstract: **Open ground storey buildings are usually used for parking in urban areas. During the past earthquakes the vulnerability of these buildings became clear. Bare frame analysis is used for designing the OGS buildings. These under-estimates the inter-storey drifts. A Multiplication Factor (MF) was introduced in order to avoid the above problem while calculating design forces. The multiplication factor used varies with various international codes. Present study focuses on the evaluation of seismic performances of regular and vertically irregular OGS buildings designed with various soil conditions. Also this work helps in understanding the effect of earthquake with various soil conditions. In this work effect of vertical irregularity in open ground storey building is also studied. For the modelling of the building the software ETABS is used and the analysis is done using response spectrum method.**

Keywords: Open Ground Storey building, infill walls, multiplication factor, response spectrum method

I. INTRODUCTION

Proper utilisation of space has become a major concern in developing countries like India due to rapid urbanisation and population growth. As a result, multi-storey residential buildings in urban areas are forced to have parking in the ground floor. In such buildings, the ground storey is built without any infill walls. It allows easy movement of vehicles but the upper storeys are covered with infill walls. Such buildings are called ‘open ground storey (OGS) buildings’.

Open ground storey (also known as soft storey) buildings are commonly used in the urban environment nowadays since they provide parking area which is most required. Due to soft storey effect OGS buildings show higher tendency to collapse during earthquakes. This is because of the large lateral displacements induced at the first floor level of OGS buildings. The energy developed during earthquake loading is transferred by the columns of the ground storey. This results in the formation of plastic hinges. Without proper care construction of open ground storey is very dangerous.

The effects of non-structural infill walls are neglected by seismic codes during analysis. This neglects the effect of infill stiffness by assuming that this would give some conservative results, Fardis and Panagiotakos (1997). But this is not true in the case of columns present in the open ground storey. Many codes (e.g., IS 1893- 2002, EC -8, IBC) recommends a factor to take care for the magnification of bending moments and shear forces. This factor is known as multiplication factor.

Fig 1. A typical OGS building located at Rourkela

II. OBJECTIVES

- To determine the effect of soil – structure interaction on the open ground storey building.
- To find out which type of soil is most suited for the construction of regular and irregular open ground storey building.
- To find out the effect of vertical irregularity in open ground storey building.

III. DESCRIPTION OF MODEL

In the present study three models of regular and irregular OGS buildings were prepared using the software ETABS and analysed. The properties of the considered building configurations in the present study are given below.

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Table 1 Modelling details of building

Plan dimension	50x30m
Spacing between frames	5m along both directions
No of storey's	G+14
Storey height	3.5m
Building frame system	Ordinary Moment Resisting Frame
Building use	Commercial
Foundation type	Fixed
Seismic zone	Zone V
Soil type	Hard, medium, soft
Importance factor	1
Response reduction factor	3
Damping ratio	5%

Table 2 Material properties

Grade of steel	Fe 415
Grade of concrete	M20, M25, M30
Density of concrete	$25kN/m^3$
Poisson's ratio of concrete	0.20
Compressive strength	$1.9kN/m^2$

Table 3 Structural members

Thickness of slab	150 mm (M20 concrete)		
Thickness of wall	200mm		
Column size in different storey's	Storey 1-5	M20	0.75m×0.4m
	Storey 6-10	M25	0.75m×0.3m
	Storey 11-15	M30	0.6m×0.25m
Beam size in different storey's	Storey 1-5	M20	0.6m×0.4m
	Storey 6-10	M25	0.6m×0.3m
	Storey 11-15	M30	0.6m×0.3m
Dead Load	Roof	$2.0 KN/m^2$	
	Floor	$2.0 KN/m^2$	
Live Load	Roof	$1.5 KN/m^2$	
	Floor	$4.0KN/m^2$	

IV. MODELS CONSIDERED FOR ANALYSIS

Following two models are considered in all the three types of soils. Totally six models were analysed using ETABS software. Response Spectrum Method is used for the analysis of the models.

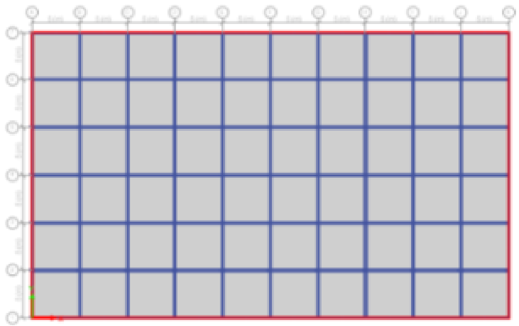

Fig. 2 Plan of the building used

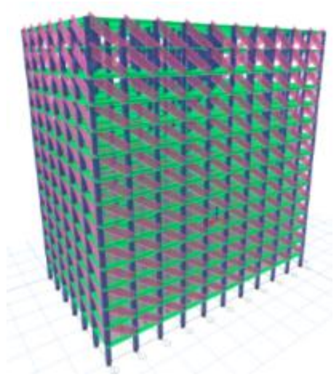

Fig. 3 3D view of regular building

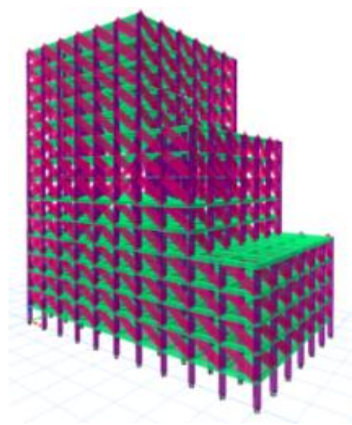

Fig. 4 3D view of irregular building

V. RESULT AND DISCUSSION

The modelling and seismic analysis for both regular and irregular building was carried out using the software ETABS in all the three soil types. The results obtained are tabulated below. The parameters which are to be studied are maximum storey displacement, maximum storey drift, base shear and overturning moments by varying the type of soil for both regular and irregular buildings.

A. REGULAR OPEN GROUND STOREY BUILDING

Table 4 Values obtained for regular Open Ground Storey building

	Type 1 (Hard soil)		Type 2 (Medium soil)		Type 3 (soft soil)	
	X	Y	X	Y	X	Y
Maximum storey displacement (mm)	30.132538	29.160644	41.265114	39.820438	50.815319	48.97925
Maximum storey drift	0.003903	0.003777	0.005324	0.005138	0.006546	0.00631
Base shear (kN)	29065	28128	39532	38148	48544	46790
Overturning moments (kNm)	912439	883009	1247821	1204135	1535777	1480285

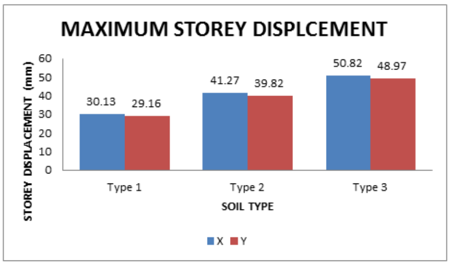

Fig.5 Storey displacement

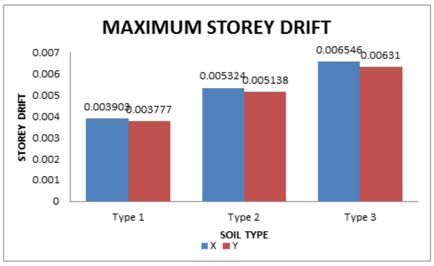

Fig.6 Storey drift

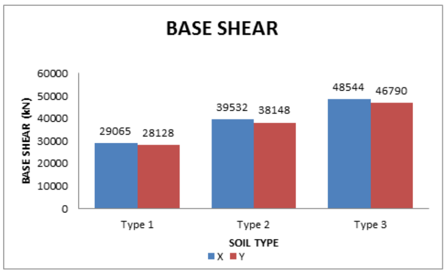

Fig.7 Base shear

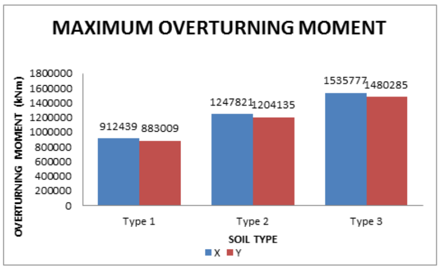

Fig.8 Overturning moment

B. IRREGULAR OPEN GROUND STOREY BUILDING

Table 5 Values obtained for irregular Open Ground Storey building

	Type 1 (Hard soil)		Type 2 (Medium soil)		Type 3 (soft soil)	
	X	Y	X	Y	X	Y
Maximum storey displacement (mm)	18.646953	19.398102	26.229091	26.382533	32.18495	32.403008
Maximum storey drift	0.004698	0.004887	0.006606	0.006645	0.008104	0.008159
Base shear (kN)	37839	39363	44161	44419	44161	44460
Overturning moments (kNm)	950537	988828	1109240	1115729	1109241	1116756

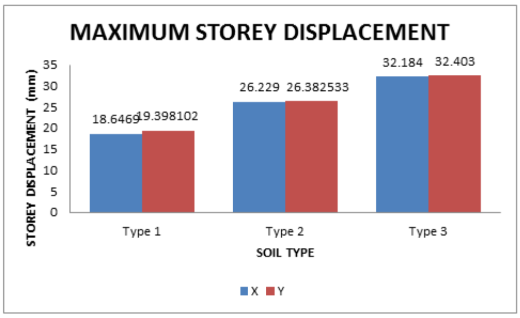

Fig.9 Storey displacement

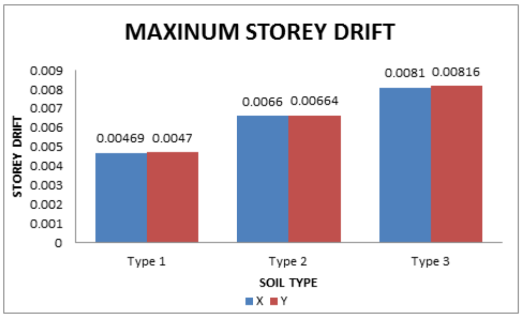

Fig.10 Storey drift

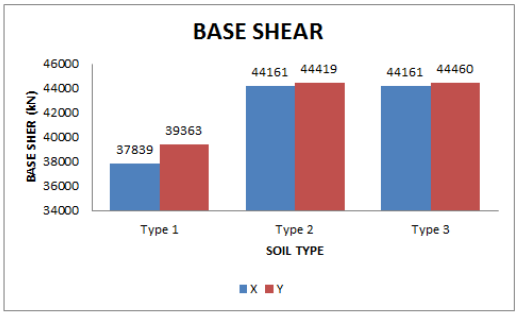

Fig.11 Base shear

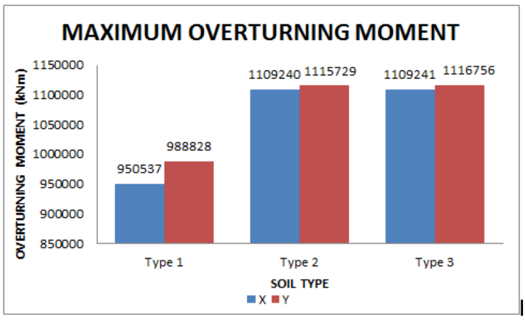

Fig.12 Overturning moment

VI. CONCLUSION

Three models of regular open ground storey building were modelled corresponding to all the three soil types. Similarly other three models were modelled corresponding to all the three soil types with vertically irregular open ground storey building. The selected models where analysed using the response spectrum method in ETABS and the conclusions obtained from the analysis are:

- The soil-structure interaction greatly affects the performance of the structure.
- The type of soil in which the building is constructed affects the strength of the building.
- The type 1 soil (hard soil) is best suited for the construction of both regular and vertically irregular open ground storey buildings. It has more strength than type 2 and type 3 soils.
- The buildings constructed in type 2 soil (medium soil) shows better performance than buildings constructed in type 3 soil (soft soil).
- Vertical irregularity also affects the performance of the open ground storey building.
- Regular OGS building have more strength than vertically irregular OGS building.
- But in the case of storey displacement vertically irregular OGS building has less storey displacement than regular OGS building.

VII. REFERENCES

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