Scope International Journal of Science, Humanities, Management and Technology. ISSN : 2455-068X
Vol.4 Issue 3 (2018) 171 - 175. Submitted 15/08/2018. Published 09/09/2018

INFLUENCE OF SOIL PROPERTIES ON THE SEISMIC PERFORMANCE OF FRAMED STRUCTURES

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***Abstract*—** Current building codes lack explicit recommendations on how to simulate the seismic performance of high-rise buildings with multiple underground stories. Designers are typically basing their analyses on subjective engineering judgment and experience. Some model and analyse the buildings cropped at the ground floor level, others include a partial number of basement floors, while a few include all the underground floors. This paper studies the seismic behaviour of reinforced concrete buildings with multiple underground stories. It seeks to provide recommendations on the number or percentage of underground stories to be accounted for in the analysis of reinforced concrete shear wall buildings. A base-case where the buildings are modeled with a fixed condition at ground level is adopted, and then the number of basements is incrementally increased to investigate changes in performance. The Beirut local site conditions are used for the analysis. The base shear, inter-story shears and moments are evaluated in order to quantify the effects of soil structure interaction on the design process.

Keywords: Key words: Dynamics of soil, Natural Time Period, Soil Structure Interaction, Stiffness.

INTRODUCTION

Since the past 4 decades, there has been a many studies done for understanding the nature of earthquakes and their impact on structures. Considering few earthquakes in recent years, it is observed that the soil-structure interaction (SSI) effects play an important role in determining the behaviour of building structures. The response of a structure at the time of an earthquake mainly depends on the ground characteristics, the surrounding soil medium, its properties and the structure itself. The movements of soil under foundation will interact with the deformations of the structure itself. Soil dynamics involves the estimation of dynamic soil properties and the study of the behaviour of various types of soils under dynamic loads. Seismic waves are transmitted through soil from the origin and the wave motion of the soil excites the structure. The extent of damage caused by earthquakes depends essentially on the dynamic response of soil deposits, which is governed by the cyclic non-linear and strength characteristics of the soil.

The foundation and the superstructure are typically designed as two independent systems, and the superstructure is fixed at the bottom. The calculated seismic response of the building is generally dependent on the structure above ground level i.e., superstructure. This method is generally simple and convenient, but the energetic characteristics and earthquake response of buildings will be different than those of actual buildings, if we do not consider the flexible property of soil at the foundation as well as the surrounding soil, which may lead to an unsafe design, especially in case of the earthquake design and for the performance analysis of major and valuable structures, such as huge sky scrapers. The foundation designer must consider the behavior of both structure and soil and their interaction with each other. The interaction between the soil and the foundation is very much important for various civil engineering cases and it covers a wide spectrum of problems. These include the study of shallow and deep foundation, floating structure, retaining wall-soil system, tunnel lining, earth structure etc.

A.) Soil Structure Interaction –

The phrase soil structure interaction is defines as the influence of soil with structure and influence of structure with soil.

B.) Dynamic Behavior of Soil –

Soil Behavior under dynamic loading depends on the strain magnitude, the strain rate and the number of loading cycles. The strength of certain soils increases under rapid cyclic loading, while saturated sand may lose strength with vibration

II. OBJECTIVES OF PROJECT

To study the literature available regarding soil-structure interaction (SSI) and understanding the effects of both on structural performance.

To study the structure without considering soil-structure interaction.

To study the structure considering soil-structure interaction

III METHODOLOGY

The steps involved in the design and analysis can be summarized as:-\

1. First to study the literatures existing by different researchers.
2. Selection of type of framed structure and plan of building and taking different heights of building. Three different types of soil are considered i.e., hard, medium and soft soil on which the RC structures are to be rested.
3. The properties of soil are taken according to IS 1893:2002.
4. For the interaction analysis, two different approaches are used –

A.) Winkler Approach :-

Winkler assumed that the surface displacement of the soil medium is proportional directly to the stress applied to it at that point and completely independent of stresses or displacement at other, even immediately neighboring point of the soil-foundation interface.

B.) Elastic Continuum Approach :-

In the case of in-situ surface deflections will occur certainly under and around the loaded region. A Winkler Model is generally limited for such soil media that has cohesion or transmissibility of applied forces

IV SOIL PROPERTIES

Table 1 presents the governing soil parameters for the different site classes used in the study. The parameters are estimated by correlating the ASCE site classification to the principles of soil mechanics.

Table 1: Soil Parameters

Property/ Soil Type	S_C	S_D
φ (friction angle) (degrees)	42	37
γ (unit weight) (kN/m^3)	20	19
ν (poisson's ratio)	0.4	0.3
V_s (Shear wave velocity) (m/s)	500	275
Relative Density (%)	90	65
G_o (initial shear modulus) (kPa)	510,000	146,500
F_a (site coefficient) (FEMA 356)	1	1
S_{xs} (design spectral acceleration at short period)	2	2
G/G_o (FEMA 356 table 4-7)	0.6	0.1

Side Soil

The side soil behavior is represented using p-y curves. P-y curves are force versus displacement functions that are generally used to model the reaction of the soil for applications involving laterally loaded piles. In this paper, P-y curves. A simplified model whereby the earth pressure is assumed to be bounded by a maximum passive pressure P_p and a minimum active pressure P_a is adopted in this study. As recommended by Briaud and Kim (1998), the active earth pressure P_a and the passive earth pressure P_p could be assumed to be mobilized at wall movements of 1.3mm (away from the retained soil) and 13mm (into the retained soil), respectively in modeling the P-y relationship. The earth pressures at a given depth are typically dependent on the soil type and properties

Foundation Soil

The foundation system of the buildings comprises of either a network of shallow spread footings or a raft foundation depending on the loading and site conditions.

Two types of shallow footings are identified: one for interior columns and another for edge columns. The foundations of the basement walls are designed as strip footings. Shallow and strip footings are designed based on the Meyerhof's bearing capacity and the elastic settlement theory criteria as outlined in Das 2007. The design is then checked for one-way and two-way shear failure according to ACI 318-08. The vertical, horizontal, and rotational elastic stiffness of the footings are calculated using the frequency independent formulas given in the FEMA 356 report. A set of 6 spring constants corresponding to the six degrees of freedom are calculated as a function of the footing dimensions and assigned to the model node of the respective footing.

The raft foundation is designed to be rigid to minimize differential settlements. According to the ACI criteria, a raft foundation is considered rigid if the spacing between columns is less than $1.75/\beta$, where,

β is a function of the raft dimensions, raft modulus of elasticity, and soil's subgrade modulus. Based on this assumption, whenever the foundation system is a raft, the model is constrained against rotational degrees of freedom at the corresponding location.

V GROUND MOTION

There are no recorded ground motions in Lebanon. This lead researchers to seek earthquake records consistent with the seismic nature of the country (Harajli 1994, Huijer 2010). A time history consistent with the 1940 El Centro Earthquake is used in this study. The El Centro earthquake, Figure 4, is produced by the strike slip Imperial fault in the Southern California region. It has a magnitude of 6.9 on the Richter scale and an epicentral distance of 13Km. This time history excitation is selected for the following reasons (Huijer 2010).

The capability of the Lebanese faults of producing earthquakes of equivalent magnitude and epicentral distances.

The common characteristics that exist between the Imperial strike-slip fault and the Yammouneh fault, the most significant fault in Lebanon.

Conclusion

Analysis is done to evaluate the effects of the soil structure interaction on the seismic performance of buildings. For each scenario the results are processed in the form of graphs comparing response quantities for the envelope of the story shear and moment demands for the buildings throughout the earthquake. Because of the extensive amount of data collected, only some representative results are provided in this document.

As this is an on-going study, the authors will further investigate the problem to come up with more definitive conclusions. The full 3D models will be analysed, the inelastic properties of the structural members will be incorporated and more refined results will be reported as and when completed.

References

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[1] Dutta, S. and R. Roy (2002), A Critical Review on Idealization and Modeling for Interaction Among Soil Foundation–Structure System, *Computers and Structures*, 80, pp. 1579-1594.

[2] Huijer, C. (2010), "Implications of the recent mapping of the offshore thrust fault system on the seismic hazard in Lebanon", Masters Thesis, American University of Beirut.

[3] American Concrete Institute (2008), ACI 318-08 Building Code Requirements for Structural Concrete and Commentary, ACI.

[4] American Society of Civil Engineers (2005), ASCE 7-05, Minimum Design Loads for Buildings and Other Structures, ASCE.

[5] Shakib H. (2004), Evaluation of Dynamic Eccentricity by Considering Soil–Structure Interaction: a Proposal for Seismic Design Codes, *Soil Dynamics and Earthquake Engineering*, 24, pp. 369-378.

