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Study of Retrofitting Technique with reference to Soil-Structure Interaction: A Review

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Abstract

Most of the world earthquake shows that there is a need to study basic conditions of earthquake vibration. During an earthquake, the behavior of any structure is influenced not only by the response of the superstructure but also by the response of the soil underneath. Soil structure interaction is in the disciplinary field, which involves structural and geotechnical engineering. The conventional method of building frame analysis assumes that columns are resting on unyielding supports. In certainty, the supporting soil strata deform unevenly under the action of loads, which causes a redistribution of forces in the frame members and stresses in the supporting soil media. Past earthquake shows that most of the structural designer does not consider the soil-structure interaction effect on the structure during an earthquake and because of that, we will not find out exact behavior of earthquake in buildings. The present work is focused on soil-structure interaction and the study of different retrofitting techniques for finding out the optimized solution for any structure which requires retrofitting.

Keywords: *Soil structure interaction, retrofitting techniques.*

I. INTRODUCTION

Earthquake in India shows that not only non-engineered structures but also engineered structures are also heavily damaged during the moderate earthquake. As waves from an earthquake reach a structure, they produce motions in the structure. These motions depend on the structure's vibration characteristics and the layout of the structure. For the structure to react to the motion, it needs to overcome its own inertia force, which results in an interaction between the structure and the soil. The extent to which the structural response changes the characteristics of earthquake motions observed at the foundation level depends on the relative mass and stiffness properties of the soil and the structure. Thus the physical property of the foundation medium is an important factor in the earthquake response of structures supported on it. The process in which the response of the soil influences the motion of the structure and the motion of the structure influences the response of the soil is termed as soil-structure interaction (SSI).

II. LITERATURE REVIEW

From an exhaustive survey done by many types of research, it was found that many researchers work on a one by one technique of retrofitting, but no one judges the effect of different retrofitting techniques on a single structure by considering soil-structure interaction. Following the literature, the survey was done to understand the effect of soil-structure interaction on the structure.

R. M. Jenifer Priyanka et al. (2012) studied though the structures are supported on soil, most of the designers do not consider the soil structure interaction and its subsequent effect on the structure during an earthquake. Different soil properties can affect seismic waves as they pass through a soil layer. When a structure is subjected to earthquake excitation, it interacts with the foundation and soil and thus changes the motion of the ground. It means that the movement of the whole ground structure system is influenced by the type of soil as well as by the type of structure. Tall buildings are supposed to be of engineered construction in the sense that they might have been analyzed and designed to meet the provision of relevant codes of practice and building bye-laws. IS 1893: 2002 "Criteria for Earthquake Resistant Design of Structures" gives response spectrum for different types of soil such as hard, medium, and soft. An attempt has been made in this paper to study the effect of Soil-structure interaction on multi-storeyed buildings with various foundation systems. Also, to study the response of buildings subjected to seismic forces with Rigid and Flexible foundations. Multi storeyed buildings with fixed and flexible support subjected to seismic forces were analyzed under different soil conditions like hard, medium, and soft. The buildings were analyzed by the Response spectrum method using the software STAAD Pro. The response of building frames such as Lateral deflection, Storey drift, Base shear, axial force, and Column moment values for all building frames was presented in this paper.

Maria I. Todorovska (2002)et this paper presents a review of the full-scale experimental studies of soil-structure interaction. It briefly reviews that the early research on soil-structure interaction starting from the 1930s. The studies of the Hollywood storage building in the US (the first structure in California where strong earthquake motion was recorded in 1933), selected research on soil-structure interaction, and full-scale testing was performed by using experimental work.

ShreyaThusoo (2015) studied Over the years, and it has been extensively established that the practice of assuming a structure being fixed at the base leads to gross errors in the evaluation of its overall response due to dynamic loadings and overestimations in design. The extent of these errors depends on a number of variables, soil type being one of the major factors. This paper studies the effect of Soil-Structure Interaction (SSI) on multistory buildings with varying under-laying soil types after proper validation of the effect of SSI. Analysis for soft, stiff, and very stiff base soils has been carried out, using a powerful Finite Element Method (FEM) software package ANSYS v14.5. Results lead to some very important conclusions regarding time period, deflection, and acceleration responses.

R. J. JARDINE et al. studied over a Recent field, and laboratory studies have shown that, even at very small strains, many soils exhibit non-linear stress-strain behavior. Nevertheless, because of its convenience, linear elasticity will continue to play an important role in the analysis of such problems as settlement, deformation, and soil-structure interaction. In this paper, the measured non-liqear stress-strain properties of a low plasticity clay are used in the finite element analysis of footings, piles, excavations, and pressuremeter tests to assess the influence of small strain non-linearity in comparison with linear elastic behavior. In all cases, non-linear behavior results in the concentration of strain and deformation towards the loading boundaries. This is shown to have important consequences for soil-structure interaction problems such as settlement profiles, pile group interaction, and contact stress distributions. Small strain nonlinearity also has a significant influence on the interpretation in terms of equivalent elastic moduli of in situ deformation tests (e.g., plates and pressuremeters) and of field measurements. It is concluded that, although linear elasticity remains a convenient tool for expressing measurements of soil stiffness unless the non-linear nature of soils is taken into account, soil-structure interaction computations and the interpretation of field measurements can be misleading.

Jenifer Priyanka et al. (2012) studied the effect of lateral force on tall buildings with a different types of irregularities. An attempt was made in this study to understand the behavior of tall buildings subjected to lateral forces for different soil conditions. Ten Storied building with various spacing of columns, such as 2.5m, 4m, and 5m of buildings with different irregularities like Vertically irregular, Mass irregular, and Stiffness irregular, were analyzed using the software STAAD Pro. The top story lateral deflection due to seismic load of these buildings was compared with regular building configuration for different soil conditions. It was found that building with soft soil gives more deflection as compared to medium and hard soil for all types of building. Building with stiffness irregularity gives more deflection as compared to other types of buildings with different irregularities.

Anand et al. (2010) studied the seismic behavior of RCC buildings with and without shear walls under different soil conditions. One to fifteen storeyed space frames with and without shear wall were analyzed using ETABS software for different soil conditions (hard, medium, soft). The values of Base shear, Axial force, and Lateral displacement were compared between two frames. Lateral displacement, Base shear, Axial force, and Moment in the column value increases when the type of soil changes from hard to medium and medium to soft for all the building frames. It was concluded that the soil structure interaction must be suitably considered while designing frames for seismic forces.

Pandey et al. (2011) studied the seismic soil-structure interaction of buildings on hill slopes. Static pushover analysis and response spectrum analysis (RSA) were conducted on five buildings, i.e., three-step back buildings and two-step back-set back buildings with varying support conditions. These buildings had been analyzed for different soil conditions (hard, medium, and soft soils) using SAP2000 software idealized by equivalent springs. The response parameters, i.e., total base shear (V), displacement from pushover analysis (δ performance point), displacement from RSA (δ elastic), and response correction factor (R), had been studied with respect to fixed base analysis to compare the effect of soil springs. In general, it was found that the response reduction factor decreases with increasing time period, but it was expected to be constant beyond a certain value of time period.

Amin et al. (2011) studied the effect of soft storey on multi-storeyed reinforced concrete building frames. Four building models (3, 6, 9, and 12 storeys) with identical building plans were considered to investigate the effect of the soft storey for multistoried reinforced concrete building frame.

Akihiro KUNISUE et al. (2000) studied the authors have been researching and developing methods of retrofitting existing reinforced concrete buildings with elasto-plastic steel dampers. In the proposed seismic retrofitting method, dampers are installed in an existing building to increase its structural strength and, at the same time, to reduce its seismic response by absorbing energy. This paper reports on a structural test conducted to investigate the structural characteristics of damper-embedded frames. The test results indicate that the proposed method of retrofitting an existing building increases both its strength and its energy absorption capacity. The paper also introduces an example of an application of the proposed seismic response control retrofitting method and demonstrates the effectiveness of the retrofit through earthquake response analysis.

Swati Nibhorkar et al. (2015) studied A higher degree of damage in a building is expected during an earthquake if the seismic resistance of the building is inadequate. The decision to strengthen it before an earthquake occurs depends on the building's seismic resistance. The structural system of the deficient building should be adequately strengthened in order to attain the desired level of seismic resistance. The seismic retrofitting of reinforced concrete buildings not designed to withstand seismic action is considered. After briefly introducing how seismic action is described for design purposes, methods for assessing the seismic vulnerability of existing buildings are presented based on the literature survey carried out. The existing building can be retrofitted using various techniques like Jacketing existing beams, columns, or joints, Use of Fibre Reinforced Cement, confinement of column by the embedded composite grid, etc. So, in this paper, efforts are made to describe the different retrofitting techniques available and their suitability for particular conditions. The traditional methods of seismic retrofitting are reviewed, and their weak points are identified. Modern methods and philosophies of seismic retrofitting are also reviewed.

III. DISCUSSION AND CONCLUSION

From the above literature reviews, it was observed that a number of experimental and analytical studies focused on seismic retrofitting techniques and extensive seismic damage control activities in practice have contributed to the present state of development. Further research should be conducted to improve the selection of appropriate retrofit techniques using criteria based on performance, economy, and constructability. There are many seismic retrofit techniques available, depending upon the various types and conditions of structures. Therefore, the selection of the type of intervention is a complex process. The methods are carried out by most of the researchers, which are concrete jacketing of columns of the ground floor, brick masonry infill in the ground floor, X and V bracing, shear wall, FRP of beams and columns. But when we considered soil-structure interaction for analyzing structure, so it gives the best analyzing results and shows the exact behavior of the structure. Hence we must consider the SSI effect while analyzing structure, which needs retrofitting.

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