International Journal of Scientific Research in Civil Engineering
© 2020 IJSRCE | Volume 4 | Issue 6 | ISSN : 2456-6667

Interaction of Sub-Base with Structure Considering Lateral Forces : A Review

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Article Info
Volume 4, Issue 6
Page Number: 60-66
Publication Issue :
November-December-2020

Article History
Accepted : 15 Nov 2020
Published : 25 Nov 2020

ABSTRACT

Lateral forces are now a days considered as the most important load to be applied for designing a tall structure. around the world it has different provisions as per country code but the factor is same to reisst lateral forces and to analyze the structure for concern region zone and base shear. for seismic analysis the most important part to be consider is soil. As soil is the main part from where shakes appears and applied to the structure. In this paper we are presenting literature review of publications and journals related to interaction of structure and sub base material also reviewing analysis tools related to structural analysis.

Keywords: Structure Analysis, Soil Interaction, Analysis Tool, Materials, Forces, Moment, Deflection.

I. INTRODUCTION

Since the hazards occurring all over the world due to seismic pressure is increasing and causing damage to the infrastructure and people, thus for designing structures prone to resist such tremors are necessary. As we all know seismic hazards generally occurs due to movement in tectonic plates beneath the earth therefore foundations and soil pressure below the structure should be analyze for safe distribution of vertical pressure of the building. Soil interaction is one of the most important aspect which is been considered by engineers and architects from several years after the examination of impacts on structure due to earthquake all around the globe.

Soil structure interaction is analyzed by interacting the combine effect of base of the structure and soil beneath. The layers of structure stated on deformable soil redistributes forces and moment because of soil interaction, in such case symmetric examination is not effective and might is inappropriate.

As in this study we are analyzing a soil structure interaction to determine its effect over the seismic design of the structure, In this chapter we are reviewing the survey of authors did researches related to interaction of soil and structure.

II. LITERATURE REVIEW

Supriya and Reddy (2019) this research paper presented the effects of soil interaction on building frame design parameters as change of modulus of sub-grade reaction from 0.010 to 0.050 N/mm3 the

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analysis was done on parameters namely shear force, bending moment and settlements for different footing sizes of 1mx1m to 4.5mx4.5m the effect of SSI was quantified using finite element analysis. The conclusion derived from the research paper stated that the shear force and axial force value in the beam and column is constant from finite element analysis was not having considerable difference. The analysis was predicting that percentage difference in bending moment in beam, column and footings was at lower EFS value i.e 0.010N/mm3 at lower footing size 1mX1m was greater than when compared to higher EFS value i.e 0.050N/mm3 at higher footing size 4.5mX4.5m which considers soil interaction. But in case of the footings they undergo some settlement the percentage difference of settlement was 14.41% and 6.72% at lower EFS value i.e 0.010N/mm3 at lower footing size 1mx1m when compared to higher EFS value i.e 0.050N/mm3 at higher footing size 4.5mx4.5m respectively, which considers soil interaction.

Magade S. B and Prof. Patankar J. P(2018) this research paper presented different parameter such as soil structure interaction, types of soil, stiffness of infill walls, and location of walls influences time period, displacement and base shear of building frame considerably. Hence it was important to consider to all these parameters in the analysis of structures. Shear walls located in the central part of the multistoried building gives lesser displacement and more base shear compared to other locations.

Hailu Getachew Kabtamu et. al. (2018) this research paper dynamic analysis of Soil Structure Interaction (SSI) effect on multi story reinforced concrete (RC) frame founded on soft soil (flexible base) and comparison was made with fixed base. Two model 2D RC frames with 7 and 12 story are selected for analysis. Winkler Spring and half space direct method models are used for flexible base for the frames founded on two types of soft soils with shear velocity Vs < 150 m/s Asper Seismic Codes of Chinese GB50011-2010 Soil IV and Ethiopian ES8-2015 soil D. The frames are subjected to strong ground motion matched to response spectrums of soft soil of Chinese GB50011-2010 and Ethiopian ES8-2015 for linear time history analysis. The dynamic analysis result showcased Spring and Fixed base mass participation 90% reaches in 2 or 3 modes but in direct method 11 to 30 modes for story 12 and 7 respectively.

The results led to the conclusion that SSI effect may not be always beneficial in multi-story RC frame compared to fixed base. Because the beneficial effect reduction in base shear may be smaller than detrimental effect of P-delta increment on vertical load carrying members. The results obtained in this study is limited to linear time history analysis regular 2D RC frame; however it is good indicator of SSI effect.

Zhenyun Tang et. al. (2017) this research paper presented the implementation of real-time dynamic substructuring (RTDS), involving the combined use of shake table array and computational engines for the seismic simulation of SSI. In RTDS system, the bridge with soil-foundation system is divided into physical and numerical substructures, in which the bridge is seen as physical substructures and the remaining part is seen as numerical substructures. The interface response between the physical and numerical substructures was imposed by shake table and resulting reaction force is fed back to the computational engine. The unique aspect of the method was to simulate the SSI systems subjected to multi-support excitation in terms of a larger physical model. The sub-structuring strategy and the control performance associated with the real-time sub structuring testing for SSI were performed. And the influence of SSI on a long-span bridge was tested by this novel testing method.

Sunny et. al. (2017) this research paper evaluated soil - structure interaction of buildings founded on Piled-Raft Foundation through Finite Element Analyses

using ANSYS v17.0 where the computation of building settlement and equivalent stress was done. The modelling was done considering condition with and without soil.

The study concluded that the interaction of building foundation-soil field and super-structure has remarkable effect on the structure. The results showcased that total deformation (vertical) of building is more in flexible base model than in fixed base model, which means that in actual case settlement occurs and it depends on type of soil beneath. In the model where soil is considered stress distribution pattern has varied. Average stress developed in model with soil is greater than other model .This study indicates that building should be modeled along with the soil in which it is resting considering all properties of soil for the analysis and design purpose.

Nitish Kumar S and Praveen JV (2016) the primary objective behind this research paper was to understand the seismic performance of superstructure considering the complex dynamic interaction between superstructures, the raft foundation resting on the soil and comparing the dynamic responses in cooperating soil flexibility with those of fixed base assumption, soil being idealized as modified Winkler model.

Finite Element Method was used to model soil structure interaction analysis of raft foundation supported framed structures by programming in SAP 2000 V14 software. The evaluation of the effect of soil structure interaction of super structure by considering the systematic parameters like time period, lateral displacement, storey drift, bending moment in X-X and Y-Y direction. Time history analysis was carried out and the parameters like base shear and roof top displacement of the building frames resting over raft foundation and soil media was further analyzed.

The results concluded that the effect of soil-structure interaction plays a significant role to increase the time period, bending moment in X-X direction, bending moment in Y-Y direction, lateral displacement. As the flexibility of the soil increases the bending moment also increases. Analytical report further stated that the SSI will affect the behavior of the structure, the structure-foundation-soil mass shows an effective approach.

Prakash M. Yesane et. al. (2016) this research paper tabulated Parametric study on soil structure interaction behavior. The vision further concluded to accurately estimate the response of structure, the effect of soil structure interaction is needed to be considered under the influence of both static and dynamic loading. Load redistribution significantly modifies the total and differential settlements. Settlements are found more in the non-linear analysis. The finite element method has proved to be a very useful method for studying soil-structure interaction effect with rigor. In fact, the technique becomes useful to incorporate the effect of material nonlinearity, non-homogeneity and interface modeling of soil and foundation. Soil-structure interaction may cause considerable increase in seismic base shear of low-rise building frames resting on isolated footings.

Rahul Sawant and Dr. M. N. Bajad (2016) the research paper investigated interaction between the super-structure and sub-structure by deriving the soil so as to capture the overall performance of the derived system. A non linear response of a single-degree-of freedom system which represented a broad range of newly designed structures was even examined allowing for flexibility of the soil-foundation system and SSI effects. Here, the non-linear frame model was a high rise residential building of G+42 storeys located at MUMBAI and time history of ELCENTRO was used to study the response of the model in ETABS. Later, a simple soil model with pile-raft foundation was employed in

MIDAS GTX NX to this nonlinear frame models to quantify the effect of SSI on the overall response of actual structures. The use of flexible base in the analysis can lead to reduction in the structural response and damage consequences in joints and infills.

The conclusion derived from the research paper stated that If SSI was to be considered, one should examine whether some simple assumptions could be applied. Main assumptions: homogeneous half-space or a layer underlain by rigid rock as a soil model, surface base mat, rigid base mat. If direct approach was used, special attention should be paid to the boundaries. Preliminary analysis of test examples (e.g., initial soil without structure with the same boundaries and excitation) was strongly recommended. Non-linearity of different kinds was to be treated properly. Primary non-linearity of the soil was handled by SHAKE.

Aleksandra Bogdanovic et. al. (2016) this research paper considered the numerical simulation of soil structure interaction problems the issue of presence of dampers in the frame further stating problems of dynamic conditions considering the frame material.

Comparison of these problems has been done by comparing the obtained results from different set up in the software ANSYS. The results of numerical analysis illustrate that using it must be paid more attention when considering the structures with and without damper elements.

For the numerical simulation of geotechnical problems the local region of interest was modeled by finite elements which enable simulation of more complex geometries. On the other hand the surrounding filed of the domain was considered using the infinite elements which have the capability to simulate the infinite region very well. In numerical simulations ANSYS software is used where using its programmable features it was possible of programming new elements such as the infinite elements.

Renu Raghuveeran and Hashifa Hassan P (2015) this research paper attempted to present structural response in seismic analysis while considering the effect of soil structure interaction for a superstructure G+7 simple square building on seismic analysis. The analysis was done on parameters namely different soil conditions and number of stories are also considered for which the buildings are modelled by alternate approaches, namely, (1) bare frame with fixed supports, (2) bare frame with supports accounting for soil-flexibility using Ansys 14.5

While evaluating the effect of SSI on primary dynamic characteristics of bare frame of varying height resting over pile grid foundation founded on different soil types derived the conclusions stating both static and transient analyses followed the same trend for 8 storeyed structures. Both demonstrated that effects of seismic responses on structure increases with increase in soil flexibility. From modal analysis, the natural period was found to be increasing with increase in soil flexibility and with number of storeys. The percentage variation in natural period increases with soil flexibility while it was found to be decreasing with increase in number of storeys. From transient analysis it was observed that Roof displacement increases with increase in soil flexibility and number of storeys. While the percentage increase in lateral deflection decreases with increase in number of storeys.

Shreya Thusoo et. al. (2015) this paper presented the effect of Soil Structure Interaction (SSI) on multistorey 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.

Conclusion derived from the research paper stated that the spectral acceleration response pattern

changes drastically as stiffness of base soil decreases. Time period of all the responses increases while considering Soil-Structure Interaction effects. The difference in time period of the building for both conditions gets increased as the stiffness of the soil increases from soft to hard.

Ghalimath A.G et. al. (2015) this research paper dealt with seismic soil structure interaction where the seismic waves circularize through soil during an earthquake, a discontinuity in the métier of wave propagation is clashed at the interface of soil and structural foundations. A structure subjected to an earthquake excitation, it interacts with the foundation and the soil, and thus changes the motion of the ground. The change in the material properties leads to scattering, diffraction, reflection, and refraction of the seismic waves at this soil-foundation interface thereby changing the nature of ground motion at that point.

This paper has presented a proposed methodology for modelling the effects of interaction between soil and building structure. The admissible ways of modeling of soil where analysed for chosen structure. There were two approches for modelling of soil–structure interaction (i) direct approach and (ii) substructure approach. In this paper stiffnesses for both static analysis and dynamic analysis were introduced.

Shehata E. Abdel Raheem et al (2014) this research paper analyzed the effects of seismic soil-structure interaction for typical multi-story building resting on raft foundation, the influence of parameters of slab-column structure-raft foundation-soil model of a practical engineering is carried using three methods of analysis, time history (TH) analysis with a suite of nine time history records, the equivalent static load (ESL) and the response spectrum (RS) methods, which are adopted in the Egyptian code for loads and forces (ECP-201; 2008).

The results concluded that the dynamic soil-structure interaction plays a considerable role in seismic behavior of mid-rise building frames including substantial increase in the lateral deflections and inter-story drifts and changing the performance level of the structures. Thus, considering soil-structure interaction effects in the seismic design of mid-rise moment resisting building frames, particularly when resting on soft soil deposit, was essential. If the SSI method is not taken into account in analysis and design properly; the accuracy in assessing the structural safety, facing earthquakes, could not be reliable. The conventional design procedures excluding the SSI method may not be adequate to guarantee the structural safety of regular mid-rise moment resisting building frames resting on soft soil deposits.

G. Saad et. al. (2012) this paper presented 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 was modeled with a fixed condition at ground level was adopted, and then the number of basements was incrementally increased to investigate changes in performance. The Beirut local site conditions was used for the analysis. The base shear, inter-story shears and moments was evaluated in order to quantify the effects of soil structure interaction on the design process.

V. Jaya et. al. (2009) In this research paper a seismic SSI analysis of the ventilation stack located in the nuclear power plant site was performed using the SASSI 2000 program, which was capable of handling 3D soil structure interaction problems involving embedded foundations of arbitrary shape. The analyses was performed using the flexible volume substructure method in frequency domain. The parametric study of the SSI model of the stack was carried out using SASSI for different ground conditions with and without foundation embedment for input ground motion having a PHA 0.078 g. The

site-specific modulus reduction and damping ratio curves developed for the actual soil conditions was used in the SSI analyses.

The results concluded that the amplitude of spectral acceleration at the top of the stack decreases considerably (25%) by the foundation embedment in the dense sand layer. The fundamental frequency of SSI system slightly increased due to presence of surrounding soil. The radiation damping derived from the deep embedment plays an important role in bringing down the structural responses. This can be used to advantage during the design process, because a larger embedment ratio results in a more stable structure.

Peizhen Li et al (2004) this research paper carried out three-dimensional finite element analysis in time domain on dynamic soil-structure interaction of a practical engineering using general-purpose finite element program ANSYS.

In order to analyze the effect of the liquefaction of sand on the seismic response of the SSI system, the effective stress method of considering the soil as equivalent linear material in every time interval was introduced here. Such procedure was realized in ANSYS program by using the ANSYS

Parametric Design Language (APDL). The earthquake response of sand-pile-high-rise building was analyzed, and the analysis results presented the liquefaction of sand has large effect on the seismic response of structure in sand-pile-structure interaction system.

The results concluded that the effect of SSI on displacement peak value of structure becomes larger along with the decrease of shear modulus of soil and the liquefaction of sand has large effect on the seismic response of structure in sand-pile-structure interaction system.

III. CONCLUSION

The researchers have tried to find out the modifications observed in structural stability due to seismic load and soil properties.

following are the outcomes of literature review:

- Frame with lateral load resisting members resist lateral forces and provide stability.
- Structure stability also depends on soil type.
- High rise Structure need to resist lateral forces for its stability and safety.

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Cite this article as :

Ankur