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**Review Article**

# Brief Study on Soil Structure Interaction

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**Abstract:** Soil Structure interaction (SSI) is an important field in seismic design and earthquake engineering. We are aware every structure response to SSI. Here in this paper various data and experimental data have been reviewed. The study has been done for foundation different soil like sand and clay. In order to have some information on SSI we should understand some basic concept of seismic wave propagation through the ground and their dynamic characteristics. The evaluation of a safe value of bearing capacity of the soil is the most critical step in the foundation design work. Incidental study on soil structure interaction action by many researches is classified. This study is in the expanding phase, likely complication enormous description of the model for the soil and structures, and should be carried ahead for its connotation.

**Keywords:** Soil Structure Interaction, Finite Element Analysis, Isolated Footing

## 1. Introduction

SSI is a phenomenon is the response of soil caused by the presence of structures. During earthquake soil conditions have a deal to with damages to structures. During an earthquake, a motion at the foundation of a structure is the most important state of seismic design. Generally SSI problem is subdivided into two parts: kinematics SSI and inertial SSI [1].

SSI mainly depends on the relative stiffness of the soil and structure, dynamic behavior of structure can have a high impact on SSI.

Since last 40 years, various techniques have been suggested for the solution of wave equations in unbounded domains. This paper briefly explains the literature present with particular focus on the dynamic soil-structure interaction. In general, there are two approaches in which it can categorize i.e.: global and local procedures.

Characteristics of the strong ground motion can define the scale of socio-economic damages. Earthquake ground motions results mainly from the three factors that are, source characteristics, the propagation path of waves, and local site conditions. The problem of SSI has become a vital feature in Earthquake Engineering, with the advancement of huge constructions on various soils such as nuclear power plants, embankment, waste landfill and earth dams. Some structures such as underground tunnel, bridges and Gravity dams may require specific attention to be given to the problems of SSI.

The basic SSI model is that in which structure has a rigid foundation. These models have an additional six degree of freedom in which there are three translations and three rotations. These models in practical found to be too simple. It's hard to find models with flexible foundations. Strong motions are recorded in structure denotes the damaged shaking is often accompanied by non-linear response of the foundation's soil. A number of times subject of SSI have been reviewed and various aspects have been studied.

Due to the response of structure the soil properties, the structure of soil and its nature of excitation get affected. Implementing SSI effect will help the designer to assess the displacement and inertial forces of the soil foundation under the influence of free field motion. . In addition, soil-bedrock models should be created as 2D or 3D using various geophysical methods for SSI (pamuk et al. 2017a; pamuk et al. 2017b) [2].

## 2. Seismic Soil-Structure Interaction

Earlier in 1983 research scholar has used a hypothetical model to determine the kinematic interaction of embedded foundations by the random vibration theory. Statically correlations of ground motion at different point show the decrease as the distance between the point increases when the ground motion contains the component of high frequency.

For the hypothetical model, earthquake records at a large scale are taken into account for example deep and shallow foundations. Foundation slab is stiffer as compared to the soil. The ground motions are observed to be a constraint and it results in the weakening of the dimension of the slab. Hence the slab will behave like a low pass filter on the ground motion due to the effect of kinematic interaction. This method has made use of a linear solution set about taking no interaction which can be used for the static and dynamic-elastic analyzer.

The method has employed a linear solution approach requiring no iteration which can be used for static and dynamic - elastic analyzer. The structures have been presumed to have one lateral and one torsional degree of freedom in their fixed base condition and have been activated by the obliquely incident, horizontally polarized, incoherent shear waves.

# 3. History of Soil Structure Interaction

Review of various works has been done which leads to the evolution of the concept of SSI. In late of 1931, professor Suyehiro visited places and delivers lectures on Seismology. Where he discussed the response of the structure and observed the damage on various types of building. He stated -very probably the primary cause is the yielding of the ground bed due to oscillation of the foundation. He concluded the cushioning action of ground at the time of an earthquake result the destructive action of a building. Professor has made some remarkable observations confirmed many times by earthquake damage patterns seen since 1932. There for rapid components of seismic vibrations do not affect the deep foundations below the surface.

The broad most of structural design is achieved below the acceptance that the structural aspects are fixed at the foundation level opposite to adaptation, settlement, and in some cases, rotation. Structures delighted by earthquake ground shaking establish inertial forces that propose base shears and bending moments at the structure foundation interface. If supporting soil and foundation system are not rigid, these internal forces encourage displacements and rotations at the structural base.

### *3.1. Inertial Interaction*

Inertial interaction refers to displacements and rotations at the foundation level of structure that result from inertia-driven forces such as base shear and moment. Inertial displacements and rotations can be a significant source of flexibility and energy dissipation in the soil structure system. System behavior and highlights some of the principal effects of inertial interaction and the conditions for which its effects are significant. The methods focus on single degree-of-freedom systems, but they can be extrapolated to multi-degree-of-freedom systems with a dominant first mode. Relatively detailed description of how foundation springs and dashpots can be specified to represent the flexibility and damping associated with soil-foundation interaction in translational and rotational vibration modes for shallow foundations (e.g., footings and mats).

### *3.2. Kinematic Interaction*

Kinematic interaction results from the presence of stiff foundation elements on or in soil, which causes motions at the foundation to deviate from free-field motions. One cause of the deviations is base-slab averaging, in which spatially variable ground motions within the building envelope are averaged within the foundation footprint due to the stiffness and strength of the foundation system. Another cause of the deviation is embedment effects, in which foundation-level motions are reduced as a result of ground motion reduction with depth below the free surface. If the foundation is pile-supported, the piles interact with wave propagation below the base slab, which can further modify foundation-level motions at the base of a structure.

The phenomena of base-slab averaging, embedment effects, kinematic pile response, and presents available models for analysis of these effects. Models for kinematic interaction effects are expressed as frequency dependent ratios of the Fourier amplitudes (i.e., transfer functions) of foundation input motion (FIM) to the free-field motion. The FIM is the theoretical motion of the base slab if the near-surface foundation elements (i.e., base slabs, basement walls) and the structure had no mass, and is used for seismic response analysis in the substructure approach.

# 4. Method of Soil Structure Interaction

### *4.1. Direct Approach*

Soil and structure are sculptural collectively in a single step reporting for both inertial and kinematic interaction in this approach. Inertial interaction raised in structure owed to own vibrations giving get up to base shear and base moment that in change gets a displacement of the foundation proportional to the free field. In kinematic interaction creates due to the front of stiff foundation parts in soil changing foundation motion to deviate from free-field motions.

### *4.2. Substructures Approach*

In this method the numerical analysis divide into many steps which is the principal of superposition is practice to isolate the two primary gets of soil structure interaction that is unfitness of foundation to fix the free field deformation on the movement of supporting soil in effect of the dynamic response of structure foundation system [2].

### *4.3. Analytical Method*

This method is dividing into three headings:-

a) Winkler Approach
b) Elastic Continuum Approach
c) Finite Element Method

#### *4.3.1. Winkler Approach*

Recently, structural engineers are mostly used foundation model for SSI analysis. It is the earliest and easiest method to form the sub grade that consists of a finite number of springs on a rigid base. This method is simple to the instrument in a structural system. Beam parts on leading of the sub grade are connected to a spring at all nodes, in a 2D structure. The springs are apart changing the structure in step direction. All spring is fixed to two nodes, but since the lower nodes are joint, indicated nodes can be removed from the equations, that's mean no nodes outside the superstructure's geometry are added to the system of equations. The spring stiffness can be considered to be uniformly distributed, in a simple model. By SGI (1993), presented a normal approximation for calculation of settlements is to consider a 2:1 stress distribution in the soil. Discrete springs for stiffness is evaluated by dividing the vertical load moving one spring q*s by the settlement $^{\delta}$, where, s is the springs spacing. With uniform spring stiffness, constant Emodulus $E_s$ through the depth in the soil and assuming 2:1 stress distribution, the stiffness of discrete spring.

#### *4.3.2. Elastic Continuum Approach*

Continuum is defined as the continuously distributed method through the space. Hook's law, the easiest elastic continuum is defined with the fundamental relation with linear isotropic behavior. Without failure criteria the elastic medium has infinite tension and compression capacity, which can be examined for soil.

ABAQUS is used for the elastic continuum approach. No experiment to exemplary in FEMD design is built, since solid parts do not continue in the software. This approach is recognized as the "correct" solution. How well they correlate to this solution compared to other SSI methods. The sub grade is presented with solid plane strain parts with the linear and isotropic material. Between the interaction of the superstructure and the sub grade is presented without friction in the tangential direction and alone correlation capacity in the vertical direction [3].

#### *4.3.3. Finite Element Approach*

This method an able to capable accepted gauge method generally used in structural engineering, detached a continuum into a sequence of aspects with maximum sizes to calculate for the mechanics of the continuum. FEM can resemble the mechanics of soil and structures improved than another method, contact with difficult geometry and applied loaded, and find non-linear development. Finite Element Method is used commonly in the study of SSI and has created some important creations in the study of SSSI. In assuming the radiation damping of semi-infinite space, the parameter of the soil should be broad sufficient. This condition claims a genuine expenditure of time and the internal memory of a computer to have full finite element method. In mostly of destructive earthquakes, soil and structures shows as big deformations that get into the non-linear stage. Over seismological calculation of a reinforced concrete structure established on pile in Los Angeles, Sivanovic examined the non-linear property of soil to be one of the extremely serious factors affecting the seismic response of a structure [4].

## 5. Result and Conclusion

The review of the current practice as applied in soil structure interaction analysis leads to the following broad conclusions.

1. To accurately estimate the response of the structure, the effect of soil structure interaction is needed to be considered under the influence of both static and dynamic loading.
2. The forces in superstructure, foundation and soil mass are significantly altered due to the effect of soil structure interaction. For accurate estimation of the design force quantities, the interaction effect is needed to be considered.
3. Load redistribution significantly modifies the total and differential settlements. Settlements are found more in the non-linear analysis.
4. Numerous investigators analyzed the interaction behavior considering foundations as raft foundation, isolated footing, grid foundation and pile foundation etc.
5. The investigators have considered the soil mass as homogenous, isotropic and behaving in the linear and nonlinear manner in the interaction analysis.
6. A limited number of studies have been conducted considering the soil mass as elasto-plastic, visco-elastic and visco plastic in interaction analyses.
7. 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 non linearity, no homogeneity and interface modeling of soil and foundation.
8. To perform nonlinear soil-structure interaction analysis, the incremental iterative technique is found to be the most suitable and general one.
9. For practical purpose Winkler hypothesis should at least be employed instead of carrying out an analysis with fixed the base idealization of structures.
10. The soil-structure interaction may cause consider an able increase in seismic base shear of low-rise building frames resting on isolated footings.
11. Soil-bedrock models should be used as 2D or 3D for SSI.

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