MODELS USED FOR SEISMIC SSI PROBLEMS: A REVIEW

Mohammad SAFI
Assistant Professor, Shahid Beheshti University, Tehran, Iran
m_safi@sbu.ac.ir

Nima MOHAMMADI
M.Sc. Student, Shahid Beheshti University, Tehran, Iran
nim.mohammadi@mail.sbu.ac.ir

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Soil structure interaction, one of the most major subjects in the domain of earthquake engineering, has been paid comprehensive attention internationally in recent decades. Soil-structure interaction phenomena concern the wave propagation in a coupled system: buildings erected on the soil surface. Its origins trace back to the late 19th century, evolved and matured gradually in the ensuing decades and during the first half of the 20th century, and progressed rapidly in the second half stimulated mainly by the needs of the nuclear power and offshore industries, by the debut of powerful computers and simulation tools such as finite elements, and by the needs for improvements in seismic safety. Analytical methods to calculate the dynamic soil–structure interaction effects are well established. When there is more than one structure in the medium, because of interference of the structural responses through the soil, the soil-structure problem evolves to a cross-interaction problem between multiple structures. Ishihara (1996) demonstrated that dilatational (compressional) waves induce almost a pure isotropic stress state in saturated soils with deviator stress components being practically negligible structure–soil–structure interaction (SSI), put forward in recent decades, means the dynamic interaction problem among the multi-structure system through soil-ground. It is (Luco & Westmann, 1971) to come up first with the structure–soil–structure interaction designation for this area of study. Its additional name is dynamic cross interaction (DCI), derived from several publications about nuclear power plant (NPP). Besides, owing to those previous studies were just confined to consider foundations placed on soil without superstructures, SSSI was also call foundation–soil–foundation interaction (FSFI). SSI studies the influence of the presence of adjacent structures to the others further through the interaction effect of the sub-soil under dynamic disturbances. Due to the difficulty in measuring model parameters and expertise required in running nonlinear dynamic analyses (Pecker, 2008). The dynamic disturbances can be either externally applied loads or seismic waves. SSI is an interdisciplinary field of endeavour, which lies at the intersection of soil and structural mechanics, soil and structural dynamics, earthquake engineering, geophysics and geomechanics, material science, computational and numerical methods, and diverse other technical disciplines. With the successful outcome about SSI, various kinds of theory methods and experimental installations are used to promote the study of SSI. This paper presents a review of soil-structure interaction studies; it provides an insight on the historical background, concepts, past and present studies and future research direction. The concept of structure–soil–structure dynamic interaction was introduced, and the research models are discussed. Based on several documents, a systematic summary of the history and status of the structure–soil–structure dynamic interaction research that considers adjacent structures is proposed as a reference for researchers. This study is in the initial stage, given its complexity and excessive simplification of the models for soil and structures, and should be carried forward for its significance. This study is made to summarize the common major models in this area of study. Furthermore, the advantages, disadvantages, and applicability of such programs are discussed.

In the laboratory, it is possible to perform an undrained cyclic simple shear test to reproduce the seismic response of saturated soil subjected to one-dimensional shear waves, as sketched in Figure 1-a. The area enclosed by the loop represents the energy dissipated during a cycle, which can be quantified mathematically by a damping ratio defined as:

$$\xi_g = \frac{\Delta E}{4\pi E} \quad (1)$$

Figure 1-c shows a reduction of the secant shear modulus with increasing the cyclic shear strain amplitude. This relationship can be described by a ‘backbone curve’ joining the tips of hysteresis loops achieved under various strain amplitudes. Even under constant shear strain amplitude, the hysteresis loop grows flatter with increasing the number of cycles n, as illustrated in Figure 1-d, especially at large strain levels. For saturated soils, increasing number of cycles is usually accompanied by a degradation of strength and stiffness, thereby leading to a degraded backbone curve.

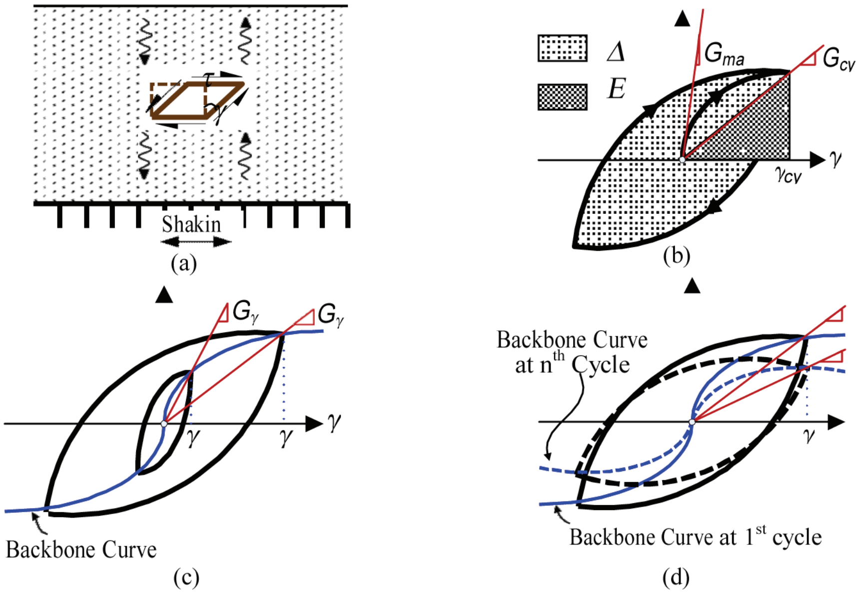

Figure 1. Cyclic response of (a) a soil element at a site subjected to shear waves, characterised by (b) a hysteresis loop which is affected by (c) cyclic strain amplitude and (d) number of cycles.

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