Impact Induced Responses of Saturated and Dry Dense Sand

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ABSTRACT

The present article includes an experimental study of the behavior of dry and saturated dense sandy soil under the action of a single impulsive load. Dry and saturated dense sand models were tested under impact loads. Different falling masses from different heights were conducted using the falling weight deflectometer (FWD) to provide the single pulse energy. The responses of dense soils were evaluated at surface of soil under impact load. These responses include; displacements, velocities, and accelerations that are developed due to the impact acting at top and the displacement at different depths within the soil using the falling weight deflectometer (FWD) and accelerometers (ARH-500A waterproof, and low capacity acceleration transducer) that are embedded in the soil in addition to soil pressure gauges and then recorded using the multi-recorder TMR-200. Based on the experimental test results, it was found that as the sand becomes saturated, the amplitude of the force-time history decreases by about 10-22% since the voids are filled with water which lead to less contact points between particles. Moreover, the resulting vertical displacement due to impact increases by about 20-60% as compared to the case of dry sand at a depth B (where B is the diameter of the bearing plate) from the bearing plate. Such a behavior is related to two compressive waves through the saturated medium; the fluid wave and the soil skeleton wave with a coupled motion of those two waves hence, makes the displacement to be larger in the saturated soil. The horizontal displacement within the soil medium at a distance B away from the edge of the footing are less than the displacements in dry state. The excess pore water pressure increases by about 40% as the amplitude of the impact force increases due to the increase of the contact pressure.

KEYWORDS
Dense Sand, Displacement, Dry, Impact, Response, Saturated

INTRODUCTION

The soil condition and its property can be quite significant in the consideration of problems deal with dynamic load in soil-structure interaction. It is very important to understand the behavior of soil under dynamic load, how the waves propagate inside the soil media and the wave attenuation mechanism inside the soil.
Soils consist of an assemblage of particles having different shapes and sizes which form a skeleton whose voids are usually filled with water and/or air. Hence, soil in general, must be considered as a one phase (dry soil), two-phase (fully saturated soil) or multi-phase (partially saturated soil) material whose state can be described by the stresses and displacements taking place in each phase (Popescu et al., 2006).

Soil is a porous medium with voids often filled with a fluid, e.g. water. The behavior of such a two-phase material is important for many engineering problems. Especially considering dynamic loading, fully saturated soil can show a different behavior compared to dry soil or drained conditions with no development of excess pore pressure. This behavior can be important for the process of pile driving, analysis of liquefaction phenomena as well as earthquake loading (Grabe et al., 2014).

Pore water pressure properties under dynamic loading play significant role on variation of soil deformation and strength. It is the key for dynamic effective stress analysis method (Tang et al., 2014).

Al-Homoud and Al-Maaitah, (1996) found that there is an increase in natural frequency and a reduction in amplitude with the increase in degree of saturation of sandy soil subjected to vertical forced vibration loading. Al-Ameri (2014) and Fattah et al. (2016) concluded from the experimental physical model that the excess pore water pressure increases with increasing the relative density of the sand, the amplitude of dynamic loading and the operating frequency. In contrast, the rate of dissipation of the excess pore water pressure during dynamic loading is more in the case of loose sand. The excess pore water pressure ratio is always reduced with depth and the maximum values near the surface of the soil. They found from their experimental results that the maximum values of displacement amplitude for saturated dense sand models are almost more than those for dry dense sand models for surface and embedded footing.

The main objectives of this research are to predict dry and saturated sand behavior under impact loads. Emphasis will be made on attenuation of waves induced by impact loads through the soil. Conducting an experimental investigation on sandy soils was established to survey how to study the behavior of these soils under the effect of impact loads with different applied kinetic energy taking into account several factors: the embedment and diameter of the foundation, and the energy of the impact load.

**Experimental Work**

A small-scale model is implemented to simulate a physical model of machine foundation resting on a dry or saturated soil medium under impact load. The total number of tests was 16 models. The dynamic system is the soil medium through which waves propagate outward from sources of impact load. The input signal of the system is the impulse response of the ground at the place of installation of a machine foundation; the output signal is the dynamic response of a location of interest situated on a foundation receiving impulse or within the soil stratum. The tests were performed on dense soils under impact load with different energy forces. Two footing sizes were adopted located at the soil surface.

**DESCRIPTION OF THE SOIL MODEL**

Figure 1 shows the setup that was used to carry out tests, it consists of a steel box with walls made of plates 2 mm thick and a base as a soil container, and the falling weight deflectometer (FWD) to apply impact loads on the soil model with a base bearing plate of two sizes which is dealt with as a shallow foundation on the soil under impact load. The steel box consists of two parts with dimensions; length of 1200 mm, width of 1200 mm and height of 800 mm. Each part has a height of 400 mm and strengthened from the outside with loops of 40 mm right angle 2 mm thick spaced at 1330 mm in the tangential direction.

The “ raining technique and tamping” was used to settle the soil in the testing tank at a give uniform soil relative. The device consists of a steel hopper, with dimensions of 1200 mm in length, 300 mm in width and 450 mm in height. The steel hopper is ended with an inclined funnel mounted
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