Chapter 18

Mechanism of Onset of Liquefaction

The Badshahi Masjid in Lahore of Pakistan, which was constructed by Shah Jahan, the fifth Mughal Emperor.
18.1 Mechanism of Liquefaction

Studies on causative mechanisms of liquefaction were initiated by shaking water-saturated model ground (Maslov, 1957; Florin and Ivanov, 1961; Yoshimi 1967). Although much was found by them, more quantitative study became possible after introducing laboratory shear tests.

Figure 18.1 indicates the volume contraction of loose Toyoura sand undergoing cyclic drained shear. This volume change induced by shear is called negative dilatancy (Sect. 1.6). If sand is saturated, pore water is drained out of sand upon this cyclic volume contraction.

In real earthquake loading, drained cyclic shear and immediate volume contraction are unlikely. When a sand deposit is of several meters in thickness, the time required for drainage is 10–30 min (see Sect. 17.3), which is much longer than the duration time of earthquake loading (10–20 s, approximately). It is thus reasonable to consider real sandy ground to be undrained during earthquake shaking. When there is a thin clayey impervious layer, furthermore, it prevents seepage and drainage from underlying deposits toward the surface.

When shear occurs under undrained conditions, pore water cannot be drained out, and develops pressure. This pressure is called the excess pore water pressure and is defined as the pore water pressure minus the hydrostatic pressure that existed before earthquake;

\[
\text{Excess pore water pressure} = \text{Pore water pressure} - \text{Hydrostatic pressure}, \quad (18.1)
\]

which is identical with (1.4). The contact force between sand grains is called the effective stress and controls the rigidity and shear strength of soil (Sects. 1.3 and 1.5). The effective stress is calculated by

\[
\text{Effective stress} = \text{Total stress} - \text{Pore water pressure} \quad (18.2)
\]

Since the total stress is equal to the weight of soil above the concerned elevation, it does not change with time (Fig. 18.2). Accordingly, the effective stress decreases when pore water pressure increases.