$$c_v \frac{\partial^2 u}{\partial z^2} = \frac{\partial u}{\partial t} + \frac{\partial u_o}{\partial t} - \frac{\partial \sigma}{\partial t} \tag{3.1a}$$

$$c_v = \frac{k(1 + e_o)}{\rho_w a_v} \tag{3.1b}$$

where u is the excess pore water pressure, u_o is the hydrostatic pressure, σ is the total stress applied to the system, k is the hydraulic conductivity, e_o is the initial void ratio, ρ_w is the mass density of the fluid (water), and a_v is the compressibility of the soil skeleton. Solving Eq. 3.1 for u and applying the continuity equation for conventional theory

$$\frac{\partial}{\partial z}\left(\frac{k}{\rho_w}\frac{\partial u}{\partial z}\right) = \frac{\partial n}{\partial t} \tag{3.2}$$

soil porosity n is determined. Knowing the porosity as a function of time and the initial thickness of the soil layer, the time history of ground level subsidence can be calculated. Except for very idealized cases, this problem must be solved numerically. Shiffman et al. (1985) also describe a nonlinear finite strain theory, which removes several assumptions of conventional theory but requires difficult numerical solution. Fig. 3.1 displays comparison of the two theories to centrifuge experiments, with the finite strain theory providing good results.

3.2 MEASURING COMPACTION

As noted in section 2, a simple yet effective device for measuring compaction rates has been developed in Japan and has been widely used there for at least the past 30 years, see Murayama (1970). This device, shown in Fig. 3.2 (see also Fig. 2.7), consists of two concentric pipes that penetrate to a desired non-compactable stratum. The outer pipe is perforated to allow the groundwater table to move freely up and down in the casing. A float-type gage monitors the water level. A strip chart and pen displacement gage, mounted on a foundation that "rides" the ground surface, records the subsidence as the pipes appear to protrude from the ground. Several of these gages located in the same area, but penetrating to different strata, provide information about the vertical distribution of compaction. A single gage which penetrates to bed-rock will record the total subsidence.