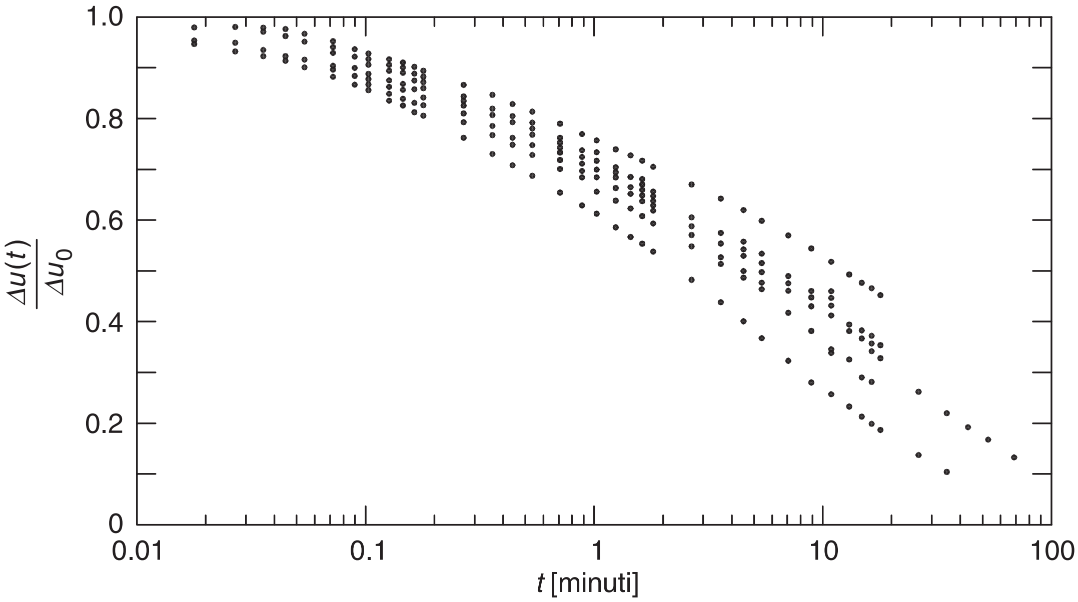

Figure 7.55 Examples of dissipation tests in Porto Tolle clay (Battaglio *et al.,* 1986).

of water between the permeameter and the soil. In this way, the boundary conditions (Figure 7.53) already seen for piezometers are realized, and all that has been stated concerning the piezometers also applies for the interpretation of this test.

(b) The **self-boring pressuremeter** offers the possibility of measuring the consolidation coefficient c_h by performing either a *strain holding test* (Clarke *et al.,* 1979) or a *pressure holding test* (Fahey and Carter, 1986). The basic aspects of these tests can be summarized as follows. If a pressuremeter cell is expanded in clay in undrained conditions, excess pore pressures are induced in the surrounding soil. If the diameter of the cell is held constant, the decrease of the excess pore pressure and the total radial stress can be measured, and this is called a *holding test*. Another possibility is to hold the total radial stress constant (pressure holding test), and the decrease of excess pore pressure and the increase in cavity diameter can be measured. The expansion of the pressuremeter is usually modelled as a cylindrical cavity expansion in a Tresca soil, and by assuming that the soil behaves elastically during the subsequent consolidation process, a closed form solution has been derived by Randolph and Wroth (1979). Futher aspects of this tests are discussed by Fioravante *et al.* (1994) and Yu (2004).

7.14.4 Piezocone dissipation tests

In recent years a lot of attention has been given to dissipation tests in clays, performed with the piezocone. The test consists of stopping the penetration of the cone and monitoring the decay of excess pore pressure with time (Figure 7.55). A simplified approach for the interpretation of dissipation records was first proposed by Torstensson (1975). The soil was assumed to be an elastic-perfectly plastic material subjected to isotropic initial stress. The initial excess pore pressure was estimated using the the cavity expansion theory (Vesic, 1972), and the consolidation process was studied using the linear uncoupled one dimensional theory.

At present, the most comprehensive investigation of this problem has been carried out by Baligh and Levadoux (1980), based on the strain-path method (Baligh, 1985), and the relevant conclusions of this work are the following.

(a) The effect of coupling between the total stresses and the pore pressure is small, except at the early stage of consolidation, so that the *uncoupled solution* provides a reasonably accurate prediction of the dissipation process.
(b) A two-dimensional analysis around the cone shows that the dissipation rate is mainly controlled by c_h and that even a tenfold change of c_v has a negligible influence on the shape of isochrones. Hence the test yields c_h values.
(c) The cone penetration process produces undrained shearing of the soil with excess pore pressure. When these excess pore pressures start to dissipate, the soil surrounding the cone is subjected to an increase of effective stresses under reloading conditions, and only after some dissipation has been taken place do the effective stresses equal those existing before the cone penetration. Therefore, the c_h obtained from early stage of consolidation (less than 50% of consolidation) is relevant for reloading conditions.

Based on this conclusion, Baligh and Levadoux (1980) suggest to compute the consolidation coefficient from:

$$c_h = \frac{TR^2}{t}, \tag{7.92}$$

where R is the radius of the pushing rod and T is the time factor, depending on the cone geometry and the location of the filter stone (Figure 7.56). The values of c_h for a dissipation of 50% of the excess pore pressure are representative of horizontal flow in the OC range. In order to obtain the consolidation coefficient in the NC range the following rule is suggested:

$$c_h(NC) = c_h(OC)\frac{C_r}{C_c}. \tag{7.93}$$

Besides all the above examined theoretical aspects, the successful interpretation of dissipation records is controlled by the requirements of a rigid and well de-aired pore pressure measuring system.

7.15 Summary

Field investigation is aimed at assessing enough information to select the most appropriate foundation solution, to highlight problems that could arise during construction, and, more in general, to highlight potential geological hazards in the examined area.

The importance of field investigation should always be firmly in mind to authorities charged to make official decisions, by considering that most failures have been caused by lack of field investigation or undetected essential features, as well as that an unsatisfactory site investigation is a matter of litigation.

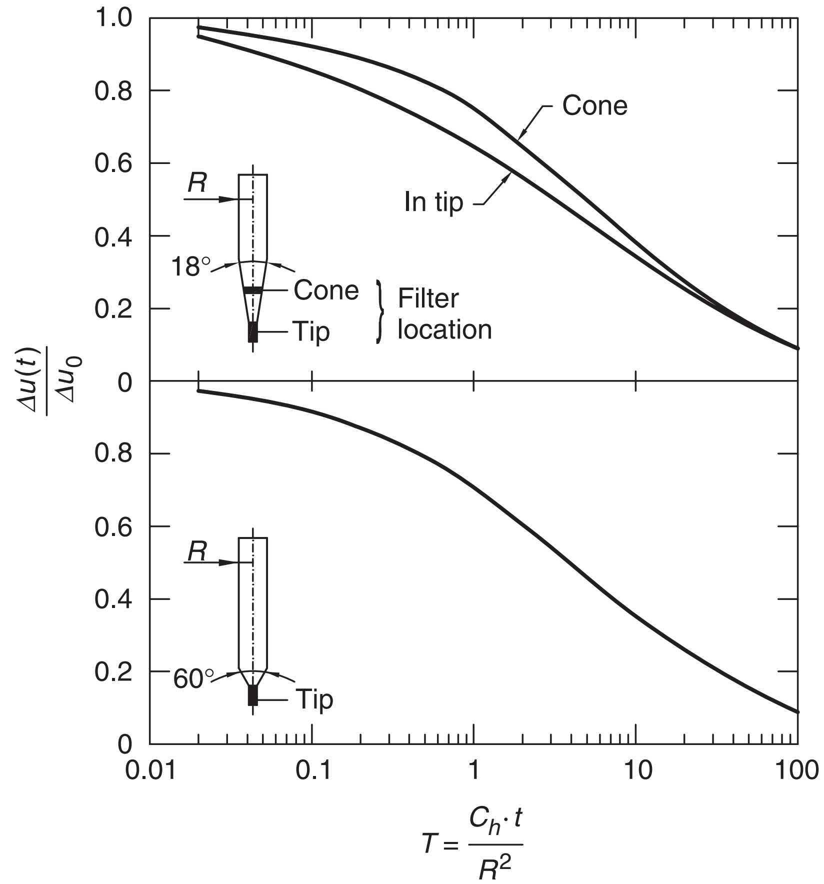

Figure 7.56 Pore pressure decay versus time factor, as predicted by Baligh and Levadoux (1980).

The best result is obtained if the programme is developed in stages and it is adapted during the investigation, when preliminary data start to be available.

A starting point is represented by desk studies, i.e. the collecting of all information sources such as geological maps and relative sections, airphotographs and reports on previously done investigations.

Preliminary investigations are aimed at confirming or reviewing the findings of desk studies, through trial pits, some preliminary borings, exploratory geophysical seismic tests and investigations aimed at defining groundwater conditions. The final step consists of a detailed investigation, including borings, sampling, *in situ* and laboratory tests.

Any carefully done investigation programme should be aimed at answering questions linked to the environment of sedimentation, synsedimentary and post-sedimentation events, including tectonic events, uplift, erosion and weathering. This outlines the multidisciplinary nature of the approach, requiring cooperation between geologists and geotechnical engineers, and there is no need to emphasize that answering the above-mentioned questions is the most fascinating aspect of field investigation.

In recent years, the capability of the existing techniques has been increased due to the introduction of new devices and to the development of more appropriate theoretical approaches.

Examples of new testing methods are related to techniques introduced in the area of environmental geotechnics, mainly aimed at identifying contamination of polluted sites.