

Chapter 11

Pore Water Pressure



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The pressure of the pore water in a porous material is a measure of the state of the water. The pore water pressure P_w is related to the RH in the pores with the Kelvin equation

$$P_w = p_{sat} + \frac{RT\rho}{M} \ln\varphi \quad (11.1)$$

where p_{sat} is the vapour pressure at saturation, R is the gas constant, T is the absolute temperature, ρ is the density of water, M_w is the molar weight of water and φ is the relative humidity. For RH <100% the pore water is negative.

The pore water pressure is related to the capillary rise h (m) or capillary suction with the gravity g and density ρ

$$P_w = \rho \cdot g \cdot h \quad (11.2)$$

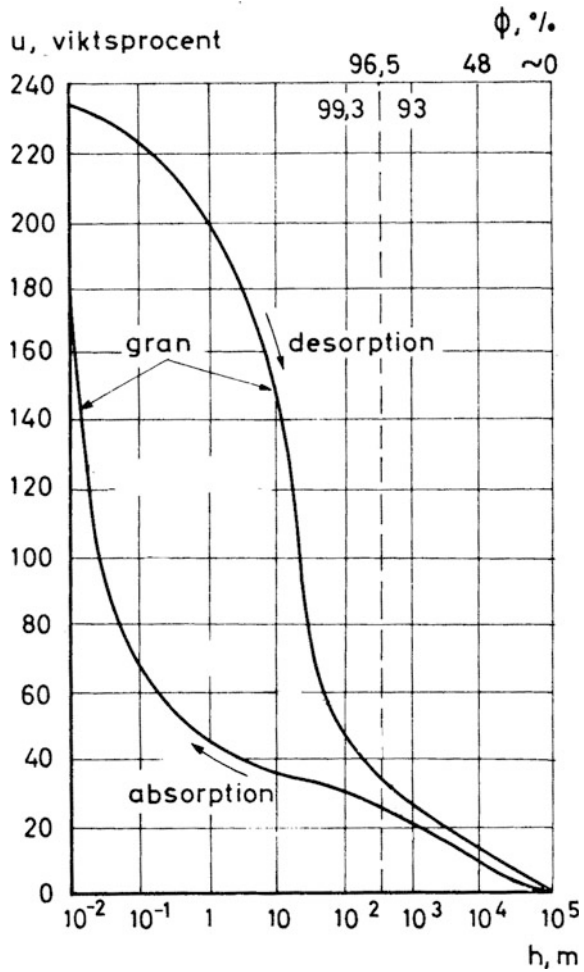
The pore water pressure is related to the moisture content via a “suction curve” where the moisture content is given as functions of the pore water pressure or the capillary rise, similar to a sorption isotherm where RH is the independent variable. An example is given in Fig. 11.1. Note the scale on the horizontal axis with a capillary rise from 1 cm to 10 km.

For RH close to 100% RH the RH is difficult to measure with good accuracy. One possibility is then to measure the pore water pressure directly, with a pressure transducer.

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Fig. 11.1 A suction curve for spruce, Penner et al. (1965), with the moisture content as a function of the capillary rise



An ISO standard (ISO 11276:1995) describes methods for the determination of pore water pressure in unsaturated and saturated soil using a tensiometer. The methods are applicable for in situ measurements in the field and soil cores.

For saturated soils traditional manometers of various types are used to measure the (positive) water pressure. Both for unsaturated soils and unsaturated building materials the pore water pressures are negative, however. That makes the pressure measurement somewhat more complicated. Traditional pressure transducers can still be used but the water next to the transducer must be de-aerated, Radocea (1992), which can be achieved by boiling the water.

Radocea (1992) used a simple pressure transducer connected to a small needle, cf. Figs. 11.2 and 11.3, to measure pore water pressures in fresh concrete.

An example of Radocea's results is shown in Fig. 11.4.

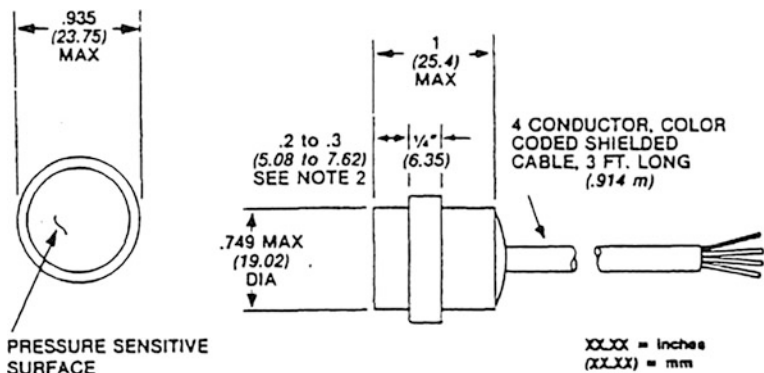


Fig. 11.2 A pressure transducer used by Radocea (1992) to determine pore water pressure in young concrete

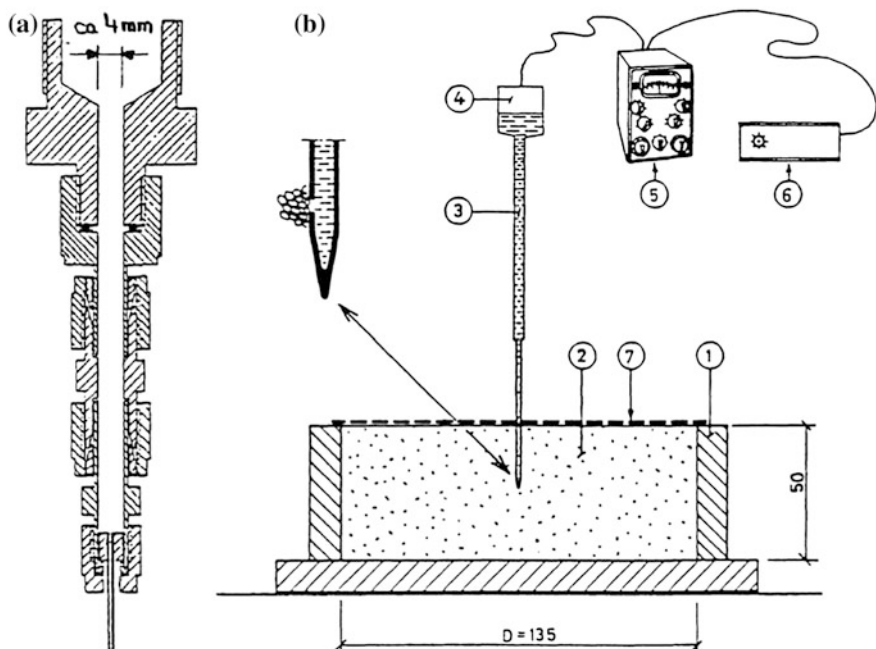
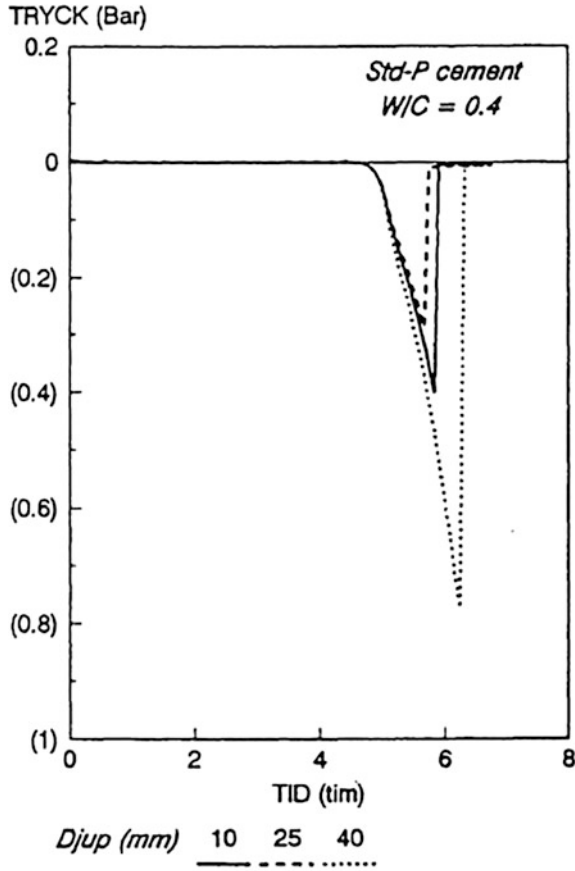


Fig. 11.3 A needle (a & b) used by Radocea (1992) to determine pore water pressure in young concrete

Pore water pressures down to close to -1 bar could be determined. In many cases, however, the water inside the needle collapsed at higher pressures than that due to entrapped air voids expanding.

Fagerlund (1973) presented a modified suction plate apparatus for determining the pore water pressure of a sample, cf. Fig. 11.5.



a.
Fig. 7.67 VAW = 0.5575

Fig. 11.4 Pore water pressures (“Tryck”) measured at three depths (“Djup”) in a fresh cement paste with a water-cement ratio of 0.45–6.5 h after mixing, Radocea (1992)

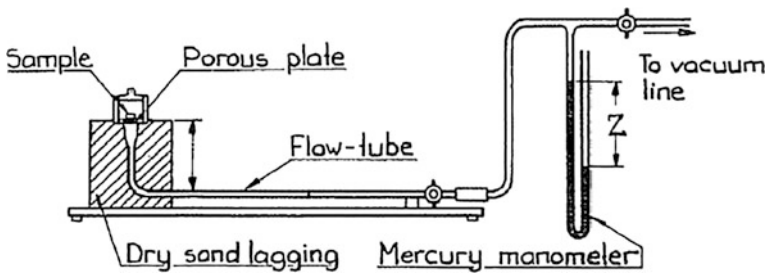


Fig. 11.5 A modified suction plate apparatus for determining the pore water pressure of a sample, Fagerlund (1973) after Cronley et al. (1952)

The sample is placed on the porous plate and covered with a protection against evaporation. The sample will suck water from the flow-tube. Decreasing the pressure with a vacuum pump prevents this. The pressure is adjusted so the meniscus in the flow-tube is kept fixed in position. The pore water pressure is read from a manometer or pressure transducer. Fagerlund (1973) claimed the technique is applicable for pressures down to -10^5 Pa.

The limitations are of course the possibilities to achieve good contact between the sample and the porous plate.