CHAPTER VI

MEASUREMENT OF CONSOLIDATION CHARACTERISTICS

6.1. Factors Affecting Measurements

The degree of exposition of any physical process depends on the degree of exactitude of the experimental set up. Terzaghi (1919) devised a drainage cell called Oedometer to confirm the basic assumptions of his theory of consolidation. The essential test arrangement in universal use as at present in a form known generally as the Casagrande Oedometer is adopted from this original device. However, various research workers have contributed towards its improvement in an attempt to understand fully the consolidation phenomenon. The major factors that influence the measurement of consolidation characteristics are sample disturbance, side friction and inadequacies of the measuring systems.

6.1.1. Sample Disturbance

The first basic expectation while testing the theory against the experiment is the ideal sample. It may not be physically possible to create an ideal soil sample in a laboratory but utmost care is demanded in the preparation of sample as bad preparation is a source of inconsistent results. Van Zelst (1948) reported that thinner samples are more prone to disturbance. Pressure-void ratio curves tend to be relatively lower as a result of disturbance. Experience of a number of research workers has shown that it is advisable to prepare samples in a laboratory by gradual deposition of soil particles under controlled conditions. However, disturbance in the sample can also occur while pushing, extracting and adjusting the oedometer ring in the set up. All these precautions assume vital importance particularly when the results are to be analysed to evaluate the influence of the factors against theoretical predictions. In the present investigations samples are obtained from a soil bed under controlled conditions.

6.1.2. Side Friction

One of the striking experimental factor that affects the results is the side friction. The presence of side friction disturbs the one-dimensional state of strain and prevents some of the axial force from reaching the bottom portions of the specimen. Taylor (1942) was the first to report the effect of side friction according to which pressure-void ratio curve was seen to fall off the true one in the direction of the larger pressures. The value of coefficient of consolidation was, however, not observed to be much affected. In order to minimise the effect of these side friction forces it is suggested to keep the thickness-diameter ratio of the specimen as small as possible, because smaller the laterial surface area in contact lesser the value of side friction. From the results of various investigators - Newland and Alley (1960) Leonard and Girault (1961), Raymond and Davis (1965) and Rosooe et al (1969) - it has been concluded that the smearing, the walls with a thin film of silicon grease, side friction can be reduced to small magnitudes even for higher thickness-diameter ratio. Roscoe (1969) reported that the magnitude of the wall friction increases significantly during the period of secondary compression. During the present investigation a comparative study of the side wall surface using consolidation rings with and without grease, coated with fine and medium sand, shows that the influence of friction is significant only at lower pressures.

6.1.3. System Inadequacies

The inadequacies in the test arrangement also affect the measurement to a certain extent. The common practice for the application of axial stress is to apply dead loads by lever arrangement which is transmitted to the soil element through a rigid metal platen. The loading by lever arrangement may not be always centrally acting. The system is prone to induce errors in applied stress due to such factors and non-uniform stress distribution below a rigid platen. The settlement reading by dial gauges are susceptible to errors due to bedding, apparatus strain, vibrations and eccentric mounting. The measurement of pore pressures during consolidation either by conventional Bishop type Null indicator or modern electronic transducers show time lag due to flexibility in the measuring system. In all electrical appliances, the general zero deficiencies also influence the measured quantities.

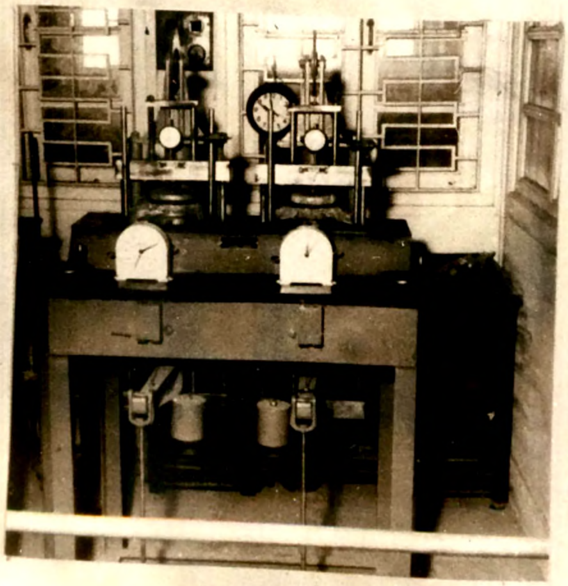
6.2. Description of Present Experimental Set Up

Experimental investigations of the present work are conducted using the conventional Casagrande type and the hydraulically pressurized Rowe type set ups. Necessary precautions against sample disturbance, side friction and time lag are taken.

6.2.1. Conventional Casagrande Type Experimental Set Up

6.2.1.1. Description : Conventional set up provides a simple and fairly accurate arrangement for volume change measurement in terms of settlement for the case of one dimensional consolidation. In this set up, a brass sampling ring of 3 inch (7.62 cms) diameter and 1 inch (2.54 cm.) height having a polished inside surface is sandwitched between two ceramic porous stones. The load is applied by placing dead weights in a counter balancing lever system (lever ratio, 1:10.5) which is transmitted to the soil element contained in the ring.

COMPONENTS



ASSEMBLY

FIG.6.1.: DETAILS OF CONVENTIONAL EXPERIMENTAL SET UP

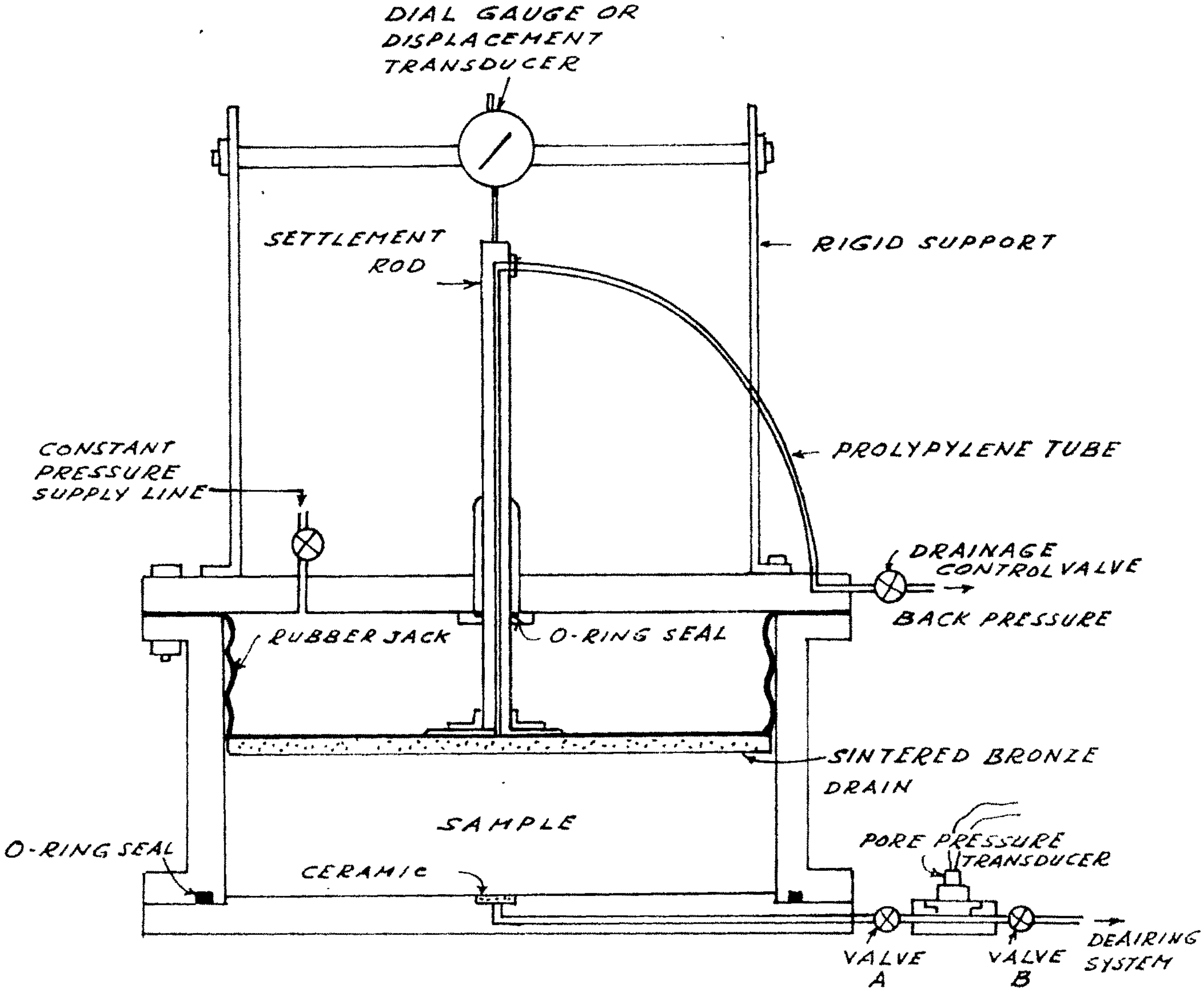


FIG. 6·2 DETAILS OF ROWE OEDOMETER

through a light weight pressufe pad dispersed through a spherical ball. The settlement is measured by a centrally mounted dial gauge.Fig. 6.1 is a photograph showing various components and the assembly of the set up employed in the present investigation.

6.2.1.2. Precautions

(i) A thin uniform layer of Silicon grease (Dow Corning) is smeared on the shining inner surface to minimise the side friction (Newland and Alley (1960); Leonard and Girault (1965); Raymond and Davis (1965); Roscoe (1969).

(ii) The consolidation pot is covered with a polythelene jacket to prevent loss of moisture (Gilboy, 1951).

(iii) The lever arm is maintained at the centre at every commencement of loading to ensure axial loading.

(iv) Ceramic porous stones are maintained clean and air free through intense boiling in water.

6.2.2. Hydraulically Pressurised Rowe Type Experimental Set Up

This experimental set up is particularly better suited for the measurement of pore water pressure; besides it eliminates the deficiencies arising out of shock prone dead load system.

6.2.2.1. Description

(a) Basic Set Up : Figs. 6.2, 6.3 and show a diagramatic sketch of the basic apparatus, photographs of various components and photographs of the assembly. The main components of basic apparatus are (i) a base plate (ii) a middle ring (iii) a top cover plate and (iv) a rubber jack. The base plate is made from rolled Bronze screwed to a bottom with three mild steel supporting legs. A ceramic 7/8" in diameter and 1/8" thick is fixed flush at the centre which has a connection to sa stainless steel block housing and electric pressure transducer. The middle ring used in this investigation is also made from rolled bronze 1/2" thick and 6" in diameter resting on 'O' ring provided in the base plate. Top cover is from 1" aluminium plate which facilitates easy handling. For the measurement of settlement a free acting brass spindle of 3/8" dia is provided at the centre of the plate reaching the top of the soil sample through a rubber jack. To eliminate any error of settlement reading due to compression of the rubber diaphram these circular washers are secured to the either sides of the diaphragm A small 'O' ring surrounding the spindle grips it tightly enough to prevent appreciable leakage but not so tight as to affect the settlement reading due to friction. The top of the spindle is connected to a drainage valve by means of polypropylene tube. Klinger valve connections are provided on the top plate for supplying distilled deaired water and applying the hydraulic pressure. A convulated rubber jack made from .07" thick white rubber (M/S Franklin Ltd., England) is used to transmit the hydraulic pressure to the sample. For the drainage of water during consolidation a porous stone housed in a thin aluminium plate is inserted between the jack and the sample. The base and the cover are bolted to the flanges on the cell body at eight

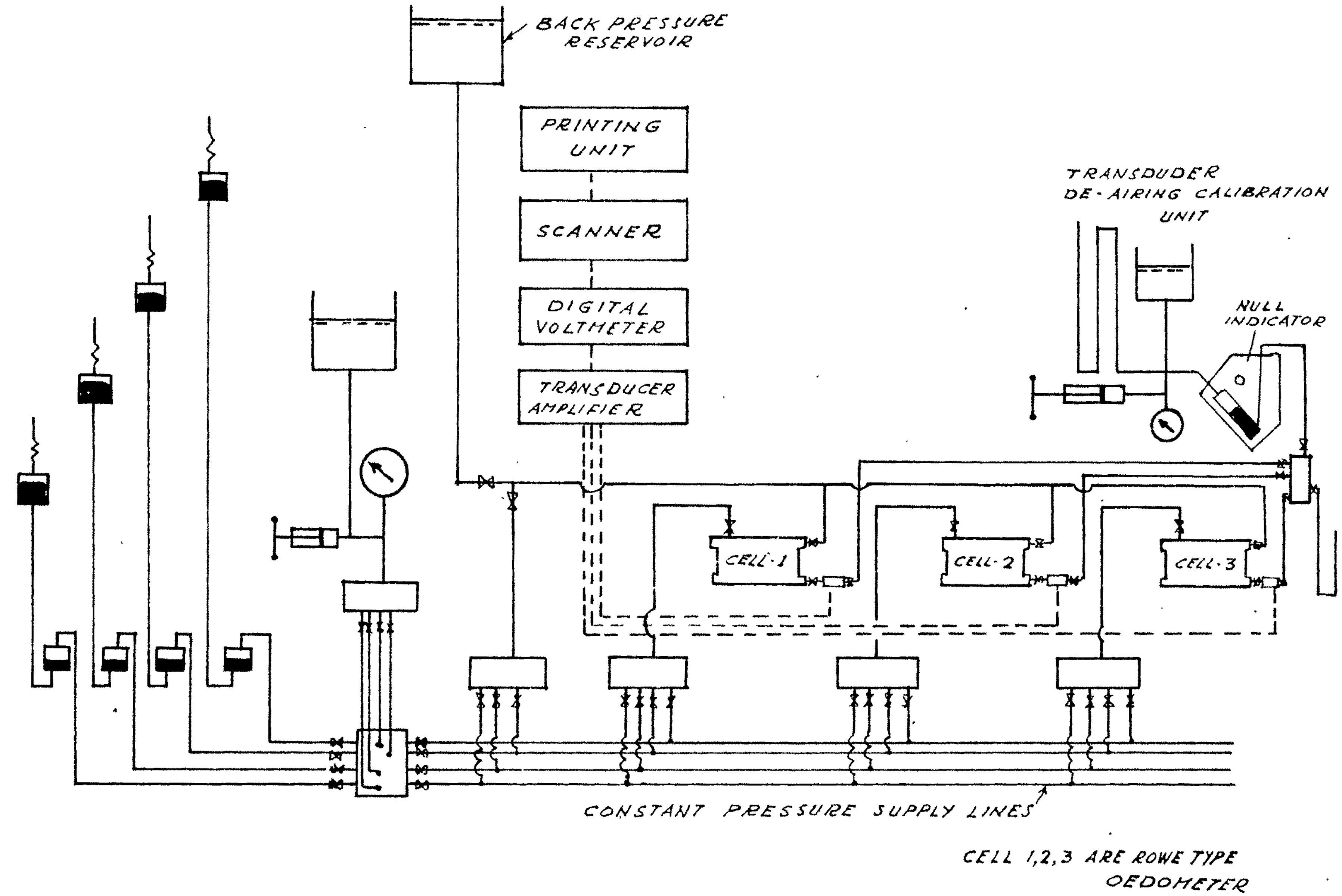


FIG.6·4 HYDRAULIC PRESSURE SYSTEM & EXPERIMENTAL SETUP positions which press the 'O' ring provided at the base and the rubber loading jack provided at the cover.

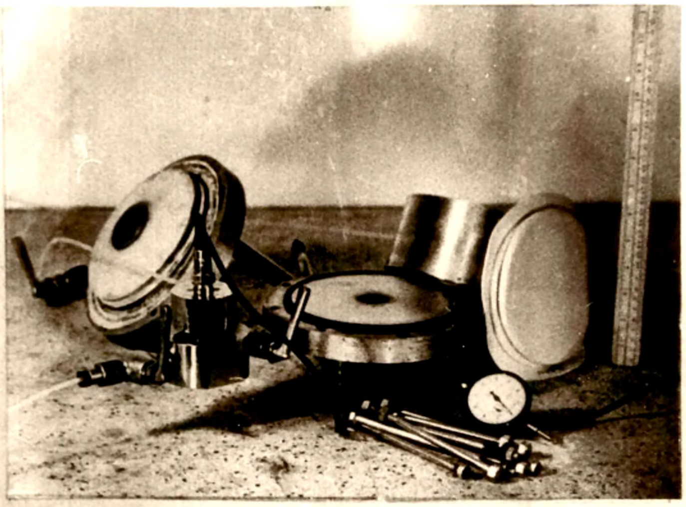
(b) Loading System :

In Figures 6.4 and 6.5 are shown respectively a diagramatic sketch and a photographic view of the hydraulic pressure system used in this investigation. The system is based on Bishop and Henkel (1957) compensated mercury pot system. A series of mercury pots are placed at predetermined elevations to supply constant pressures of 00.1, 0.2, 0.4, 0.8, 2,4, and 4 kg/cm^2 (Ton/ft.^{2}) A sliding pot similar to Bishop and Henkel (1957) is also included in the system for adjusting to smaller pressures. The system covers a range from 0 to 10 kg/cm (0 to 150 psi) and can supply hydraulic pressures of any value in this range accurate to 0.1 kg/cm^2 by suitable combinations. The pressure lines are carried round the laboratory walls by Polypropylene tubings and a series of brass junction blocks. The pressures in these lines are maintained by a screw pump and water system.

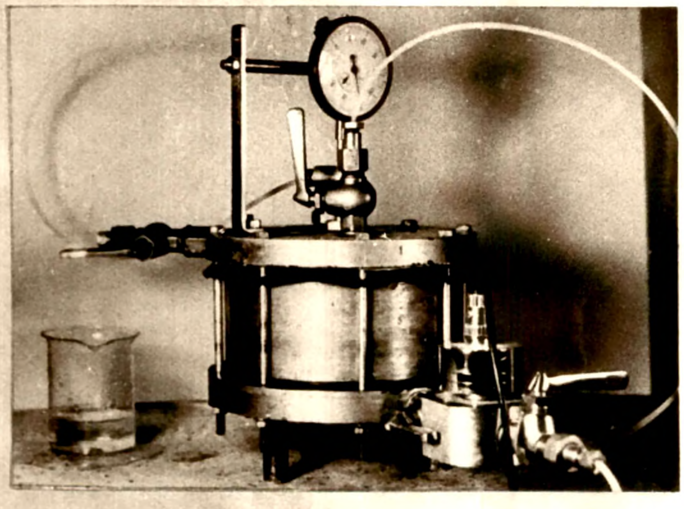
(c) Associated Equipments :

Figures 6.6 and 6.7 give the photographs of various equipments employed for conducting the consolidation tests.

A system consisting of deformation dial gauge, pressure transducers, transducer amplifier, digital voltmeter, electrica scanner and printer unit is employed for the measurement of settlements and pore water pressures. Detailed specifications



COMPONENTS



ASSEMBLY

FIG. 6.3 : DETAILS OF ROWE OEDOMETER

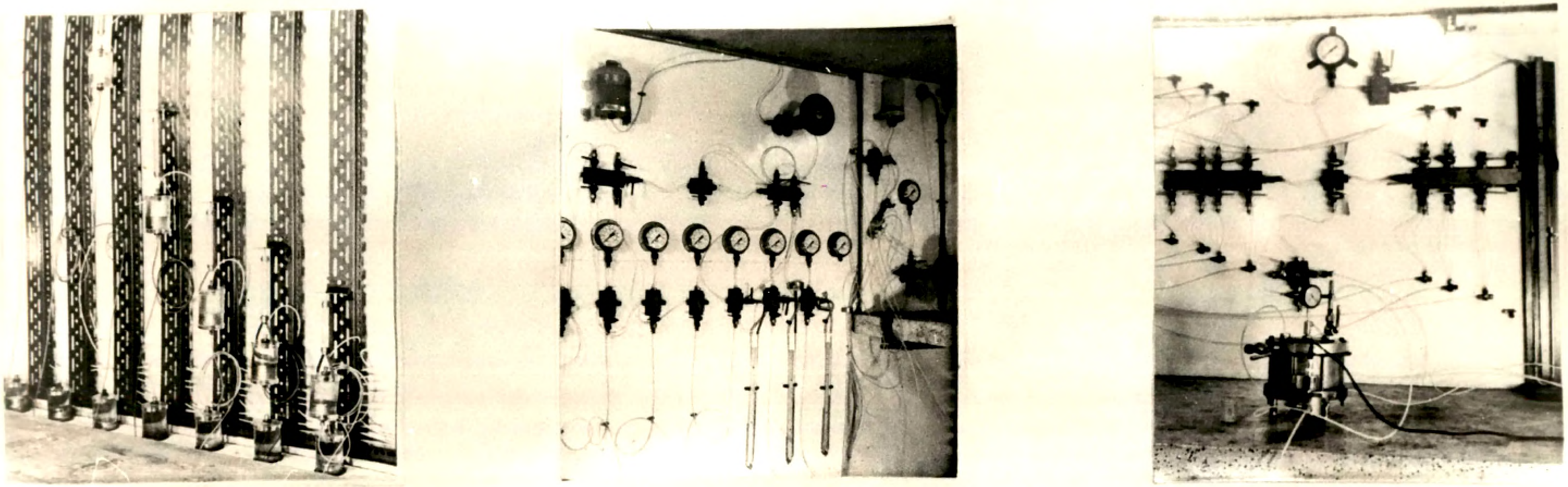
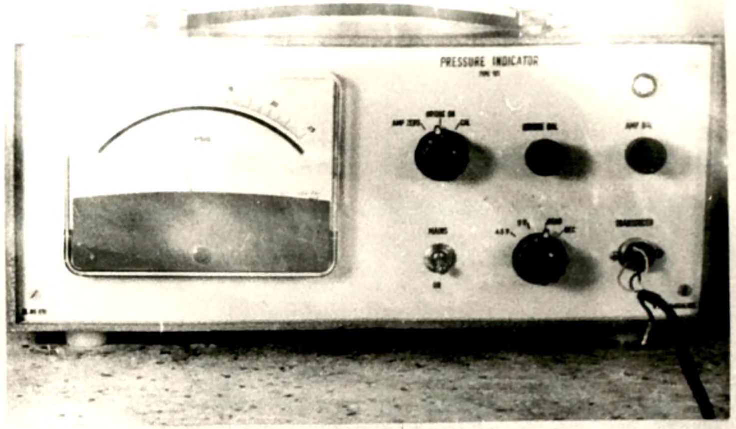
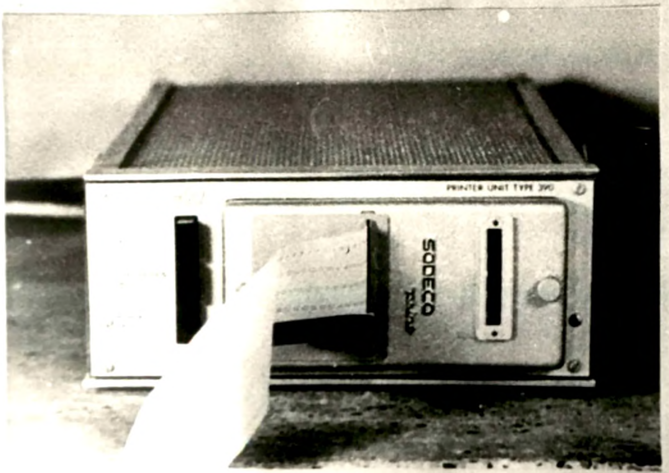


FIG. 6.5.: HYDRAULIC PRESSURE SYSTEM

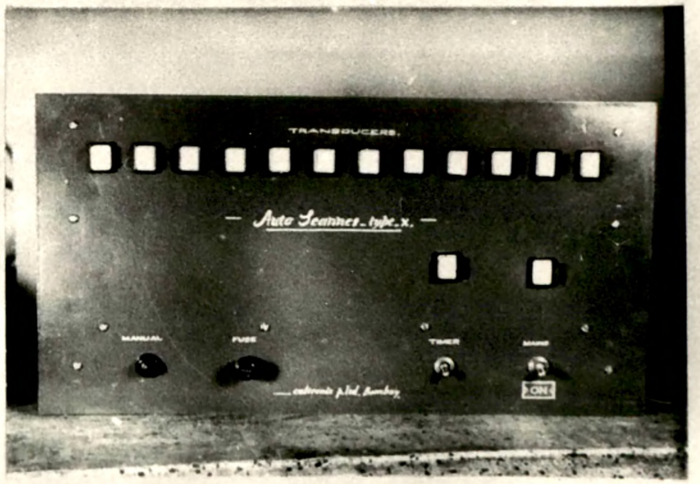
DIGITAL VOLTMETER



TRANSDUCER AMPLIFIER



PRINTER



SCANNER

FIG. 6.6. : ASSOCIATED ELECTRONIC INSTRUMENTS

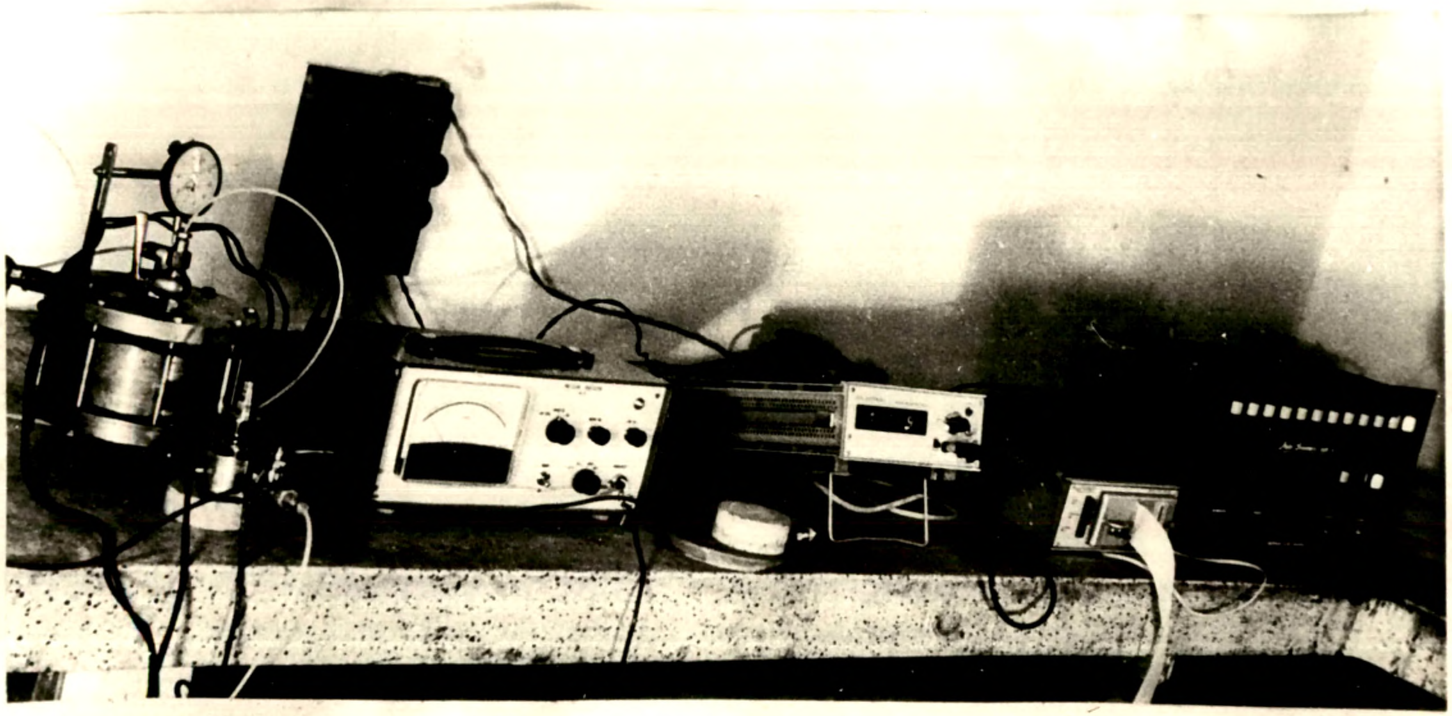


FIG. 6.7 : EXPERIMENTAL SET UP FOR CONSOLIDATION STUDIES ON CLAYS

of each of the equipments will be found in Volume II, Appendix D.

6.2.2.2. Precautions :

(i) The entire system is maintained air free by means of standard Bishop type null indicator appratus and observing utmost care against infiltration of aif through any operation.

(ii) Smearing of thin uniform layer of silicon grease on polished inside surface and using higher diameter height ratio (Appeoximately 6) help minimise the side friction.

(iii) To reduce the effect of system flexibility to a minimum the transducer is directly placed near the base valve connection coming from the control ceramic plate.

(iv) The experimental investigations are conducted in a constant temperature room ($20^{o}C \pm 1^{o}C$) which minimises the inconsistency in the readings.

6.3. Sample Preparation

The method for sample preparation as advocated in the publications of Rowe and Bardem (1966), Rowe and Shield (1966) is followed. A uniform slurry mixed at double the liquid limit is poured in the pot which is agitated by vacuum pump for an hour to deair the slurry. An aluminium platé with saturated porous stone is placed over the slurry in the oedometer consolidated to 0.05 kg/cm^2 with the help of dead loads. After the initial sqeezing out of the water the dead load is removed and the sample is scribed down to desired constant thickness.

The plate with the rubber jack is then tightened against the middle ring and the clay sample is consolidated to 0.1 kg/cm^2 with the drainage valve open. Compression of the sample is noted to get the exact initial thickness of the sample. Samples for the conventional Casagrande test are prepared separately in a similar manner in a 10" dia oedometer. Sampling rings of conventional oedometer are inserted in the soil cake thus prepared, maintaining vertical alignment and guarding against sample disturbance.

Soil samples for studying the influence of oriented drainage path are obtained by inserting the rings in horizontal, vertical and inclined directions. Method adopted for preparing the samples of Dispersed and Flocculent configuration is that of Lambe (1954). A chemical suspension is prepared by adding sodium tetra phosphate powder in proportion of one percentage by weight of soil in 100 cc of distilled water. This solution is used for creating a dispersed structure in the soil sample. Flocculent structure is developed by using sodium poly acrylate produced from acrylate powder with monomer solution in 1:10 proportion. Samples at different degrees of saturation are selected from various stages of moisture content from a standard proctor test.