2.1. MEASURING EQUIPMENT AND MATERIALS

Measuring equipment and materials employed for testing are as follows:

Load application:

(1) Screw jack
(2) Load cell
(3) Load indicator
(4) Hydraulic jack
Settlement measurement:

(5) Dial gauge

Pressure measurement:

(6) Pressure cells
(7) Pressure indicator
(8) Switching and Balancing unit

Material used specially for fixing pressure cells in the models:

(9) Dentoplast or Stone plaster

Brief description and specification for each of the above are as follows:

2.2 BRIEF DESCRIPTION AND SPECIFICATION

(1) Screw Jack

Description:

The screw jack is inserted between the loading frame and the load cell in "close" condition, the load cell being placed over the model resting on sand bed. The screw can be opened by rotating it through arms. Opening of the screw creates force on load cell on one end and is balanced by reaction loading of loading frame on the other hand. The model thus receives reaction loading.

The screw jack should have factor of safety of 2.5 or more. For smooth application of load, the diaphragm of diameter 100 mm to 150 mm shall be used. For smaller capacity, the pitch of the screw shall be small. It may be increased for other cases. It should be perfectly aligned and should transfer the load in a direction perpendicular to its cross-section.
**Specification:**

Capacity : 40 kN

Diaphragm : 100 mm diameter

Pitch of the screw : 1 mm

(2) Load cell

**Description:**

It is an electronic instrument used to measure the applied load accurately. It is inserted between the diaphragm of the screw jack and the model, and is connected to the load indicator. The screw of the jack is rotated very slowly through diaphragm and the load indicator is constantly watched to apply the required load. Calibration of load cell against standard loading system is necessary to comply with zero drift.

The load cell employs foil type strain gauges bonded to the load column. The transducer consists of single piece body machined from special steel, heat-treated for maximum stability. High inherent linearity with low creep and high ultimate safety factors. It uses a full bridge strain gauge configuration.

Capacity : 40 kN

Rated output : 1 mV/v +/- 0.5%

Non-linearity : 0.1% FSD

Resistance : 120/350 ohms +/- 1%

Temperature : 0° to 80° C

Overload : Allowable 150%

Breaking 300%
(3) Load Indicator

Description:

Load cell is connected to the load indicator. The indicator facilitates to read the load up to required accuracy, which depends on its resolution power. Load indicator accepts directly strain gauge based force transducer. It can be made to display force or any other force derived parameter in engineering units, through panel mounted screwdriver calibration adjust control. Standard features include automatic polarity indication, zero check, and zero suppression facility.

Specification:

<table>
<thead>
<tr>
<th>Display</th>
<th>3-1/2 digit LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. reading</td>
<td>+/- 1999 counts</td>
</tr>
<tr>
<td>Load cell excitation</td>
<td>5 to 10 volts, DC adjustable</td>
</tr>
<tr>
<td>Controls</td>
<td>zero spans through 10-turn potentiometer</td>
</tr>
<tr>
<td>Calibration</td>
<td>Display through push button adjusts through 10 turn Potentiometer</td>
</tr>
<tr>
<td>Resolution</td>
<td>1:100 e.g. For 100 kg range, resolution of 1 kg can be adjusted</td>
</tr>
<tr>
<td>Capacity</td>
<td>10 tonne</td>
</tr>
<tr>
<td>Linearity</td>
<td>+/- 0.05% FSD</td>
</tr>
<tr>
<td>Temperature range</td>
<td>10° to 60°C</td>
</tr>
</tbody>
</table>
Operation:

Adjust zero reading with ‘ZERO’ pot at zero position available on front panel. Apply desired load (say 1t) and observe the reading. Adjust the reading to 100, 1000, etc. as per resolution required by rotating the span pot. Push the micro switch to check the calibration counts.

(4) Hydraulic jack

Description:

Hydraulic jack applies load through oil pressure. The jack opens as the pressure is applied through a thin pipe by proper leverage. It applies the load similar to the screw jack. As the load is applied through oil pressure, it is recommended not to apply the load with inclination of more than $15^\circ$.

A heavy pressure exists in the pipe. The pipe must be very strong to resist the high pressure. Also, there should not be any leakage which can reduce the pressure and hence the efficiency.

Specification:

Capacity - 10 t and 50 t

Efficiency - 90% and 85%

Maximum inclination - $15^\circ$.

Calibration of these jacks against standard system is necessary in each experiment.

(5) Dial gauges: (Batty make)

Description:

Standard dial gauges are used to measure settlement and tilting. Thus they are used as extensometer and compressometer. To measure settlement the dial
gauge is initially compressed. Its rod extends with the settlement. Thus it acts as an extensometer. While using the dial gauges for tilt measure, one side gauge should open (extensometer) while the other will close (compressometer).

**Specification:**

L.C. 0.001 cm.

**Precaution**

Movement of the rod shall be extremely smooth and it should be cleaned with cotton after every use and with acetylene after 10 uses.

(6) **Pressure cell**

Primary requirement of a cell for measuring pressure in granular material is to produce a system that gives linear calibration characteristic so that any departure from linearity should be associated with stress distribution within sand mass. Integrated diaphragm type stainless steel pressure cells are used for the measurement of vertical stress in sand mass as well as contact pressure at the bottom face of the footing. The pressure cells have circular disc type body machined from special stainless steel, treated for maximum stability. Pressure transducers employ foil type strain gauges bonded to the pressure sensitive diaphragm on one side of the cell. The gauges are fixed with strain gauge glue on the sensitive area of the diaphragm, which is equal to 45% of the total area.

**Specification:**

<table>
<thead>
<tr>
<th>(a) Pressure cell size</th>
<th>Diameter, mm</th>
<th>thickness, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
(b) Strain gauge

Gauge resistance: 120/350 ohms ± 1%

Gauge factor: 2.0

Size: 3 mm X 1.5 mm

(c) Cable colour codes

<table>
<thead>
<tr>
<th>Colour</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Excitation +</td>
</tr>
<tr>
<td>Green</td>
<td>Excitation +</td>
</tr>
<tr>
<td>Yellow/White</td>
<td>Input +</td>
</tr>
<tr>
<td>Black</td>
<td>Input</td>
</tr>
</tbody>
</table>

(d) Capacity

- 0 - 1 kg/cm²
- 0 - 5 kg/cm²

Pressure cells are frequently calibrated against standard mercury manometer calibration system.

(7) Digital pressure indicator

Description:

It is used to read the pressure values. It is designed to provide direct display of pressure when used in conjunction with strain gauge based pressure transducer. It incorporates circuits for transducer excitation, amplification, and analogue to
digital conversion. Its digital display can be made to display pressure directly in desired engineering units.

**Specification:**

- **Display**: 3-1/2 digit LED
- **Max. Counts**: +/- 1999
- **Excitation**: 5 to 10 volts DC adjustable.
- **Controls**: zero span through 10 turn potentiometer
- **Resolution**: 1:1000

**Operation**:

- Adjust zero by rotating central screw.
- Apply known pressure and adjust desirable counts.
- Check the calibration by pushing micro switch.

**Switching and Balancing unit**

**Description**:

Switching and balancing (S/B) unit is used as an intermediate device inserted between pressure cells and pressure indicators to facilitate the reading of desired cell. Two types of S/B units are used viz. seven channels and 20 channel. The pressure cells are numbered and connected to the S/B unit. The S/B unit facilitates in channelling the reading of a particular cell. Also, it minimises the zero drift of the pressure cells. With the use of S/B unit chronological order of readings can be maintained.

The S/B unit is connected to the pressure indicator. Thus with the use of S/B unit, the pressure indicator can be used to get readings of all the connected cells.
Specification:

<table>
<thead>
<tr>
<th>Channels</th>
<th>20 channel, 7 Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour codes</td>
<td>Function</td>
</tr>
<tr>
<td>Red</td>
<td>Excitation +</td>
</tr>
<tr>
<td>Green</td>
<td>Excitation +</td>
</tr>
<tr>
<td>Yellow/White</td>
<td>Input +</td>
</tr>
<tr>
<td>Black</td>
<td>Input -</td>
</tr>
</tbody>
</table>

Extension:

'Next' button of the S/B unit facilitates to join another S/B unit in the series. This may be done when the number of cells is more.

9 Dentoplast

To fix up the pressure cells at the bottom face of the footing for the measurement of the contact pressure, a new system is developed against the conventional system of punching the body of the footing and fixing the cell within the footing. Base of the footing is thickened by placing Dentoplast in which the pressure cells can be fixed. Dentoplast is nothing but 'stone plaster', which a dentist uses it to fill up the gap in the teeth. The difference is that the dentist uses a few milligrams of dentoplast where as we have used it in terms of kilograms.

Properties:

Dentoplast is a gypsum (Cas$_4$, 2 H$_2$O) based product. Gypsum is ground and heated to 110-120° C to drive of water of crystallisation. The result is the product calcium sulphate hemihydrate (Cas$_4$)$_2$, H$_2$O called stone plaster.
CaSO₄, 2H₂O  110° to 120° C  (CaSO₄)₂, H₂O
Gypsum  Stone plaster
(Calcium sulphate dihydrate)  (Calcium sulphate hemihydrate)

Adhesion between the particles of hemihydrate is a factor in determining the amount of water required. Small amounts of some surface-active materials such as gum arebic plus lime added to hemihydrate can reduce markedly the water requirements of stone plaster.

Setting reaction:

Reaction (1) can be reversed as follows:

(CaSO₄)₂, 2H₂O + 3H₂O → 2CaSO₄, 2H₂O + Heat

1. When the hemihydrate is mixed with water, a suspension is formed that is fluid and workable.

2. The hemihydrate dissolves until it forms a saturated solution.

3. This saturated solution of the hemihydrate is supersaturated with respect to the dehydrate so the latter precipitates out.

The reaction rate can be followed by the exothermic heat evolved.

W/P ratio

The ratio of the water to the hemihydrated powder is expressed as water/powder ratio. The W/P ratio is very important factor in determining the physical and chemical properties of the final product. The higher the W/P ratios the longer will be the setting time and the weaker will be the gypsum product.
Setting time

Reaction requires a definite time for completion. The setting time generally measured by the Vicat needle. The time that elapses from the start of the mix until the needle no longer penetrates to the bottom of the plaster is known as the setting time.

Setting time is affected by following factors.

1. FINESS: The finer the particle size of the hemihydrate, the faster the mix will harden.

2. W/P RATIO: The more water used for mixing, the fewer nuclei there will be per unit volume. Consequently, the setting time will be prolonged.

3. MIXING: Within practical limits, the longer and the more rapidly the plaster is mixed, the shorter will be the setting time.

Strength

The strength of a plaster or stone increases rapidly as the material hardens after the initial setting time. For this reasons two strengths of the gypsum products are recognised, the wet strength and the dry strength. The dry strength may be two or more times the wet strength.

With increase of period of drying the compressive strength of the set stone plaster is increase but after 24 hours increase is very less. Greater the W/P ratio, the less is the dry strength of the set material, but the tensile strength is less affected by variations in the W/P ratio than the compressive strength. However, the materials mixed at a high W/P ratio have tensile strength as high as 25 percent of the corresponding compressive strength. When mixed at low W/P ratios the tensile strength less than 10% of the corresponding compressive strength.

With an increase in mixing time the strength will be increased to a limit that is approximately equivalent to that of a normal hand mixing for one minute.