CHAPTER 11

PREFABRICATED COIR GEOTEXTILE

VERTICAL DRAINS

11.1 INTRODUCTION

Construction of unpaved roads in rural areas in many of the cases are accomplished by forming embankments along the banks of the paddy fields or swampy areas and hence the construction of roads and embankments are so closely interconnected that one may not be able to visualise the two constructions independently. One of the major difficulties in these constructions is the presence of saturated soft clay and only very poor soil will be available for construction and hence some sort of ground improvement techniques should be resorted to facilitate speedy and uniform stabilisation of the soft soil.

Of the various methods of ground improvement techniques available, pre-loading is the most successful one. The main disadvantage of this method is that, the time required for consolidation is very long and also the surcharge load required is significantly high. In many cases to pace with the speed of construction activities pre-loading may not be always a viable solution. In such cases, the presence of vertical drain can greatly reduce the pre-loading period. Installation of vertical drains results in the reduction of the length of drainage path in radial direction.

Since it is obvious that the coefficient of consolidation in the horizontal direction is much higher than that in the vertical direction, and that the vertical drains reduce the drainage path considerably in the radial direction, the effectiveness of vertical drains
in accelerating the rate of consolidation and improving the strength of soft soil is remarkably improved. In this chapter, the discussion on the use of coir geotextiles in accelerating the consolidation process, by way of prefabricated vertical drains are intended, utilising the drainage and filtration functions of coir geotextile.

The main reason for using the prefabricated vertical drain is its ability to reach the desired degree of consolidation within a specified time period in which both radial and vertical consolidation will be considered in calculating the settlement. Most of the prefabricated vertical drains used for ground improvement applications are of polymeric type. These are costly and not eco-friendly also. The main disadvantage of polymeric type of drains is that its capacity may be effectively surplus to the requirements. In such situations, deliberate and designed use of geosynthetic, which has a predictable reduction in capacity with time, is a good engineering solution. With increasing environmental awareness and sustainability, along with high cost of petroleum products, developing countries lead to investigations of substitutes for polymeric materials, using natural products.

In the present study two types of prefabricated vertical drains using coir geotextiles were developed and their effectiveness were studied by conducting experiments as detailed in the following section.

11.2 APPLICATION OF VERTICAL DRAINS

Vertical drains are artificially created drainage paths which can be installed by one of the several methods and which can have a variety of physical characteristics. The use of vertical drains along with pre-compression has the sole purpose of shortening the drainage path of the pore water, thereby accelerating the rate of primary
consolidation. When used in conjunction with pre-compression, the principal benefits of a vertical drain system are:

- To decrease the overall time required for completion of primary consolidation due to pre-loading.
- To decrease the amount of surcharge required to achieve the desired amount of pre-compression in the given time.
- To increase the rate of strength gain due to consolidation of soft soils where stability is of concern.

The following characteristics of prefabricated vertical drain (PVD) should be considered during the design and construction.

- Ability to be installed vertically into compressible subsurface soil strata under field conditions,
- Ability to permit pore water in the soil to seep into the drain,
- A means by which the collected pore water can be transmitted up and down the length of the drain.

The use of PVDs has largely replaced the vertical sand drains for many applications. The important advantages are economic competitiveness, less disturbance and the speed and simplicity of installation.

11.3 PREPARATION OF COIR GEOTEXTILE DRAINS

Two types of coir geotextile drains were developed in the present research work. One is of circular type and the other is of rectangular type. The circular drains were made by wrapping the coir geotextiles twice over 50.8 mm diameter rigid PVC pipes. To keep the geotextiles in position, it is tied by binding wires at 200 mm to 250 mm intervals. For easy penetration of these drains a perforated metallic cone was made.
To make a rectangular type of drain, three wooden reapers of 20 mm x 10 mm (this can be even bamboo strips or waste wood cuttings) are placed at 20 mm clear gap between them. This is glued to coir geotextiles and wrapped all around in four layers. The ends are glued to avoid separation. Perforated metallic V-shaped shoes is placed at the ends at the time of installation to facilitate easy penetration. The cross sections of the drains are shown in Fig.11.1. Drains were made with two varieties of coir geotextiles designated as H2M8 and H2M6.

![Cross section of coir geotextile drains](attachment:image)

#### (a) Rectangular drain

#### (b) Circular drain

*dimensions not to scale*

Fig. 11.1 Cross section of coir geotextile drains

### 11.4 TESTING PROGRAMME

The experimental work is aimed at finding the reduction in time for the consolidation settlement due to the provision of coir geotextile drains in loose and sensitive soils.
Though not impossible, it is very difficult to mobilise the equipment and to conduct tests in the field. To bypass these difficulties and also to have controlled conditions, experiments were done in a test tank fabricated for the purpose in the laboratory. The four series of experiments conducted are tabulated in Table 11.1. The disposition of drains within the test tank is shown in Fig. 11.2.

**Table 11.1 Summary of experiments conducted**

<table>
<thead>
<tr>
<th>Series</th>
<th>Pattern of arrangement</th>
<th>Type of Drain</th>
<th>Type of coir geotextile</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>No drain</td>
<td>Circular</td>
<td>H2M6</td>
</tr>
<tr>
<td>II</td>
<td>Single drain at centre</td>
<td>Circular</td>
<td>H2M8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Circular</td>
<td>H2M8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rectangular</td>
<td>H2M6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rectangular</td>
<td>H2M8</td>
</tr>
<tr>
<td>III</td>
<td>Three drains in</td>
<td>Circular</td>
<td>H2M6</td>
</tr>
<tr>
<td></td>
<td>Triangular pattern</td>
<td>Circular</td>
<td>H2M8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rectangular</td>
<td>H2M6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rectangular</td>
<td>H2M8</td>
</tr>
<tr>
<td>IV</td>
<td>Four drains in</td>
<td>Circular</td>
<td>H2M6</td>
</tr>
<tr>
<td></td>
<td>Rectangular pattern</td>
<td>Circular</td>
<td>H2M8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rectangular</td>
<td>H2M6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rectangular</td>
<td>H2M8</td>
</tr>
</tbody>
</table>
A single central drain, three drains in triangular pattern and four drains in rectangular pattern were tried.

![Diagram of coir geotextile vertical drains]

(a) Circular

(b) Rectangular

Fig. 11.2 Disposition of coir geotextile vertical drains

11.4.1 Preparation of Test Set-up

A steel tank of size 650mm x 650mm x 850mm was fabricated using mild steel plates and mild steel angles. Bracings were provided on the sidewalls in the diagonal directions to prevent buckling of the plates during loading. Inside of the tank was painted with glossy metallic paint to have a smooth surface, in order to nullify the friction between the soil and inner surface of the tank. Clayey silt was used for this test programme. The soil was soaked in water for 3 days and made into a thick slurry
form. The slurry was transferred into the tank in small quantities and was stirred well to remove the entrapped air to the maximum possible. This was continued until soil is filled in the tank to a depth of 700 mm. Three days rest period was given before commencing the experiment.

11.4.2 Installation of Vertical Drains

11.4.2.1 Installation of circular type of drains

To install circular type coir geotextile vertical drains, first the perforated metallic cone was placed in the required position and the drain wrapped over PVC pipes were held in vertical position over it. The drains were pressed into the soil to the required depth (50 mm from the bottom of the tank). After reaching the required depth the PVC pipe was withdrawn slowly and simultaneously rice husk was added to the hole. The step-by-step procedure was continued until the drain was installed. Fig. 11.3 illustrates the sequence of installation of circular vertical drains.

11.4.2.2 Installation of rectangular type of coir geotextile drains

To install the rectangular type of coir geotextile drains, a perforated metallic V-shaped shoe was placed over the soil surface. The drain was placed centrally in the groove and pressed to the required depth. The sequences of installation of rectangular drains are illustrated in Fig. 11.4.
1. Placing the metallic cone shoe at the surface.
2. Placing the coir geotextile drain wrapped around PVC pipe centrally over it.
3. Pressing the drain to the required depth.
4. Releasing the PVC pipe and simultaneously adding rice husk.
5. Completed circular coir geotextile drain.

Fig. 11.3 Installation of circular type coir geotextile vertical drains
1. Placing the metallic V notch over the soil surface.
2. Placing the rectangular drain over it.
3. Pressing the drain to the required depth.
4. Completed rectangular coir geotextile drain.

Fig. 11.4 Installation of rectangular type coir geotextile vertical drains

11.4.3 Testing

After installing the drains in the desired configuration the surface of the soil was leveled and a filter paper was placed over it covering the entire soil surface. Above this 5 mm thick perforated steel plate was placed over it. Two layers of coir geotextiles were placed over this, which act as the drainage blanket. Above this a 38 mm thick perforated metallic plate was placed to distribute the load evenly over the surface. The plates were made perforated for the easy escape of water and hence to
avoid building up of pore water pressure. Additional load was placed on the top of the steel plates by putting mild structural steel sections. The details of test set-up are shown in Fig.11.5. The tests were performed under a pressure of 10 kPa, for which a total load of 3.60 kN was applied. The loading was done with the help of a tripod and a differential pulley arrangement.

![Diagram showing test set-up](image)

**Fig. 11.5 Schematic test set-up for vertical drain**

The settlement measurements were taken with the help of four digital displacement sensors having sensitivity of 0.01 mm and the average value is recorded. Settlements were taken at varying time intervals until the settlement is nearly constant. Photographs showing testing sequences are given in Fig.11.6.
Fig. 11.6 (a) tank filled with soil slurry

Fig. 11.6 (b) Perforated steel plate 38 mm thick being placed
Fig. 11.6 (c) Set - up is ready for taking readings

Fig. 11.6 (d) Noting down the readings

Fig. 11.6 Sequence of testing programme
11.5 RESULTS AND DISCUSSION

The behaviour of two types vertical coir geotextile drains made of two varieties of woven coir geotextiles in different configurations in reducing the time of settlement were studied. Thirteen experiments were conducted and primary consolidation settlement measurements were taken under an applied pressure of 10kPa. The performance obtained with the provision of coir drains in terms of percentage increase in settlement and percentage reduction in time for a settlement of 10mm is summarised in Table 11.2.

11.5.1 Type of Drain

Two types of drains were considered, one is of circular cross section and the other is of rectangular cross section. For the circular type the central core pipe is withdrawn during installation whereas in the case of rectangular drains the full section is driven and kept as such in the soft ground. Fig. 11.7 shows the comparison of the time settlement behaviour for single drain (made of H2M8 and H2M6 coir geotextiles) at centre. Here it is seen that the drain with circular cross section is performing better. Similar trend was observed for other dispositions viz., three drains in triangular pattern and four drains in rectangular pattern (Fig. 11.8 and Fig. 11.9). This may be due to the fact that the effective area of drain is 50% more in the case of circular drains compared to rectangular drains. The percentage increase in settlement after 48 hours for the circular drains when compared to rectangular drains is 25 to 55%. Another reason which favours the circular type may be that the drain was filled with rice husk which is a free draining material. Again, while making rectangular drains, four wraps were made to get a stable workable drain whereas, two windings only were required.
in the case of circular drains to get a self-supporting drain. This was possible because rice husk was added while PVC pipe was withdrawn.

**Table 11.2 Performance comparison of drains in terms of settlement and time**

<table>
<thead>
<tr>
<th>Expt . No.</th>
<th>Description</th>
<th>% Increase in settlement in 24 hours</th>
<th>% Increase in settlement in 48 hours</th>
<th>% Reduction in time for 10 mm settlement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Soil without drain</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Circular drain (H2M8) – 1 at centre</td>
<td>64.77</td>
<td>72.73</td>
<td>70.23</td>
</tr>
<tr>
<td>3</td>
<td>Circular drain (H2M6) – 1 at centre</td>
<td>64.77</td>
<td>68.18</td>
<td>67.44</td>
</tr>
<tr>
<td>4</td>
<td>Circular drain (H2M8) – 3 Nos. – Triangular pattern</td>
<td>112.5</td>
<td>122.73</td>
<td>81.86</td>
</tr>
<tr>
<td>5</td>
<td>Circular drain (H2M6) – 3 Nos. – Triangular pattern</td>
<td>64.77</td>
<td>78.18</td>
<td>71.63</td>
</tr>
<tr>
<td>6</td>
<td>Circular drain (H2M8) – 4 Nos. – Rectangular pattern</td>
<td>76.14</td>
<td>81.82</td>
<td>74.42</td>
</tr>
<tr>
<td>7</td>
<td>Circular drain (H2M6) – 4 Nos. – Rectangular pattern</td>
<td>64.77</td>
<td>68.18</td>
<td>66.51</td>
</tr>
<tr>
<td>8</td>
<td>Rectangular drain (H2M8) – 1 at centre</td>
<td>23.86</td>
<td>21.82</td>
<td>43.26</td>
</tr>
<tr>
<td>9</td>
<td>Rectangular drain (H2M6) – 1 at centre</td>
<td>21.59</td>
<td>17.27</td>
<td>43.72</td>
</tr>
<tr>
<td>10</td>
<td>Rectangular drain (H2M8) – 3 Nos. – Triangular pattern</td>
<td>50.00</td>
<td>45.45</td>
<td>69.77</td>
</tr>
<tr>
<td>11</td>
<td>Rectangular drain (H2M6) – 3 Nos. – Triangular pattern</td>
<td>40.91</td>
<td>34.54</td>
<td>61.86</td>
</tr>
<tr>
<td>12</td>
<td>Rectangular drain (H2M8) – 4 Nos. – Rectangular pattern</td>
<td>42.05</td>
<td>38.18</td>
<td>62.33</td>
</tr>
<tr>
<td>13</td>
<td>Rectangular drain (H2M6) – 4 Nos. – Rectangular pattern</td>
<td>40.91</td>
<td>34.54</td>
<td>55.81</td>
</tr>
</tbody>
</table>
Fig. 11.7 Effect of type of drain on the time settlement behaviour
(single drain at center)
Fig. 11.8 Effect of type of drain on the time settlement behaviour. (Three drains- Triangular disposition)
11.5.2 Pattern of Arrangement

In order to study the effect of layout of drains, three different patterns were tried, viz., one at centre, three drains in a triangular pattern and four drains in a rectangular...
pattern. Fig. 11.10 shows the results of a typical case of circular drains made of H2M8 coir geotextiles. It was observed from the figure that the triangular pattern is showing better performance. Similar trend was observed for rectangular type of drain also (Fig. 11.11). This behaviour may be due to the fact that the horizontal drainage path i.e. the maximum distance the water has to travel to reach free draining medium, is reduced in a staggered triangular disposition.

![Graph showing the effect of drain disposition on time settlement behaviour](image)

**Fig. 11.10 Effect of drain disposition on time settlement behaviour**

*(Circular drains)*
11.5.3 Types of Coir Geotextiles

Two types of coir geotextiles were employed for the study. A set of six experiments each were done on drains made up of H2M8 and H2M6 geotextiles. Figs. 11.12, 11.13, and 11.14 compares the time settlement behaviour of drains made of two types of coir geotextiles in different dispositions. When single drain is used both H2M8 and H2M6 performed more or less in the similar way as we can see from Fig.11.12. But in all other cases it is seen that drains made of H2M8 is showing better performance in terms of reduction in consolidation time. The H2M6 geotextiles has wide opening and less rigidity. Being more flexible, kink formation may be more while using H2M6 and hence the poor performance.
Fig. 11.12 Influence of type of coir geotextiles on the behaviour of drains
(One at centre)

Fig. 11.13 Influence of type of coir geotextiles on the behaviour of drains
(Triangular layout)
11.6 SUMMARY

In general, the time for consolidation is very much reduced due to the provisions of circular and rectangular coir drains in all the configurations tested. While comparing the performance of the types of coir drains, it is seen that drains using H2M8 performed better than that of H2M6 coir geotextiles. Also the triangular configuration is found to be more efficient than the other patterns tried. Much better result was obtained with circular type of drains compared to rectangular type of drains.