Experimental Assessment of Sub Surface Irrigation on Parched Territories by using Clay Porous Pipe in a Model
Veena Pachpor¹, Akshay Minde², Aminuddin Shaikh³, Shankar Kangle⁴, Ashish Bhosale⁵
BE Student¹, 2, 3, 4, 5
Department of Civil Engineering
Bharati Vidyapeeth Group of Institute, Technical Campus College of Engineering, Lavale, Pune, Maharashtra, India

Abstract:
Drought can be devastating and unlike earthquakes or hurricanes, there is no immediate response for disaster management. At Gokhale Institute of Politics and Economics (GIPE), a ten-member team will go to drought-prone Beed, Latur and Osmanabad districts and take a week-long survey to understand why authorities fall short in taking planned and immediate steps. Dr Rajas Parchure, Director of GIPE, told The Indian Express that the survey was not a fact-finding one to assess the ground reality. “There has been ample evidence reported from various districts about the scarce water scenario. Migration of people living in these droughts hit areas to other cities has also been recorded. What we aim to find out is why there has been a failure in planning policies and identify the loopholes,” said Parchure. The state government has officially declared that 60 per cent of its villages were facing a ‘drought-like’ condition. Drought comes in several degrees and hence at times it may not qualify to be termed as a disaster. The research team’s plan is to study the norms and check what should be the proportion or severity of drought to term it as a disaster and what kind of response should be anticipated.

Keywords: Subsurface Irrigation, Parched Regions, Terracotta Clay, Porous Pipe.

I. INTRODUCTION

Figure 1. Drought in Marathwada

Marathwada region has been reeling under drought condition since 2013. It is in a part of the scanty rainfall area of Central Maharashtra. The region coincides with the Aurangabad Division of Maharashtra. It includes districts of Aurangabad, Jalna, Beed, Osmanabad, Nanded, Latur, Parbhani and Hingoli. Out of these eight districts, five are the worst affected, namely Beed, Jalna, Parbhani, Nanded and Osmanabad. Marathwada region has a population of about 1.87 crore and geographical area of 64.5 thousand sq.km. The region had faced several droughts in the past. Droughts have occurred in the years 1899, 1918, 1972 and 2012 onwards. The 1972 drought is in the recent past; which people still remember. In 1972, food and fodder were the main concerns, but now drinking water is more important. It is multi-dimensional drought. Global climatic situation is also playing in the process, which was not so acute 50 years before.

1.4 Introduction to Porous Clay Pipe:

Figure 1.2 Subsurface Porous Clay Pipe Irrigation

The porous clay pipe is a traditional method of sub-surface irrigation in which porous clay pipes are buried in the soil at regular intervals and water is supplied continuously to these pipes from a source. Water seeps out of the porous wall of the pipe and moves radially outwards from the pipe which creates a wetting front along the length of the lateral. Porous clay pipes are a means of water application that conserve water by applying water directly to the roots of plants, thereby limiting evaporation losses. The Porous clay pipes are consist of baked short length pipes (10 to 15 cm) made from clay. The geometry of wetted zone around a pipe in the soil depends on many factors such as permeability of pipe, applied volume of water, and the soil type. In this system, conveyance and seepage of the water are done instantaneously by the Pvc pipe and Porous Clay pipe
respectively. This method of irrigation can be used in many arid and semi-arid regions of the world. It can be suitable for row crops grown in rows such as vegetables and trees.

II. LITERATURE REVIEW


Abstract:
In this experiment the unglazed hollow clay pipes were manufactured from a mixture of clay (locally available) and saw dust in the ratio of 3:1 and with an insufficient porosity ranging from 50-60% at a local manufacturing unit primarily manufacturing Filter Clay Candles. The porous clay pipes were made as unglazed to retain their natural porosity i.e. the walls remain micro-porous. The pipes were then tempered by burning them in a pit fire from firewood at an undetermined temperature to eliminate the swelling and shrinking properties of clay, which would cause cracking of the pipes. The outer diameter of the clay pipe was 5 cm, the inner diameter of the clay pipe was 3 cm and length of the pipes was 17.5 cm. Clay pipes were connected using a plastic (PVC) coupler of suitable size and pipes were then assembled to produce a required length of pipe that can be installed in respective rows.

Conclusion:
The proposed “Porous Clay Pipe” irrigation can facilitate sufficient moisture to the soil and crop. There was adequate moisture distribution beneath the porous pipe even after 10 days following water application to the crops. The amount of moisture retained by the soil was higher when compared to the unirrigated soil. The Porous Clay Pipe Irrigation offers double yield as compared to Rain-fed agriculture. The growth of crops during the cropping period and the quality of yield under Porous Clay Pipe Irrigation was much superior to the Rain-fed agriculture. Considerable water saving in agriculture can be attained using this method of irrigation. The method is slightly costlier but considering its ease of installation, maintenance and operation, and if the same pipes are used for up to 3-5 years, the cost can be considerably reduced. The persistent use of this technique would pay high returns to the farmer in the long run facing water scarcity. Instead of depending only on rain, taking up this technique can help farmers in improving their economic conditions and thereby the local and national economy. The method also demonstrates that productivity, soil and water conservation can be attained using Porous Clay Pipe Irrigation technique.

Background Information

3.1 Subsurface Irrigation:
Subsurface irrigation uses a network of polyethylene pipes located just under the ground’s surface to apply disinfected effluent in the root zone of plants, preventing airborne drift and minimizing runoff. Note that effluent that has not been disinfected, such as from septic tanks must be disposed of below the soil (at least 300 mm deep). Subsurface irrigation requires less maintenance than surface irrigation, and there is also less chance of surface saturation and effluent runoff. By reducing the chance of human contact, it also significantly reduces the public health risks.

Figure 3.1 (b) An installed subsurface irrigation
Subsurface irrigation puts effluent largely below the depth of the root zone of most crops. This means there is limited nutrient uptake and it is unlikely to result in a healthy growing crop. Careful hydraulic design of subsurface irrigation is essential to ensure correct sizing and choice of components, including providing for adequate effluent pumping, effluent filtration, line flushing, placement of vacuum release valves, and correct spacing of laterals and emitters. Consideration of rainfall is important for sizing subsurface irrigation areas as for surface irrigation, however subsurface irrigation may allow for higher nutrient uptake in the same location.

3.1.1 Advantages of Subsurface Irrigation
- Health risks are minimized.
- The system is easily automated.
- Consumption of nitrates by the plant material is increased.
- The systems are durable and have a long life.

3.2 Black Cotton Soil:
These are mostly clay soils and form deep cracks during dry season. An accumulation of lime is generally noticed of varying depths. They are popularly known as “Black cotton soils” because of their dark brown color and suitability for growing cotton. These are also known as Indian regurs. These soils are deficient in nitrogen, phosphoric acid and organic matter but rich in calcium, potash and magnesium. Black cotton soils and other expansive soils have typical characteristics of shrinkage and swelling due to moisture movement through them. During rainy season, moisture penetrates into these soils, due to which they swell. Most of the fine-grained clays, including black cotton soils have their grains which are more or less in the form of platelets or sheets (just like leaves of a book), and their grains are not round. When moisture enter between the platelets under some hydrostatic pressure, the particles separate out, resulting in increase in the volume. This increase in volume is commonly known as swelling. If this swelling is checked or restricted (due to the construction of footings over it), high swelling pressure, acting in the upward direction, will be induced. This would result in severe cracks in the walls etc. and may sometimes damage the structural units, such as lintels, beams slabs etc. During summer season, moisture moves out of the soil and consequently, the soil shrinks. Shrinkage cracks are formed on
the ground surface. These shrinkage cracks times also known as
tension cracks, may be 10 to 15 cm wide on the ground surface
and maybe 1/2 to 2 m deep.

3.2.1 Characteristics of Black Cotton Soil:

Black Cotton Soil is considered as a very poor type of soil hav-
ing black colour with very fine grain. This type of soil contains
pure clay particles with about 85-100 percentages passing
through 75-micron Sieve. Atterberg Limits tested in laboratory is
tabulated in Table-1. The test shows the Liquid limit for BC Soil
samples are ranging 55-60 and Plastic Limit for the same ranges
30-40. Thus, Plasticity Index of BC Soil found to the range of
20-35. At the liquid limit, the volume change is of the order of
200 to 300% and results in swelling pressure as high as 8 kg/cm
2 to 10 kg/cm2. As such BC Soil has very low bearing capacity
and high swelling and shrinkage characteristics. Primitive
pieces of terracotta were just left to harden and bake in the hot
sun, while later pieces (before kilns) were fired in the ashes of
open fires. Another great property that terracotta has is that it can
withstand varied temperature changes with a lower chance of
 cracking, making it incredibly functiona

3.3 Tests Conducted

1. Grading Test of Soil

A sieve analysis (or gradation test) is a practice or procedure
used (commonly used in civil engineering) to assess the particle
size distribution (also called gradation) of a granular material by
allowing the material to pass through a series of sieves of
progressively smaller mesh size and weighing the amount of
material that is stopped by each sieve as a fraction of the whole
mass.

GRAIN SIZE ANALYSIS OF SOIL (WET METHOD)

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>IS Sieve Size (mm)</th>
<th>Wt. Retain (gm)</th>
<th>% Wt. Retain</th>
<th>Cumulative % Wt. Retain</th>
<th>Cumulative % Passing</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>100.00</td>
<td>Cobbles 0%</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>100.00</td>
<td>Gravel Coarse 17%</td>
</tr>
<tr>
<td>3</td>
<td>53</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>100.00</td>
<td>Gravel Medium 19.35%</td>
</tr>
<tr>
<td>4</td>
<td>37.5</td>
<td>75.00</td>
<td>5.67</td>
<td>12.93</td>
<td>87.07</td>
<td>Gravel Fine 21.47%</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>96.00</td>
<td>7.26</td>
<td>19.19</td>
<td>82.62</td>
<td>Sand Coarse 13.30%</td>
</tr>
<tr>
<td>6</td>
<td>19</td>
<td>59.00</td>
<td>4.46</td>
<td>23.65</td>
<td>78.99</td>
<td>Sand Medium 17.16%</td>
</tr>
<tr>
<td>7</td>
<td>16</td>
<td>48.00</td>
<td>3.63</td>
<td>27.28</td>
<td>73.85</td>
<td>Sand Fine 7.94%</td>
</tr>
<tr>
<td>8</td>
<td>12.5</td>
<td>68.00</td>
<td>5.14</td>
<td>32.42</td>
<td>69.56</td>
<td>Silt &amp; Clay Size 14.97%</td>
</tr>
<tr>
<td>9</td>
<td>6.3</td>
<td>140.00</td>
<td>10.58</td>
<td>43.00</td>
<td>63.27</td>
<td>Total Sample 1323.00</td>
</tr>
<tr>
<td>10</td>
<td>4.75</td>
<td>49.00</td>
<td>3.70</td>
<td>46.70</td>
<td>59.56</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>2.36</td>
<td>108.00</td>
<td>8.16</td>
<td>54.86</td>
<td>51.40</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>2.0</td>
<td>127.00</td>
<td>9.60</td>
<td>64.46</td>
<td>41.80</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1.18</td>
<td>94.00</td>
<td>7.41</td>
<td>71.87</td>
<td>34.39</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0.600</td>
<td>78.00</td>
<td>5.90</td>
<td>77.77</td>
<td>28.50</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>0.425</td>
<td>48.00</td>
<td>3.63</td>
<td>81.40</td>
<td>24.87</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0.300</td>
<td>57.00</td>
<td>4.31</td>
<td>85.71</td>
<td>20.56</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>0.150</td>
<td>45.00</td>
<td>3.40</td>
<td>88.24</td>
<td>17.16</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>0.075</td>
<td>29.00</td>
<td>2.19</td>
<td>90.43</td>
<td>14.97</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Pan</td>
<td>198.00</td>
<td>14.97</td>
<td>100.00</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

1.3. Result: - The soil sample tested in this test was found to be
fine graded soil

2. Liquid Limit Test

The liquid limit is the moisture content at which the groove,
formed by a standard tool into the sample of soil taken in the
standard cup, closes for 10 mm on being given 25 blows in a
standard manner. This is the limiting moisture content at which
the cohesive soil passes from liquid state to plastic state. Liquid
limit is significant to know the stress history and general prope-
ties of the soil met with construction. From the results of liquid
limit, the compression index may be estimated. The compression
index value will help us in settlement analysis. If the natural
moisture content of soil is closer to liquid limit, the soil can be
considered as soft if the moisture content is lesser than liquids
limit, the soil can be considered as soft if the moisture content is
lesser than liquid limit. The soil is brittle and stiffer.
2.3 Observation:
Table No. 5.2 Test Report- Atterberg Limits (Liquid Limit)

<table>
<thead>
<tr>
<th>No. of Blows</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crucible No.</td>
<td>16</td>
<td>22</td>
<td>27</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Weight of Crucible + Wet Soil (g)</td>
<td>38.2</td>
<td>34.7</td>
<td>36.3</td>
<td>50.8</td>
<td></td>
</tr>
<tr>
<td>Weight of Crucible + Dry Soil (g)</td>
<td>33.1</td>
<td>30.0</td>
<td>31.8</td>
<td>44.5</td>
<td></td>
</tr>
<tr>
<td>Weight of Water (g)</td>
<td>5.17</td>
<td>4.69</td>
<td>4.44</td>
<td>6.35</td>
<td></td>
</tr>
<tr>
<td>Weight of empty Crucible (g)</td>
<td>20.2</td>
<td>16.7</td>
<td>16.8</td>
<td>19.7</td>
<td></td>
</tr>
<tr>
<td>Weight of Dry Soil (g)</td>
<td>12.9</td>
<td>13.3</td>
<td>15.0</td>
<td>24.7</td>
<td></td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>40.0</td>
<td>35.2</td>
<td>29.4</td>
<td>25.6</td>
<td></td>
</tr>
<tr>
<td>No. of Blows</td>
<td>16</td>
<td>22</td>
<td>27</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

2.4 Computation / Calculation
Plot the relationship between water content (on y-axis) and number of blows (on x-axis) on semi-log graph. The curve obtained is called flow curve. The moisture content corresponding to 25 drops (blows) as read from the represents liquid limit. It is usually expressed to the nearest whole number.

Flow index $I_f = \frac{(W_2 - W_1)}{\log(N1/N2)}$

2.5 Result: - Liquid Limit % = 32%

3. Plastic Limit Test
The plastic limit (PL) is determined by rolling out a thread of the fine portion of a soil on a flat, non-porous surface. The procedure is defined in ASTM Standard D 4318. If the soil is at a moisture content where its behavior is plastic, this thread will retain its shape down to a very narrow diameter. The sample can then be remolded and the test repeated. As the moisture content falls due to evaporation, the thread will begin to break apart at larger diameters. The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of 3.2 mm (about 1/8 inch). A soil is considered non-plastic if a thread cannot be rolled out down to 3.2 mm at any moisture possible.

Observation: -
Table No. 5.3 Test Report-Plastic Limit Test

<table>
<thead>
<tr>
<th>Crucible No.</th>
<th>A6</th>
<th>A7</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of Crucible + Wet Soil (g)</td>
<td>21.93</td>
<td>21.18</td>
<td></td>
</tr>
<tr>
<td>Weight of Crucible + Dry Soil (g)</td>
<td>21.24</td>
<td>20.47</td>
<td></td>
</tr>
<tr>
<td>Weight of Water (g)</td>
<td>0.69</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>Weight of empty Crucible (g)</td>
<td>17.74</td>
<td>16.83</td>
<td></td>
</tr>
<tr>
<td>Weight of Dry Soil (g)</td>
<td>3.50</td>
<td>3.64</td>
<td></td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>19.71</td>
<td>19.51</td>
<td></td>
</tr>
</tbody>
</table>

Result: -
The Plastic limit shall be determined for at least three portions of the soil passing 425 microns IS sieve. The average of the result calculated to the nearest whole numbers shall be reported as the Plastic limit of soil.

4. Free Swell Index Test
The clay and specially the black cotton soils have a tendency to swell in small or more proportion when submerged in water. Free swell or differential free swell also termed as free swell index, is the increase in volume of soil without any external constraint when subjected to submergence in water.

Observation:
Table No. 5.4 Test Report - Free Swell Index Test of Soil

<table>
<thead>
<tr>
<th>Particular</th>
<th>Test No 01</th>
<th>Test No 02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of the soil specimen read from the graduated cylinder containing distilled water (Vd)</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Volume of the soil specimen read from the graduated cylinder containing kerosene (Vc)</td>
<td>9.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Free Swell Index (%) = \frac{V_d - V_c}{V_c} \times 100</td>
<td>33.33</td>
<td>30.00</td>
</tr>
</tbody>
</table>

Result: -
Shrinkage Limit (average of two determinations), WS =31.665

Methodology
4.1 Data Collection
4.2 Materials and Testing:
i. Material
- Clay

ii. Testing
- Grading test of soil
- Liquid Limit Test
- Plastic Limit Test
- Free Swell Index Test
- Water Absorption Test on pipe
- Flexural Strength Test on pipe
- Compressive Strength of Pipe
- Perculation Test

4.3 Installation of Porous Clay Pipe:

Figure 4.1 Installation of Porous Clay Pipe
To design, install and operate a Clay porous pipe/subsurface irrigation system, one must understand:
1. The components of the irrigation system (porous pipe, controller, valves, filters, meters, installation equipment, etc.)
2. The soil.
3. The irrigation waters.
4. The plant life to be irrigated.

Experimental Work Performed
5.1 Introduction:
The aim of the experiment is to study Clay porous pipe system in Sub-surface irrigation and to compare the existing irrigation system with clay porous pipe system in the term of efficiency, productivity, life span etc. For this study purpose the experiment has been performed at Bharati Vidyapeeth’s college of engineering, Lavale.

5.2. Description of Model:
1. Length = 1100 mm
2. Width = 335 mm
3. Height = 170 mm
4. Area = (1100*335) = 368500 mm²
5. Volume = (1100*335*170) = 62.64x10⁶ mm³
6. Height of Water Tank = 545 mm

5.3.5. Description of Pipe:
1. Outer Diameter (D) = 50 mm
2. Inner Diameter (d) = 35 mm
3. Height = 142 mm
4. Area = \( \pi \left( \frac{D^2}{2} \right) - \pi \left( \frac{d^2}{2} \right) \) = 1001.38 mm²
5. Volume = \( \pi R^2 h - \pi r^2 h \) = 142.19x10³ mm³

5.4 Experimental Procedure:

Figure 5.3 Experimental Arrangement of Model
1. In the model there is water tank installed at certain height which is controlled by valve which regulates the velocity of flow passing from the pipes.
2. At certain length there are sections of CPVC pipe and clay porous pipe situated in subsurface.
3. The porous pipe is installed at 6 cm below the soil.
4. Water is allowed to flow from the tank then water reaches the normal pipe which act as a normal pipe function then water flows through porous pipe here the pipe allows the water to get into the soil by pores.
5. Aggregates are provided around the whole porous clay pipe to reduce the pressure of water and to prevent the blockage of pipe.

1.5 Testing on pipe:
1. Water Absorption Test On Pipe
Water absorption refers to the property of absorbing water when materials are exposed to water. It is expressed by the water-absorption ratio. A test to determine the moisture content of pipe as a percentage of its dry weight. The sample is weighed, dried in an oven, then reweighed under standard conditions. It is calculated as the moisture content, which is equal to: divided by the difference of weights then multiplied by 100 to express it as a percentage.

Figure 5.6 Water Absorption Test

Observation: -
Table 5.5 Test Report - Water Absorption Test of Pipe

<table>
<thead>
<tr>
<th>S No.</th>
<th>Observation &amp; Calculation</th>
<th>Unit</th>
<th>Determination No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Pipe No</td>
<td>g</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Mass of Wet Pipe (M₁)</td>
<td>g</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td></td>
<td>g</td>
<td>305</td>
</tr>
<tr>
<td>3</td>
<td>Mass of Dry Pipe (M₂)</td>
<td>g</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>g</td>
<td>270</td>
</tr>
<tr>
<td>4</td>
<td>Mass of Water</td>
<td>g</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>( \text{MW} = (M₁ - M₂) )</td>
<td>g</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>Water Content</td>
<td>g</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>( \frac{(M₁ - M₂)}{100} )</td>
<td>%</td>
<td></td>
</tr>
</tbody>
</table>
Result: -
Average of two determinations shall be taken. The water content of the sample = 0.325%

2. Flexural Test on Pipe
Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. A flexure test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is the flexural strength of that particular sample. Unlike a compression test or tensile test, a flexure test does not measure fundamental material properties. When a specimen is placed under flexural loading all three fundamental stresses are present: tensile, compressive and shear and so the flexural properties of a specimen are the result of the combined effect of all three stresses as well as (though to a lesser extent) the geometry of the specimen and the rate the load is applied. The most common purpose of a flexure test is to measure flexural strength and flexural modulus. Flexural strength is defined as the maximum stress at the outermost fibre on either the compression or tension side of the specimen. Flexural modulus is calculated from the slope of the stress vs. strain deflection curve. These two values can be used to evaluate the sample materials ability to withstand flexure or bending forces.

![Image of pipe for flexural strength test](image-url)

**Figure. 5.7 Arrangement of Pipe for Flexural Strength Test**

### 2.1 Observation Table:
**Table No. 5.6 Test Report- Flexural strength of Clay Porous Pipe**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Dimension of Pipe</th>
<th>Condition</th>
<th>Breaking Load (N)</th>
<th>Average Breaking Load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outer Dia (mm)</td>
<td>Inner Dia (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>49</td>
<td>34</td>
<td>Dry</td>
<td>76.2</td>
</tr>
</tbody>
</table>

**2.2 Result:** Flexural strength of Clay porous pipe is = 76.2 N.

### 3. Compressive Strength of Pipe
Crush tests are carried out on pipes to test their strength and ductility. These characteristics can be of considerable significance in situations where the integrity of pipework must not be affected by earthquakes, especially when pipes are laid directly in the ground.

### 3.1 Observation:
**Table No. 5.7 Test Report- Compressive Strength of Terracotta cube**

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Dimensions (mm)</th>
<th>Area (mm²)</th>
<th>Load (N)</th>
<th>Compressive strength (N/mm²)</th>
<th>Average Compressive Strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length</td>
<td>Width</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>209.5</td>
<td>99.0</td>
<td>14</td>
<td>44.6</td>
<td>7.38</td>
</tr>
<tr>
<td>2</td>
<td>209.5</td>
<td>99.0</td>
<td>14</td>
<td>56.9</td>
<td>7.62</td>
</tr>
<tr>
<td>3</td>
<td>209.5</td>
<td>99.1</td>
<td>14</td>
<td>71.4</td>
<td>7.42</td>
</tr>
</tbody>
</table>

**3.2 Result:** Compressive Strength of the clayey soil is = 7.48N

### Result and Discussion
**Irrigation through ‘Porous Clay Pipes’:**
The amount of volume of water applied was 5 liters to grow fenugreek (methyl) plant during the study. For irrigating cm² of land using “Porous Clay Pipe Irrigation” technique a total of 5 liters of water would be required. The irrigation frequency for the experimentation was of 10 days. This duration was selected because the soil was black cotton which has higher field capacity as compared to soils such as sand, sandy loam. Further, from the previous experiences of the farmer, and by calculation it was known that the requirement of water to irrigate cm² land with surface irrigation method was 10-12 liters. Thus 70 to 80% water savings were obtained with subsurface Porous clay pipe irrigation system.

### III. CONCLUSION
Experiment on growing fenugreek (methyl) with subsurface porous clay pipe irrigation method showed that water savings up to 80% were achieved with this method compared to that of surface flood irrigation method. The proposed “Porous Clay Pipe” irrigation can facilitate sufficient moisture to the soil and crop. There was adequate moisture distribution beneath the porous pipe even after 10 days following water application to the crops. The amount of moisture retained by the soil was higher when compared to the surface irrigation method. The “Porous Clay Pipe Irrigation” offers double yield as compared to Rain-fed agriculture. The growth of crops during the crop period and the quality of yield under “Porous Clay Pipe Irrigation” was much superior to the Rain-fed agriculture. Considerable water saving in agriculture can be attained using this method of irrigation. The method is slightly costlier but considering its ease in installation, maintenance and operation, and if the same pipes are used for up to 3-5 years, the cost can be considerably reduced. The persistent use of this technique would pay high returns to the farmer in the long run in areas facing water scarcity. Instead of depending only on rain taking-up of this technique can help farmers in improving their economic conditions and thereby the local and national economy. The method also demonstrates that productive
soil and water conservation can be attained using “Porous Clay Pipe Irrigation” technique.

**Future Scope**

Porous Clay Pipe Irrigation will help farmers as it will have a long durable period compared to normal techniques as this method can last up to max 25 years as other methods just have a conventional life of 5-6 years. Porous Clay Pipe Irrigation also has an efficient saving of water than the normal techniques as its save more than 80% of water than conventional methods which may result in saving water which will be a concern in future time.

**IV. REFERENCES:**


