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| 16. Abstract<br><p>The Tube Suction Test (TST) was developed in a cooperative effort between the Finnish National Road Administration and the Texas Transportation Institute (TTI) for assessing the moisture susceptibility of granular base materials.</p> <p>This project was initiated by the Texas Department of Transportation (TxDOT) in order to develop a standard test procedure for the TST. The Materials &amp; Pavements Division at the Texas Transportation Institute (TTI) and the Geotechnical Soils &amp; Aggregates Branch of the Texas Department of Transportation (TxDOT) conducted a series of tests for determination of repeatability and reproducibility of the Tube Suction Test (TST) in a single lab and inter-laboratory between TTI and TxDOT. Four TxDOT districts (Yoakum, Tyler, Austin, and Waco) participated in the reproducibility study program. Brigham Young University also participated in this program as a subcontractor under TTI.</p> <p>Further research was conducted for determining different aspects with potential negative effects on the testing readings. The following factors were considered: the quality of the porous stones, the use of tap water versus distilled water in the sample molding procedure, and the surface texture of the sample.</p> |  |   |   |  |           |
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**REPEATABILITY AND REPRODUCIBILITY STUDY FOR TUBE  
SUCTION TEST**

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## **DISCLAIMER**

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The United States government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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## INTRODUCTION

The Tube Suction Test (TST) was developed in a cooperative effort between the Finnish National Road Administration and the Texas Transportation Institute (TTI) for assessing the moisture susceptibility of granular base materials (1). Moisture susceptibility represents the potential of a soil to develop or hold water by capillary rising and produces detrimental or unstable conditions under traffic load.

The water rising due to capillarity transforms the soil's relative dielectric value. Adsorbed water molecules are arranged in layers around soil particles as the electrical attraction diminishes with the increasing distance from the soil particle. The water molecules beyond the electrical capture are considered unbound, and depending on permeability, changes in pressure and temperature can migrate further (2).

The dielectric value (DV) is a measure of the unbound water within the soil sample. The strength of the material and its ability to resist repeated freeze-thaw cycling are considered to be directly influenced by the unbound water. The Tube Suction Tests reveal the state of bonding of the water within soil particles and should not be considered as a simple measure of the moisture content (1).

The equipment used for TST consists of a (Adek Percometer™) equipped with a capacitance-based dielectric surface probe with a head diameter of 50 mm and a measuring frequency of 50MHz (Figure 1). The dielectric values are measured at the surface of the sample at specific time intervals for 10 days.



**Figure 1. Percometer Used for TST.**

A graph of surface dielectric values versus time is used for moisture susceptibility analysis. The final dielectric value is determined as the average of the dielectric values recorded in the last three days of testing. The following ranking is recommended:

| Final DV | classification     |
|----------|--------------------|
| < 10     | good quality bases |
| 10 – 16  | marginal quality   |
| >16      | poor quality (3)   |

The Materials & Pavements Division at the Texas Transportation Institute and the Geotechnical Soils & Aggregates Branch of the Texas Department of Transportation (TxDOT) conducted a series of tests for determination of repeatability and reproducibility of the Tube Suction Test in a single lab and inter-laboratory between TTI and TxDOT. Four TxDOT districts (Yoakum, Tyler, Austin, and Waco) participated in the reproducibility study program. Brigham Young University participated in this program as a subcontractor under TTI. The preliminary results of this testing program indicated further research is needed in order to clarify the effect of some potential factors.



## **RESEARCH OBJECTIVES**

Repeatability and reliability of TST represented two main concerns during the development of this new investigation procedure. Different aspects with potential negative effects on the testing readings were considered for the next stage of research. Extended series of testing were conducted at TTI in order to evaluate the influence of the following factors on the final DV:

- the quality of the porous stones,
- the use of tap water versus distilled water in the sample molding procedure, and
- the surface texture of the sample.

The materials used for these testing programs were Spicewood (low moisture susceptibility) and Caliche (high moisture susceptibility).





## OVERVIEW

### TEST PROCEDURES

The TST represents a reliable and extremely useful investigation technology for separating the poor performers from good quality unbound aggregates.

The testing protocol, originally developed by TTI and modified by TxDOT, is described in the Test Method Tex-144-E (draft). Some of the outlines are presented below:

- The specimens molded at Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) are placed in the oven, with porous stones at the top and the bottom.
- After 2 days of drying at  $140 \pm 9$  °F ( $60 \pm 5$  °C), the specimens are taken out, cooled down at room temperature, and then placed in a flat-bottomed stainless steel pan with distilled water.
- The readings of dielectric values (influenced by the capillarity) are recorded for 10 consecutive days. Specimens with a final DV less than 10 are expected to provide a good performance, while those with DV above 16 are expected to provide poor performance as base materials. Specimens with a final DV between 10 and 16 are expected to exhibit marginal performance.



## TEST RESULTS

TxDOT and TTI conducted an inter-laboratory reproducibility study. Both agencies molded 10 identical samples for Caliche and Spicewood, and exchanged five of them each other for dielectric value test. Using the two-sided t test, researchers determined whether the paired sets of dielectric values differed from each other in a significant way, considering the null hypothesis that there is no significant difference between the two sets of data. The confidence level is 90 percent. The results are presented in [Table 1](#) for Spicewood and [Table 2](#) for Caliche (Note: M = Molded Samples, T = Tested Samples).

**Table 1. Inter-Laboratory Comparative Results and Statistical Analysis for Spicewood.**

|                    | TxDOT (MT) vs. TTI (MT) |      | TxDOT (MT) vs. TxDOT(M)-TTI (T) |      | TTI (MT) vs. TTI(M)-TxDOT(T) |      | TxDOT(M)-TTI(T) vs. TTI(M)-TxDOT(T) |      |
|--------------------|-------------------------|------|---------------------------------|------|------------------------------|------|-------------------------------------|------|
|                    |                         | 9.4  | 12.8                            | 9.4  | 11.3                         | 12.8 | 11.5                                | 11.3 |
|                    | 8.4                     | 13.8 | 8.4                             | 8.1  | 13.8                         | 11.3 | 8.1                                 | 11.3 |
|                    | 9.3                     | 12.7 | 9.3                             | 10.2 | 12.7                         | 13.4 | 10.2                                | 13.4 |
|                    | 9.5                     | 12   | 9.5                             | 9    | 12                           | 13   | 9                                   | 13   |
|                    | 10.5                    | 12.4 | 10.5                            | 10.2 | 12.4                         | 10.5 | 10.2                                | 10.5 |
| Mean               | 9.4                     | 12.7 | 9.4                             | 9.8  | 12.7                         | 11.9 | 9.8                                 | 11.9 |
| STDEV              | 0.7                     | 0.7  | 0.7                             | 1.2  | 0.7                          | 1.2  | 1.2                                 | 1.2  |
| t                  | 7.4                     |      | 0.527                           |      | 1.28                         |      | 2.8                                 |      |
| $t_{\alpha/2, df}$ | 1.8                     |      | 1.8                             |      | 1.8                          |      | 1.8                                 |      |
| Null Hypothesis    | Rejected                |      | Not Rejected                    |      | Not Rejected                 |      | Rejected                            |      |

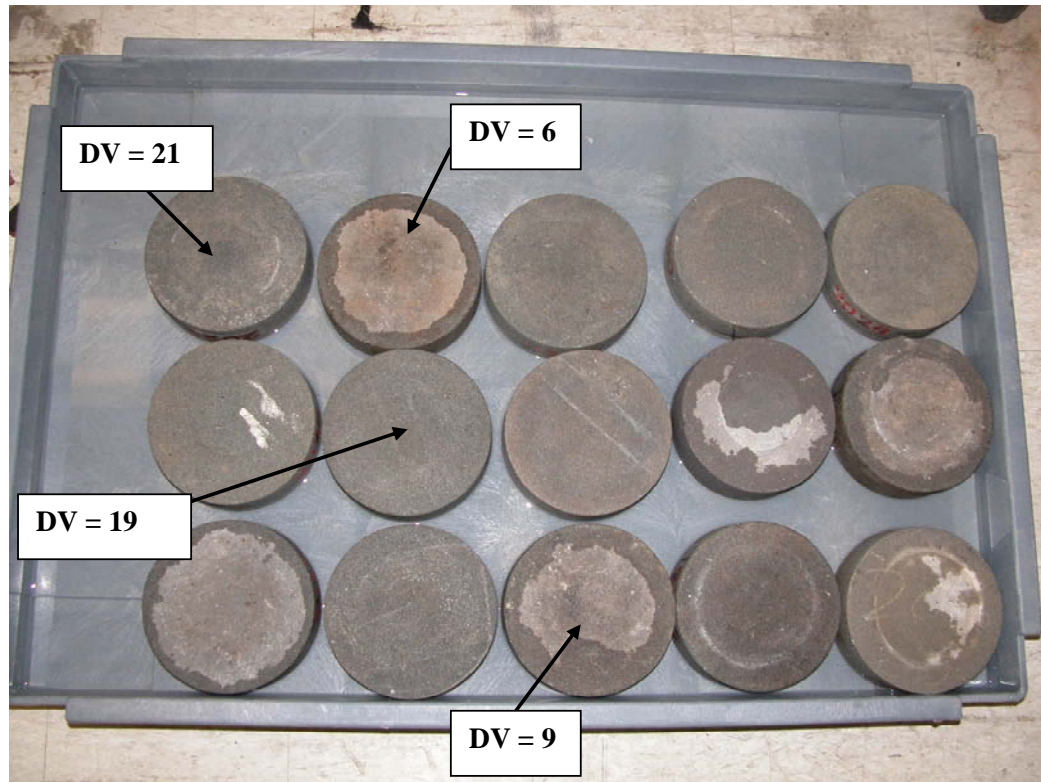
**Table 2. Inter-Laboratory Comparative Results and Statistical Analysis for Caliche.**

|                      | TxDOT (MT) vs. TTI (MT) |      | TxDOT (MT) vs. TxDOT(M)-TTI (T) |      | TTI (MT) vs. TTI(M)-TxDOT(T) |      | TxDOT(M)-TTI(T) vs. TTI(M)-TxDOT(T) |      |
|----------------------|-------------------------|------|---------------------------------|------|------------------------------|------|-------------------------------------|------|
|                      | 15.1                    | 26.4 | 15.1                            | 21.9 | 26.4                         | 24   | 21.9                                | 24   |
|                      | 20                      | 23.1 | 20                              | 20.2 | 23.1                         | 25.4 | 20.2                                | 25.4 |
|                      | 19.4                    | 25.8 | 19.4                            | 25.2 | 25.8                         | 24.8 | 25.2                                | 24.8 |
|                      | 20.1                    | 24.1 | 20.1                            | 21.8 | 24.1                         | 21.9 | 21.8                                | 21.9 |
|                      | 18.4                    | 25.5 | 18.4                            | 22   | 25.5                         | 23.3 | 22                                  | 23.3 |
| Mean                 | 18.6                    | 25   | 18.6                            | 22.2 | 25                           | 23.9 | 22.2                                | 23.9 |
| STDEV                | 2.1                     | 1.3  | 2.1                             | 1.8  | 1.3                          | 1.4  | 1.8                                 | 1.4  |
| t                    | 5.77                    |      | 2.93                            |      | 1.283                        |      | 1.63                                |      |
| t <sub>α/2, df</sub> | 1.8                     |      | 1.8                             |      | 1.8                          |      | 1.8                                 |      |
| Null Hypothesis      | Rejected                |      | Rejected                        |      | Not Rejected                 |      | Not Rejected                        |      |

The statistical analysis indicated the paired sets of dielectric values differed from each other in a significant way in some cases (when the null hypothesis was rejected). These results required further research for determining possible causes for such variations.

The quality of the porous stones has an important influence on the final DV. The clogged porous space can impede proper capillary ascension during TST. Therefore, only clean porous stones must be used.

In order to assess the influence of this factor on the final DV, researchers conducted parallel readings of DV for a set of brand new porous stones and a set of stones extensively used in previous different testing, with impurities clogging the material. [Figure 2](#) illustrates the different levels of wetting for these two different sets. After 1 day of soaking, the stones with impurities still exhibit extended dry areas where the water didn't raise up. The values for DV are less than half for the used stones (DV = 6 - 9), compared with the DV for the new, clean stones (DV = 19 - 21).



**Figure 2. Dry Areas on Some Clogged Porous Stones, after 1 Day of Soaking.**

Furthermore, two sets of five specimens each were molded in similar conditions (distilled water). The samples from the first set were placed on stones with clogged porous space which resulted from extensive usage and lack of proper cleaning and maintenance. TST conducted on these sets provided the results presented in [Table 3](#). As expected, the clogged porous stones impede the capillary rise, and the final DV are reduced.

**Table 3. Effect of Clogged Porous Stones on TST Results.**

| Spicewood Clogged Stones | DV      | Spicewood Distilled Water | DV      |
|--------------------------|---------|---------------------------|---------|
| Specimen 1               | 10.8    | Specimen 1                | 12.4    |
| Specimen 2               | 9.6     | Specimen 2                | 13.2    |
| Specimen 3               | 9.4     | Specimen 3                | 12.3    |
| Specimen 4               | 10.2    | Specimen 4                | 11.8    |
| Specimen 5               | 11      | Specimen 5                | 12.2    |
| Average                  | 10.2    | Average                   | 12.38   |
| STDEV                    | 0.70711 | STDEV                     | 0.51186 |

For the evaluation of the second factor on the final DV, a set of five specimens of Spicewood were molded using tap water, and a second set of five specimens were molded using distilled water. [Table 4](#) presents the TST results. The statistical analysis of the final DV for these two sets of samples does not indicate significant differences. However, the researchers recommend the use of distilled water for molding as a standard procedure. It is possible to encounter tap water with different mineralogical composition, which can influence the results of future TST.

**Table 4. Effect of Tap Water versus Distilled Water on TST Results.**

| Spicewood Tap Water | DV        | Spicewood Distilled Water | DV        |
|---------------------|-----------|---------------------------|-----------|
| Specimen 1          | 13.8      | Specimen 1                | 12.4      |
| Specimen 2          | 13.3      | Specimen 2                | 13.2      |
| Specimen 3          | 13.8      | Specimen 3                | 12.3      |
| Specimen 4          | 14.2      | Specimen 4                | 11.8      |
| Specimen 5          | 12.9      | Specimen 5                | 12.2      |
| Average             | 13.6      | Average                   | 12.38     |
| STDEV               | 0.5049752 | STDEV                     | 0.5118594 |

A flat and smooth specimen surface is required for a good contact with the Percometer's probe. Any irregularities or missing can induce lower readings for the dielectric values. In order to evaluate the influence of the surface texture of the sample on the final DV, two sets of Spicewood specimens were molded. For the second set, the irregularities of the samples' surfaces were filled with fines (passing through Sieve #40). [Figure 3](#) presents one of these specimens, with rough surface, before filling with fines.



**Figure 3. Surface Irregularities before Filling with Fines for TST Sample.**

The researchers considered another approach for a better determination of dielectric values for specimens with rough surface. From the five DV readings recorded each day, the three lowest values were disregarded, and the remaining two values (the highest) provided the average DV which counted for analyzing the moisture susceptibility. The comparative results from the TST for these sets of specimens, presented in [Table 5](#), indicate higher final DV for samples with fines on the surface and for the case with DV as average of the two highest values, which were recorded from a better contact between the surface and the probe.

**Table 5. Comparative TST Results for Spicewood.**

| Spicewood Tap water | DV    | Spicewood Distil Water | DV    | Spicewood Distil Water (Fines on Surface) | DV    | Spicewood Tap water (AVG Two Highest DV/daily) | DV     |
|---------------------|-------|------------------------|-------|---|-------|--|--------|
| Specimen 1          | 13.8  | Specimen 1             | 12.4  | Specimen 1                                | 14.8  | Specimen 1                                     | 14.2   |
| Specimen 2          | 13.3  | Specimen 2             | 13.2  | Specimen 2                                | 15.7  | Specimen 2                                     | 14.21  |
| Specimen 3          | 13.8  | Specimen 3             | 12.3  | Specimen 3                                | 14.3  | Specimen 3                                     | 14.66  |
| Specimen 4          | 14.2  | Specimen 4             | 11.8  | Specimen 4                                | 13.7  | Specimen 4                                     | 14.56  |
| Specimen 5          | 12.9  | Specimen 5             | 12.2  | Specimen 5                                | 12.9  | Specimen 5                                     | 14.16  |
| Average             | 13.6  | Average                | 12.38 | Average                                   | 14.28 | Average  | 14.408 |
| STDEV               | 0.505 | STDEV                  | 0.512 | STDEV                                     | 1.064 | STDEV  | 0.237  |

Due to some material limitations, the testing program for Caliche was reduced to a number of two series of three specimens each. The first batch contained samples molded with tap water. The specimens from the second batch were molded with distilled water, and their surfaces were filled with fines (passing through Sieve #40) if any irregularities were encountered. Also, the option of recording the average of the two highest DV is considered. [Table 6](#) presents the TST results for Caliche.

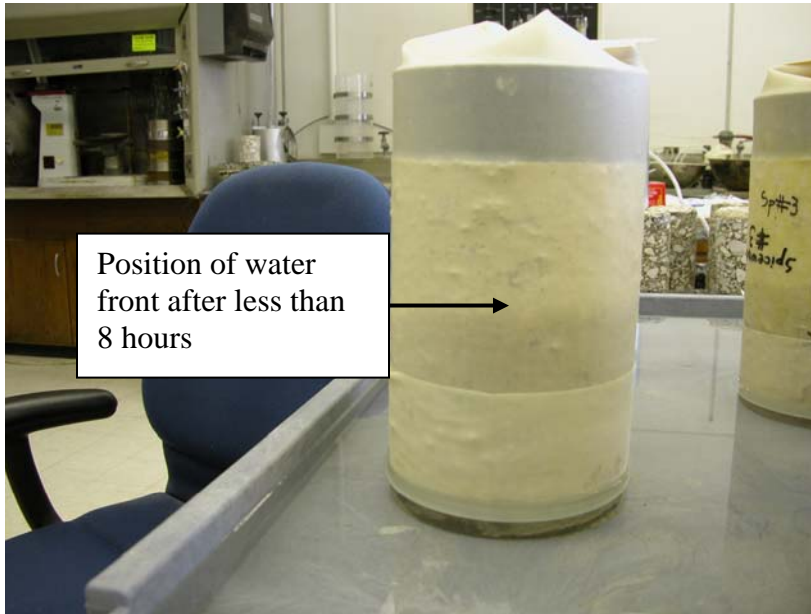
**Table 6. Comparative TST Results for Caliche.**

| Caliche    | Distilled Water, fines | Tap Water | AVG Two Highest DV/daily |
|------------|------------------------|-----------|--------------------------|
|            | DV                     | DV        | DV                       |
| Specimen 1 | 24.3                   | 24.8      | 27.1                     |
| Specimen 2 | 23                     | 25.9      | 26.7                     |
| Specimen 3 | 22.1                   | 22.2      | 23.6                     |
| Average    | 23.13                  | 24.3      | 25.8                     |
| STDEV      | 1.11                   | 1.9       | 1.92                     |

The results clearly indicate there is no significant difference between the two approaches in the case of the sample's rough surface (i.e., filling the surface with fines and considering the average of the two highest DV).



Caliche exhibits high moisture susceptibility, with final DV higher than 20. The front of raising capillary water reached half of the specimen height in less than 8 hours from the initial moment of TST. [Figure 4](#) illustrates the position of capillary water front within the sample.



**Figure 4. Level of Water by Capillary Rising within the Sample.**



## CONCLUSIONS AND RECOMMENDATIONS

The TST represents a reliable and extremely useful investigation technology for separating the poor performers from good quality unbound aggregates. This project studied the repeatability and reliability of TST for two base materials: Spicewood (with low moisture susceptibility) and Caliche (with high moisture susceptibility). The effect of a number of factors on testing readings was determined:

- The quality of porous stones: The final DV for the same specimens were significantly smaller when clogged stones were used for TST. This aspect can affect the classification of the material tested and can falsely indicate a lower moisture susceptibility. The porous stones used at the bottom of the specimen must be clean in order to ensure an appropriate ascension of capillary water.
- The use of tap water versus distilled water for sample molding: The comparative results for specimens molded with tap water and with distilled water didn't indicate a real difference. However, the researchers suggest only the distilled water should be used for molding as tap water with possible higher content of minerals can be encountered at different lab locations, with potential for affecting the osmotic suction.
- The samples surface texture: The fines covering the surface irregularities provide a smoother contact interface between the base material and the Percometer's probe. In this case, the DV readings offer a more accurate image of the material's moisture susceptibility. Also, the average of the two highest DV recorded each day can be used. The researchers consider the filling of the surface irregularities with fines can generate errors as the experience of the operator is required for obtaining a smooth surface.

The findings presented in this research lead to the following recommendations:

1. Clean the porous stones thoroughly. Keep them in distilled water for washing away any impurities within the porous space. Dry them completely and run the TST in order to determine the final DV for these materials. Place the porous

stones in a pan and fill it with distilled water up to half of the porous stones. Take readings for DV during 1 day. After 24 hours, the final DV should be in the range of 16-22.

2. Use only distilled water for specimens molding.
3. Check the samples surface before placing in the oven. If any significant irregularities are noticed, consider the following method: Collect five readings for dielectric values each day. Disregard the three lowest values and compute the average of the two highest DV. This is the value considered for determining the moisture susceptibility.

Based on the findings of this study and the continuing work of the Soils and Aggregates section in TxDOT, the TST test protocol continues to evolve and to be refined. The latest version of this test protocol is attached in an [appendix](#) to this report.

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**APPENDIX**  
**TUBE SUCTION TEST PROTOCOL**

**December 31, 2005**





## Tube Suction Test

This method determines the dielectric constant (value) of base materials and soils. The dielectric constant is an indicator of the ability for moisture to migrate through the materials.

### Apparatus

- Apparatus outlined in Test Method Tex-101-E, Part II
- Apparatus outlined in Test Method Tex-103-E, Part I
- Apparatus outlined in Test Method Tex-113-E
- Apparatus outlined in Test Method Tex-114-E
- Oven maintained at  $60 \pm 5^\circ\text{C}$  ( $140 \pm 9^\circ\text{F}$ )
- Latex membrane (Diameter = 6"; Height = 14")
- Plastic sheet disk (Diameter = 6")
- Filter paper (Diameter = 6")
- Flat-bottomed plastic or steel pan, wide and shallow, for soaking specimens
- Adek Percometer™

### Materials

Distilled or deionized water

### Procedure

| Step     | Action  |
|----------|---|
| <b>1</b> | <b>Prepare the base or subgrade soil sample as in Test Method Tex-101-E, Part II.</b>   |
|          | <b>Use Test Method Tex-113-E (draft) or Tex-114-E depending on the materials to determine the optimum moisture content (OMC) and maximum dry density (MDD) of the material for molding the test specimens.</b>  |
| <b>3</b> | <b>Obtain a representative sample of prepared material in sufficient quantity to prepare three (3) specimens. Bring the material to optimum moisture using distilled or deionized water.</b><br>Note: Ions in regular tap water can influence the results of the test by increasing the osmotic suction component of the aggregate.   |
| <b>4</b> | <b>Compact each specimen at optimum moisture content and maximum dry density according to Test Method Tex-113-E, Part I (draft) or Tex-114-E, Part II depending on the materials. The specimens should be 6 in. (152.4 mm) in diameter and <math>8 \pm 0.13</math> in. (<math>203.2 \pm 3.2</math> mm) in height.</b><br>Note: The surface of each specimen should be made as smooth as possible after compaction. Remove or reposition any coarse aggregate protruding from the specimen surface and fill any large voids as necessary. However, application of fines across the whole specimen surface should be avoided. |
|          | <b>Weigh each specimen in the mold to the nearest estimated 0.001 lb. (0.5 g.) and</b>  |

|    |  |
|----|--|
| 5  | record as $W_{TOTAL}$ . Measure the height of the specimen using a micrometer and record it as $H_t$ .   |
| 6  | Weigh two porous stones (previous dried at $60 \pm 5 \text{ }^\circ\text{C}$ ( $140 \pm 9 \text{ }^\circ\text{F}$ )) together and record the total weight as $W_{STONE}$ .   |
| 7  | Place a filter paper on top of one porous stone, carefully <b>flip over</b> the specimen with mold, and place it over the porous stone. Place the whole set in the hydraulic press to extrude the specimen from the mold.  |
| 8  | Once the specimen is extruded, place the other porous stone on top of the specimen. Then weigh the specimen with two porous stones and record as $W_{COMPACT}$ .   |
| 9  | Run unconfined compressive strength (UCS) of one of the specimens at OMC and record it as $U_{OMC}$ . Save the other two specimens for determining the dielectric value.   |
| 10 | Place the specimen with the two porous stones in an oven equipped with a circulating fan and maintained at $60 \pm 5 \text{ }^\circ\text{C}$ ( $140 \pm 9 \text{ }^\circ\text{F}$ ) for $48 \pm 2$ hours.  |
| 11 | Remove the specimen from the oven and allow it cooling down at ambient temperature for at least 2 hours. Weigh the specimen with the two porous stones to the nearest 0.001 lb. (0.5 g.) and record the weight as $W_{DRY}$ .  |
| 12 | Use the Adek Percometer <sup>TM</sup> to take five initial dielectric readings on the specimen surface as the first day readings. Four readings should be equally spaced around the perimeter of the specimen, and the fifth should be in the center as shown in <a href="#">Figure 5</a> . The probe should have a surcharge with a load of $5 \pm 0.5$ lb. ( $2.3 \pm 0.23$ kg) to ensure adequate contact of the probe on the top surface of the specimen.<br>Note: This pattern should be followed each time dielectric values are measured. |
| 13 | Place a latex membrane around the specimen with the aid of an expander and roll the membrane down to cover half of the bottom porous stone. Place a plastic sheet disk between the top of the specimen and the top porous stone, as shown in <a href="#">Figure 6</a> .  |
| 14 | Place the specimen in a flat-bottomed stainless steel or plastic pan and fill the pan with distilled/deionized water. The water depth should come up to about a 0.25 in. above the top of the bottom stone, as seen in <a href="#">Figure 7</a> . The water bath should be maintained at this depth throughout the testing. Avoid splashing the specimen surfaces with water during the test.<br>Hint: Make a mark on the pan to indicate the level of water prior to test.  |
| 15 | Take five dielectric value readings on the top surface of the specimen daily for 10 days. Take the readings at the same time during each day, if at all possible.  |
| 16 | The test is completed when the elapsed time exceeds 10 days. Measure and record final surface dielectric values.   |
| 17 | Run the unconfined compressive strength for each specimen and record it as the residual strength ( $U_{RES}$ ) after 10-day capillary soaking period. Weigh the specimen only and record it as $W_{WET}$ .   |
| 18 | Determine the final moisture content of the specimen according to Test Method Tex-103-E, Part I, but use the entire sample instead in the procedure. Record the weight of the oven-dry aggregate solids as $W_S$ .   |

## Calculations

- Calculate the actual gravimetric moisture content (MC, %) of the specimen, it should be close to the optimum moisture content from the moisture-dry density relationship curve,

$$MC = 100 (W_T - W_{STONE} - W_S) / W_S$$

Where:

$W_T$  = Weight of the specimen and dry porous stones, lb. (g.)

$W_{STONE}$  = Weight of the dry porous stones, lb. (g.)

$W_S$  = Oven dry weight of the soil solids after the test, lb. (g.)

- Calculate the initial gravimetric moisture content ( $MC_{INITIAL}$ , %) of the specimen after the 2-day drying period,

$$MC_{INITIAL} = 100 (W_{DRY} - W_{STONE} - W_S) / W_S$$

Where:

$W_{DRY}$  = Dry weight of the specimen after the 2-day drying period with the two porous stones, lb. (g.)

$W_{STONE}$  = Dry weight of the two dried porous stones, lb. (g.)

$W_S$  = Oven dry weight of the soil solids after the test, lb. (g.)

- Calculate the gravimetric moisture content loss ( $MC_{LOSS}$ , %) of the specimen after the 2-day drying period,

$$MC_{LOSS} = MC - MC_{INITIAL}$$

Where:

MC = Gravimetric moisture content when molded the specimens, %

$MC_{INITIAL}$  = Gravimetric moisture content after the 2-day drying period, %

- Calculate the final gravimetric moisture content ( $MC_{FINAL}$ , %) of the specimen after the 10-day soaking period,

$$MC_{FINAL} = 100 (W_{WET} - W_S) / W_S$$

Where:

$W_{WET}$  = Wet weight of the specimen after 10-day soaking period, lb. (g.)

$W_S$  = Oven dry weight of the soil solids after the test, lb. (g.)

- Calculate the gravimetric moisture content gain ( $MC_{GAIN}$ , %) of the specimen after the 10-day soaking period,

$$MC_{GAIN} = MC_{FINAL} - MC_{INITIAL}$$

Where:

$MC_{\text{INITIAL}}$  = Gravimetric moisture content after 2-day drying period, %

$MC_{\text{FINAL}}$  = Gravimetric moisture content after 10-day soaking period, %

- Calculate the retained ratio of unconfined compressive strength (R, %) of the specimen after the 10-day soaking period,

$$R = 100 (U_{\text{RES}} / U_{\text{OMC}})$$

Where:

$U_{\text{OMC}}$  = Unconfined compressive strength at optimum moisture content, psi (MPa)

$U_{\text{RES}}$  = Unconfined compressive strength after 10-day soaking period, psi (MPa)

### Graphs

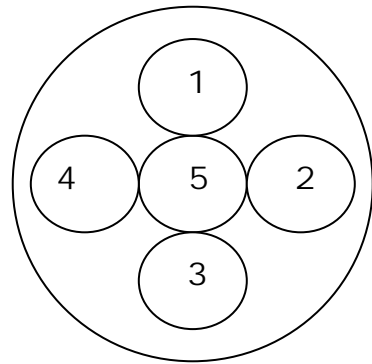
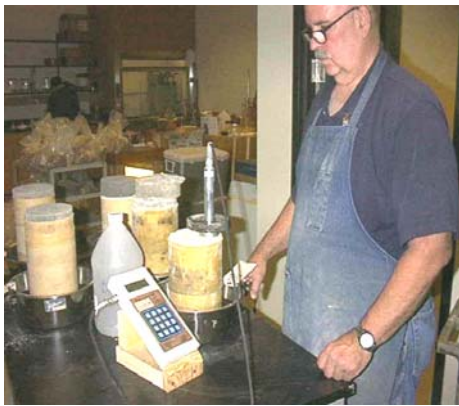
- Plot the dielectric constant versus time curve for each specimen.

### Test Report

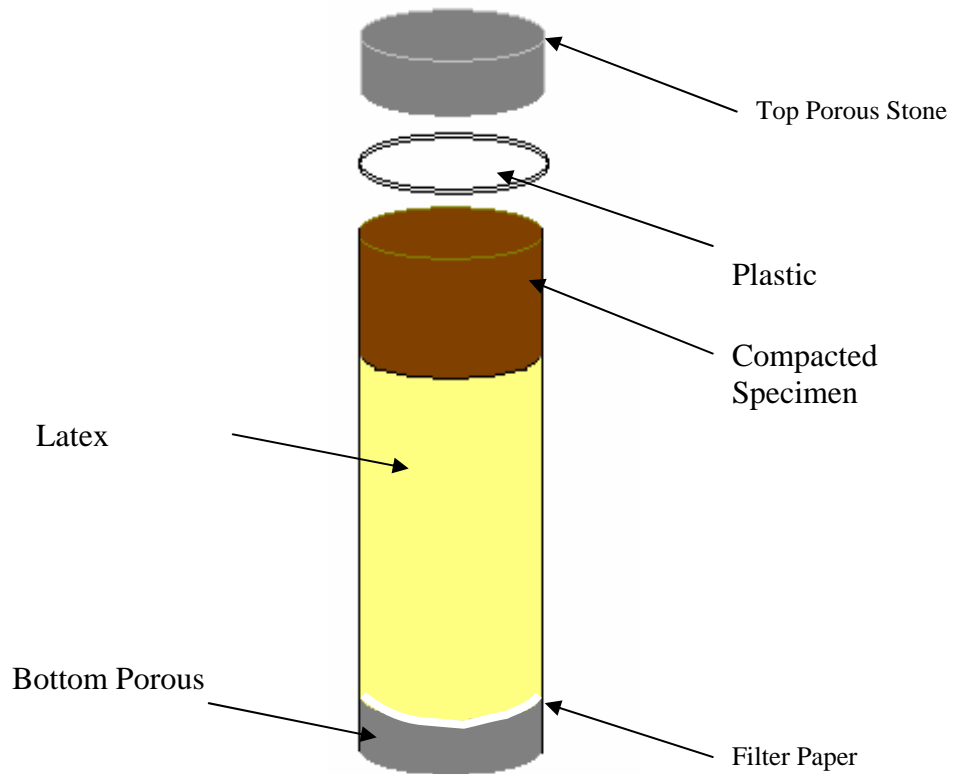
- Report the average dielectric value of last three days as the final dielectric value of the specimen after capillary soaking period.
- Report the initial and final gravimetric moisture content, the moisture content loss after 2-day drying period and the moisture gain after 10-day soaking period. The final moisture content is indicative of the water content this aggregate may attain in the field given the availability of water.
- Report the percentage retained ratio of the unconfined compressive strength after 10-day capillary soaking period with respect to the UCS at optimum moisture content.

### Notes

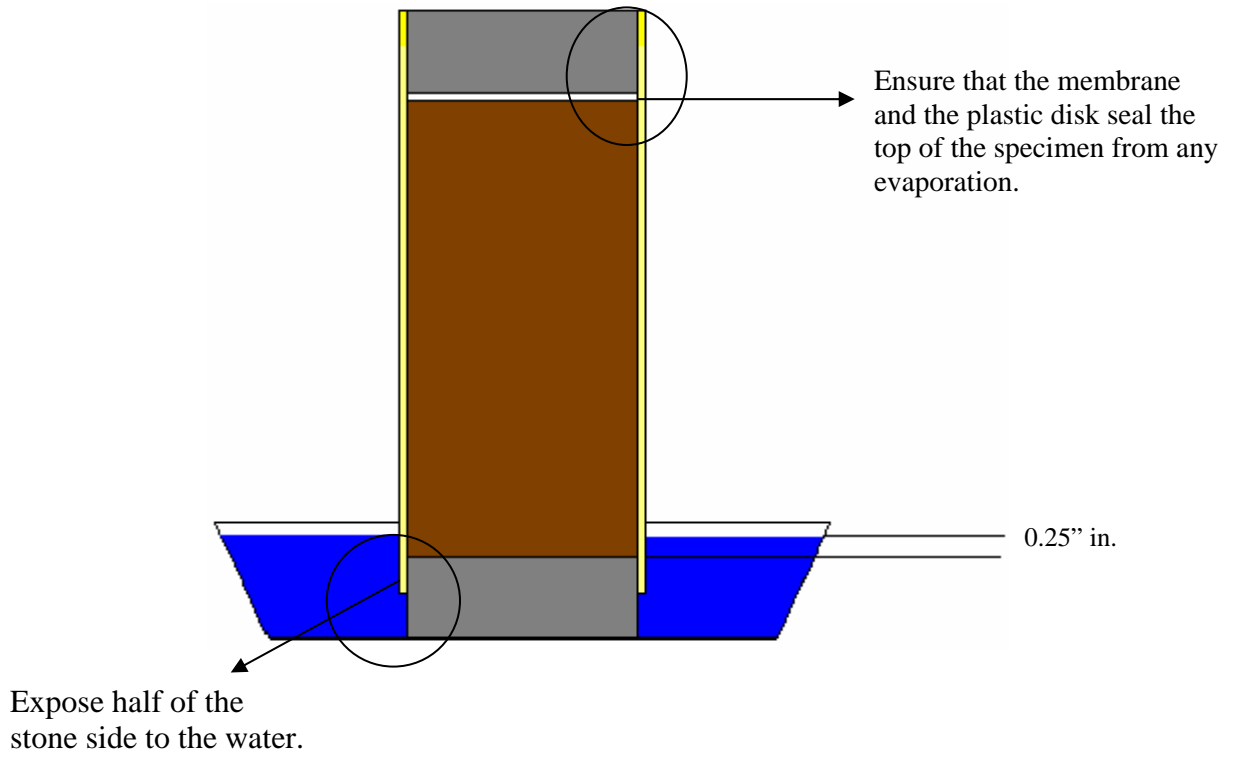
- Specimens with final dielectric values less than 10 are expected to provide a good performance, while those with dielectric values above 16 are expected to provide poor performance as base materials. Specimens having final dielectric values between 10 and 16 are expected to be marginally moisture susceptible.
- The 10-day capillary soaked unconfined compressive strength (UCS) of the specimens should not be less than 75% of the original unsoaked UCS for good pavement performance.



**Figure 5. Using the Adek Percometer™**



**Figure 6. Specimen Assembly for Tube Suction Testing.**



**Figure 7. Capillary Soaking Set Up.**