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ARCADIA

LABORATORY TEST REPORT

ASTM D3385-03

PERMEABILITY TEST

August 17th, 2020
DOC-2008-03 Rev. 00

0. Summary

The purpose of this Test is to show that, in Sand stabilized with Arcadia, the Sand is still capable of filtering water, as permeability should not reach zero and cause floods, even in desert areas.

To conduct this Test, we hammered two metallic rings into the soil treated by Arcadia and examined the water permeability (drainage) through the stabilized surface, following: *'ASTM. 2003. D3385-03 Standard test method for infiltration rate of soils in field using double-ring infiltrometer. Annual Book of ASTM Standards 04.08. Amer. Soc. Testing Materials, West Conshohocken, PA .'*

1. Test Procedure

Test Date: August 4th, 2020

Test Equipment:

- N.1 Double Ring Infiltrometer

Test Materials:

- To produce the Sample with Arcadia:
  - Geomaterial (Sands): 200 kg
  - Urea Concentration: ≥ 0.03 M
  - Protein Source: ≤ 20 g/l
  - Indigenous Ureolytic Bacteria (natural indigenous population)

Test Phases:

i. Feed the bacteria of the Sample for 14 days in a Container at a temperature of 25°C to 30°C
ii. Dry the Sample for 14 days at a temperature of 45°C
iii. Insert the Double Ring Infiltrometer into the Sand treated with Arcadia
iv. Fill the Double Ring Infiltrometer with 30cm of water
v. Measure the permeability (filtration) of the Sand treated with Arcadia

Geomaterial Characteristics:

Test	Unit	Fine Sand
pH		7.9 – 9.6
Ca^{2+}	ppm	120 - 380
Clay	%	6% - 11%
Silt	%	10% - 14%
Sand	%	80% - 86%
Particle Size	mm	0.002
EC	m mho/cm	0.86 – 0.92

Tab. 1: Geomaterial composition

Fig. 1: Geomaterial (Sand)

Fig. 2: Arcadia Culture in Laboratory

Fig. 3: Autoclave

Fig. 4: Incubator

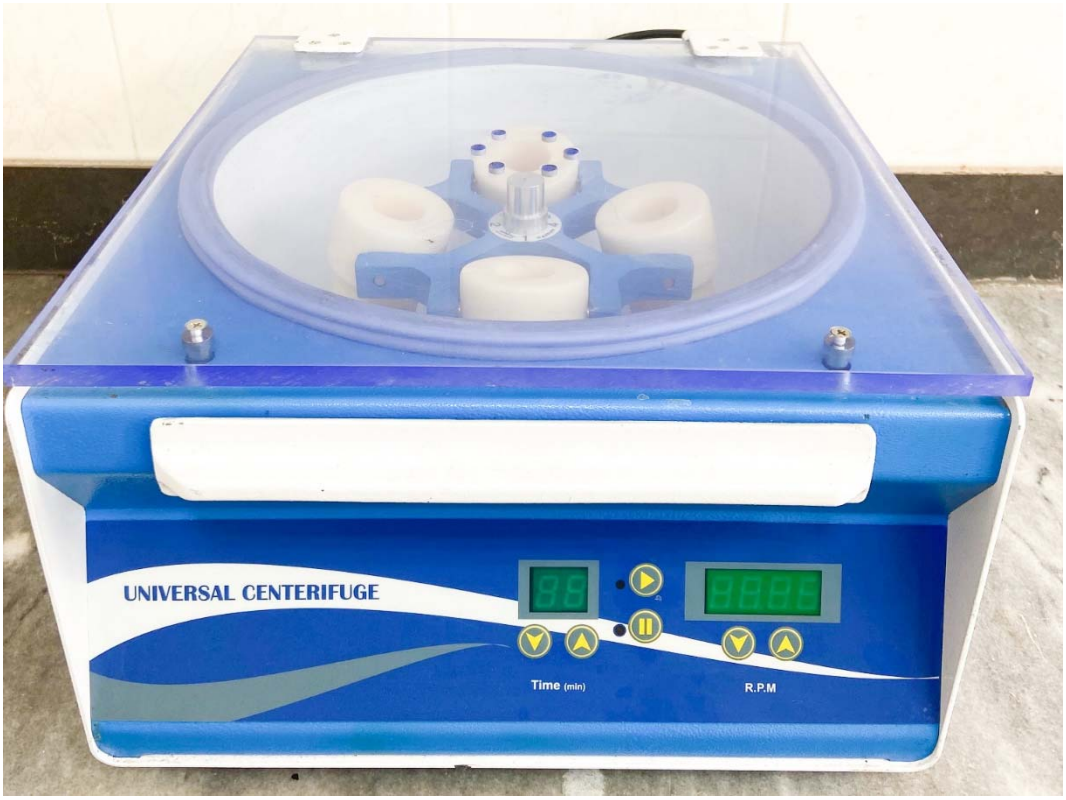


Fig. 5: Centrifuge

Fig. 6: Glassware

Fig. 7: Laboratory Substances used for Arcadia

2. Test Execution

The water permeability into soil was measured through use of a Double Ring Infiltrometer (Fig. 8): two iron rings with a height of 30cm, larger ring diameter of 40cm and smaller ring diameter of 20cm.

The Test phases are as follows (see Fig. 9 for reference):

1. The two rings are hammered into the Soil treated with Arcadia at a dept equal to 1/3rd of the ring's height (Hr)
2. A plastic layer is placed to avoid water to drain before the timer starts
3. The rings are filled with an initial level of 30cm of water (L_0)
4. The plastic layer is removed, times starts, water permeates through the Soil treated with Arcadia and the height h(t) is recorded each minute

Note that all the bacteria were indigenous and already naturally living in the Sand soil.

Fig. 8: Double Ring Infiltrometer

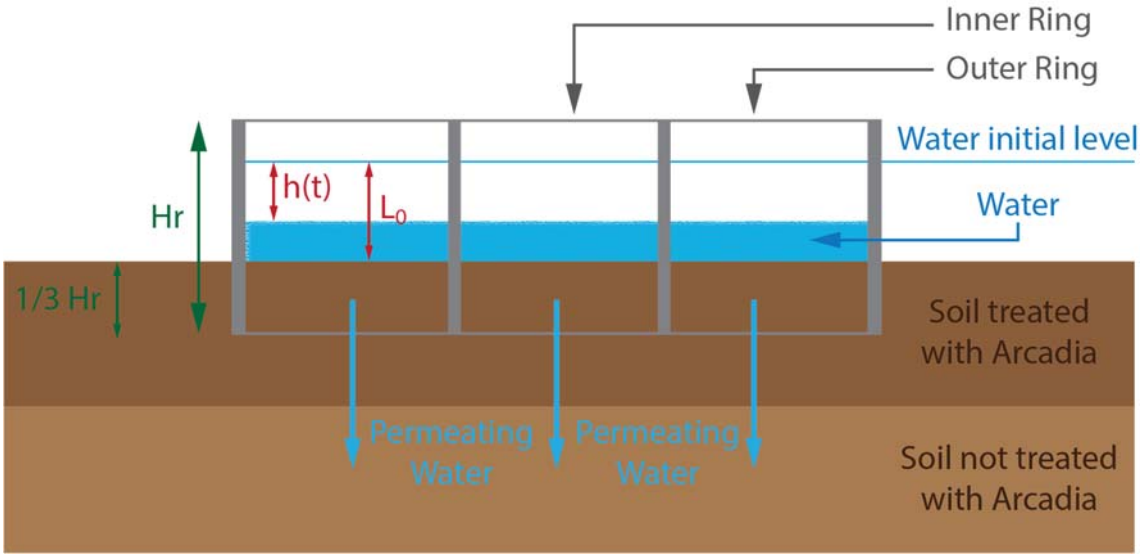


Fig. 9: Permeability Test Scheme

Fig. 10: Internal ring and plastic layer

Fig. 11: Internal ring and plastic layer

Fig. 12: Internal and External rings

Fig. 13: Permeability Test in progress

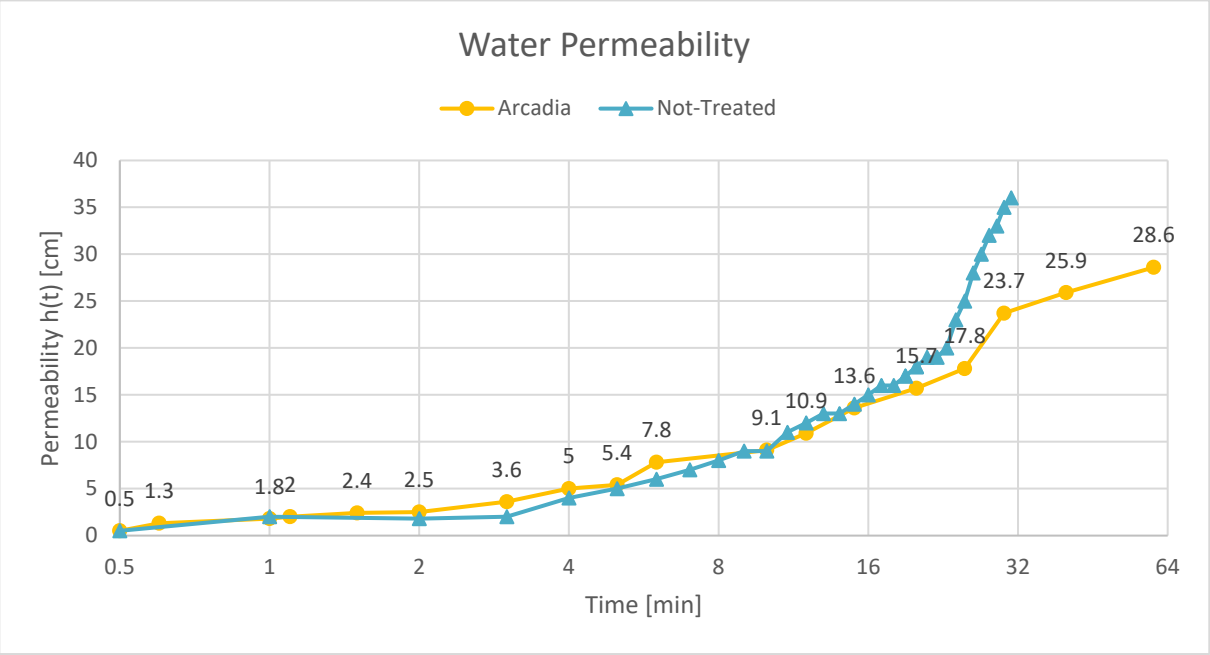
Fig. 14: Permeability Test in progress

Fig. 15: Permeability Test complete

3. Conclusions

The Test was successful: we proved that in the Sand treated with Arcadia method water can easily permeate.

As indicated in Graph. 1, the water permeability reaches 28.6 cm in one hour.
This result shows that the permeability of Sand is moderately rapid after stabilization (see Tab.2), compared to Sand samples.



Graph. 1: Measured permeability of Arcadia Sample over time

This Test's results show the following benefits achieved:

1. With Arcadia it is possible to stabilize the Sand without jeopardizing the area with any possible floods
2. With Arcadia it is possible to stabilize the Sand while the rain can still penetrate into the ground

Soil permeability Agriculture Standards		Arcadia Sample After stabilization
Soil permeability	Permeability [cm/hour]	Permeability [cm/hour]
Very slow	Less than 0.13	-
Slow	0.13 - 0.3	-
Moderately slow	0.5 - 2.0	-
Moderate	2.0 - 6.3	-
Moderately rapid	6.3 - 12.7	-
Rapid	12.7 - 25	-
Very rapid	More than 25	28.6

Tab. 2: Soil Permeability categories (reference from FAO)

Moreover, with Arcadia it is also possible to engineer the characteristics of the soil to decrease the permeability.
This will allow to create layers of soil with different permeability, that can be exploited for agriculture and many other applications, such as in Fig. 10.

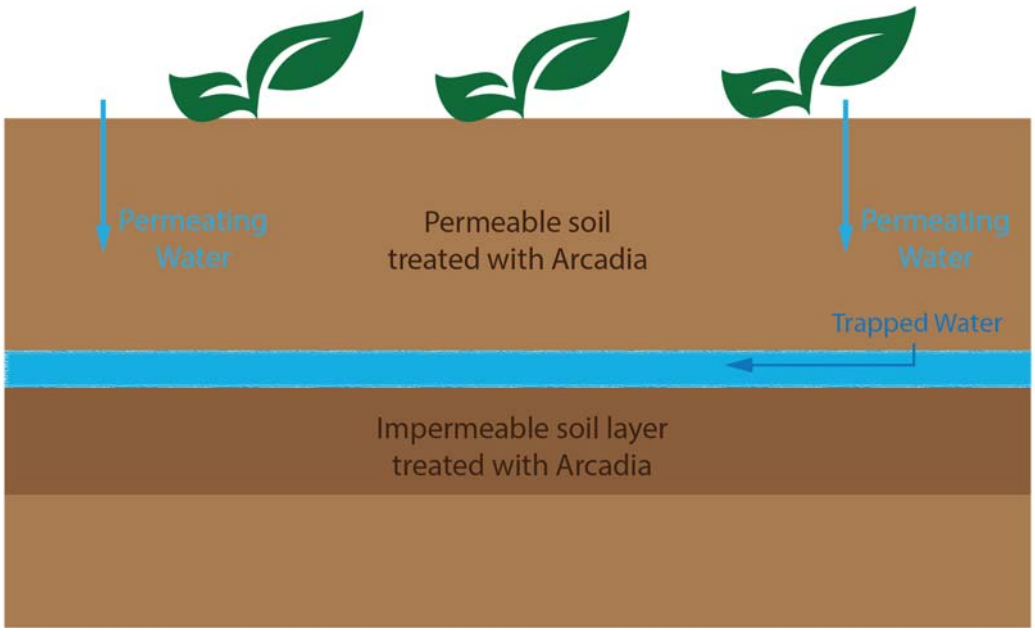


Fig. 10: Structure of permeable and impermeable layers

4. Attachments

A1 – Permeability Test Certificate