# Measurement of Suction and Infiltration on Slopes of Unsaturated Residual Soils

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Saravanan Mariappan
Nexus EC Sdn. Bhd., Kuala Lumpur, Malaysia .


Faisal Hj. Ali
National Defence University of Malaysia

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Project Leader: Prof. Dr. Faisal Haji Ali

# Measurement of Suction And Infiltration On Slopes of Unsaturated Residual Soils

Faisal Haji Ali, Low Tian Huat & Saravanan Mariappan

Department of Civil Engineering, Universiti Malaya.

**Abstract**
Instability is an extremely important consideration in the design and construction of man-made slopes and natural slopes. Slope failures and landslides are influenced by geologic, topographic and climatic factors. In tropical region, most of the slope failure occurs during severe rainfall. Rain water infiltrates into the slope and reduce the soil matric suction and the strength of the soil. Most residual soils especially in slopes are in unsaturated condition and therefore matric suction is an important factor to be considered in the design or analysis of slopes. The soil matric suction, the water content and the solute content and how they vary with time are often the most important variables in soil engineering design. Field instrumentation work to monitor variation of soil matric suction with rainfall are described in this paper and the test results are presented.

## 1.0 Field Measurement of suction and rainfall

The objective of the study is to determine the variation of field suction and rainfall. The measurement was done by carrying out field intsrumentation on each slope under consideration. Suctions were measured using tensiometers and the rainfall was measured using an automatic logging tipping bucket rain gauge. Fig.1 shows the schematic arrangement of the field instrumentation. An automatic data acquisition system which allowed continuous monitoring and supported by a solar powered set was used.

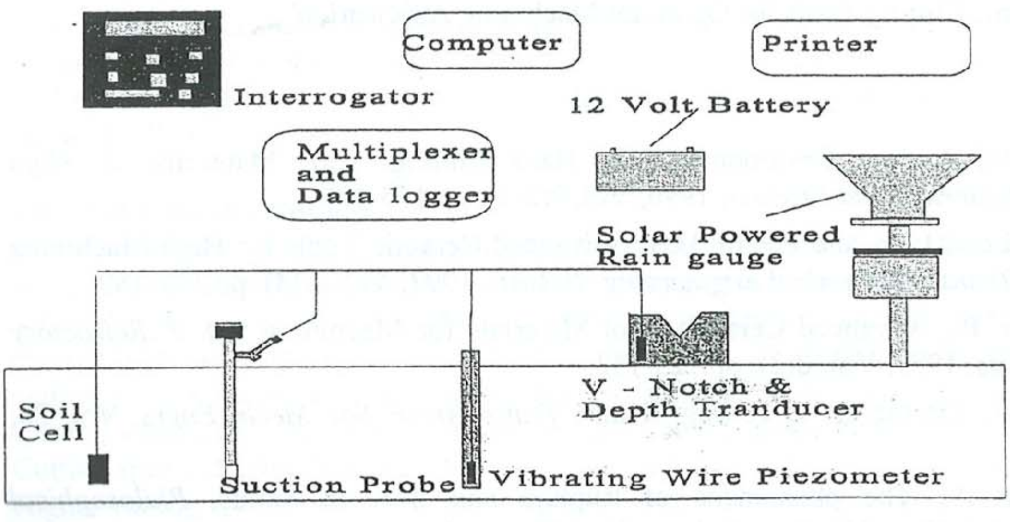


Figure 2: Schematic Presentation of Intrumentation at site

Fig.1 Schematic presentation of the field instrumentation

## 2.0 Granitic Residual Soil

The site was an exposed profile of a cut slope along the Kuala Lumpur-Karak Highway. The weathering profiles were very distinctive and various instruments for measuring suctions, soil moisture, rainfall and water table were installed [1].

The data from the 27 sensors were automatically recorded at a preset time interval and were periodically downloaded to a computer for further analysis.

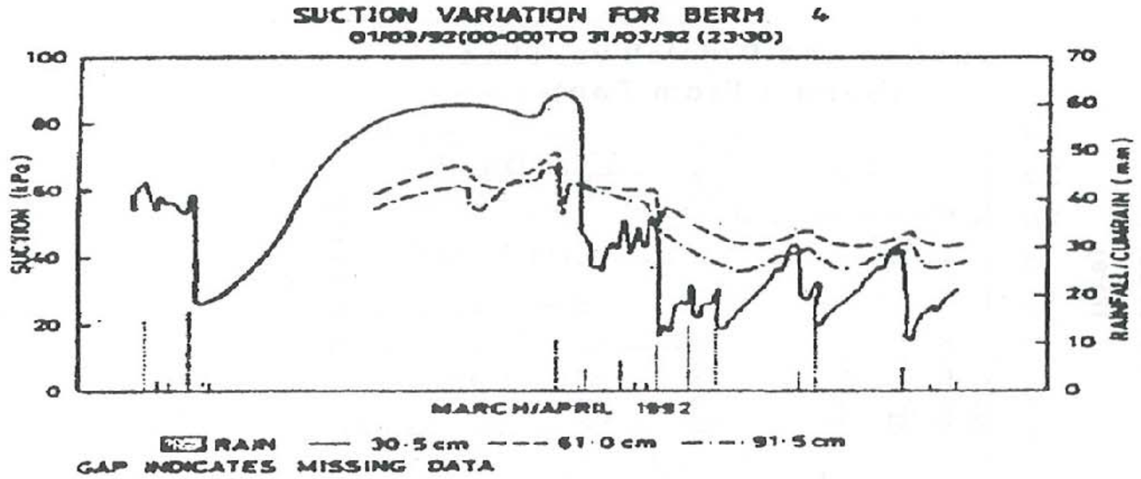


Fig.2 A typical variation of suction with rainfall

Fig.2 Shows the responses of the tensiometers located at berm 4. The suction reading for the shallower depth seems to be higher than for the deeper locations. Furthermore the response due to rainfall is less pronounced as the depth increases. There seems to be a limiting value for suction at various depths. The suction values level up to certain values depending on the depth after a spell of dry weather. The largest drop in suction is from a value of 89.2 kPa to 35.4 kPa.(depth 30.5 cm). The drop in suction decreases as the depth increases. The suction fluctuations for different berms at 30.5 cm depth are relatively large [2]i.e. from below 10 kPa to above 85kPa while for depths 61.0 cm and 91.0 cm the fluctuations are smaller (i.e. between 25kPa and 65kPa )

## 3.0 Sedimentary Residual Soil

The instrumentation was attempted to study the change of soil matric suction with the rainfall on a cut slope along the link road of The Kuala Lumpur International Airport (KLIA) Malaysia [3]. The cut slope mainly consists of two types of weathered sedimentary residual soil, i.e., weathered sandstone and shale. These residual soils come in alternate bedding which is almost vertical. The weathered sandstone bed basically is the thicker bed and the study was concentrated in one of these beds. The soil consists of very fine sand and silt. 20 numbers of tensiometer and 20 numbers of moisture block and a rain gauge were installed on the slope to monitor the changes of matric suction with respect to rainfall. The tensiometers and moisture blocks were installed at different depths. At each berm, 4 numbers of tensiometers and moisture block were installed i.e., with depth of 0.5m, 1m, 3m.The normal coring tools could not be used because the soil is brittle and hard. A specially designed motorised auger was fabricated for the installation purpose

Fig.3 shows a typical suction variation with rainfall (one month duration) for one of the berms. It clearly shows that as the depth increases, the matric suction reduces. During the time interval of 14000 to 24000 minutes, there is no rainfall and all the four tensiometers are recording increments in matric suction. When the rain starts , matric suction does not reduce immediately. Due to the infiltration of rain water into the ground, after rainfall the matric suction continues to reduce slowly for all depths . From Fig.3 , in the time interval of 0 to 13000 minutes, the 3.0m depth tensiometer gives very low suction values. This is mainly due to the water which has infiltrated during the earlier rainfall periods.

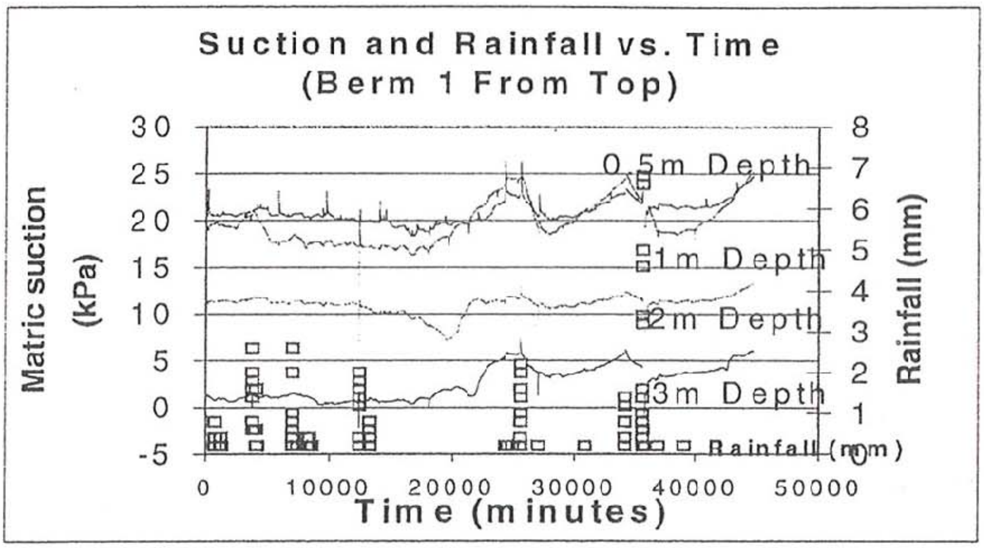

Fig.3 Typical suction variation with rainfall for one-month duration.

Recently, infiltration study was performed by using rain simulator . Water was sprayed on the slope using sprinklers as shown schematically in Fig.4. A number of large water tanks were placed at some locations on the slope in order to have enough water supply for the study. In addition to the existing tensiometers, seven small tip tensiometers were installed at 75 mm below ground surface. Four different surface conditions were studied i.e. grass + geotextile cover, geotextile only cover and bare slope. Fig.5 shows a typical variation of suction with time. In the figure shallow tensiometers are represented by 1 to 7 and existing tensiometers are denoted by A (0.5 m), B (1.0 m) and C (2.0 m). It is interesting to note that some of the shallow tensiometers indicate initial increase in suction as soon as the sprinkling begin.

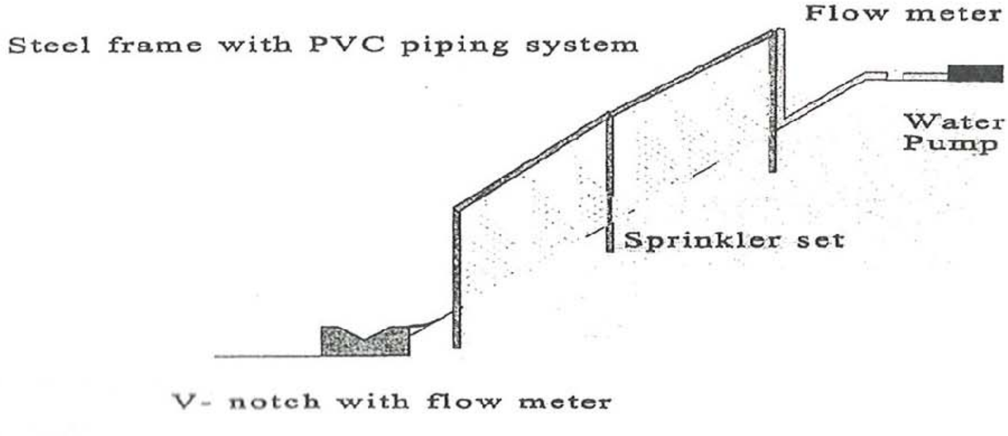

Fig.4 Infiltration test using rain simulator

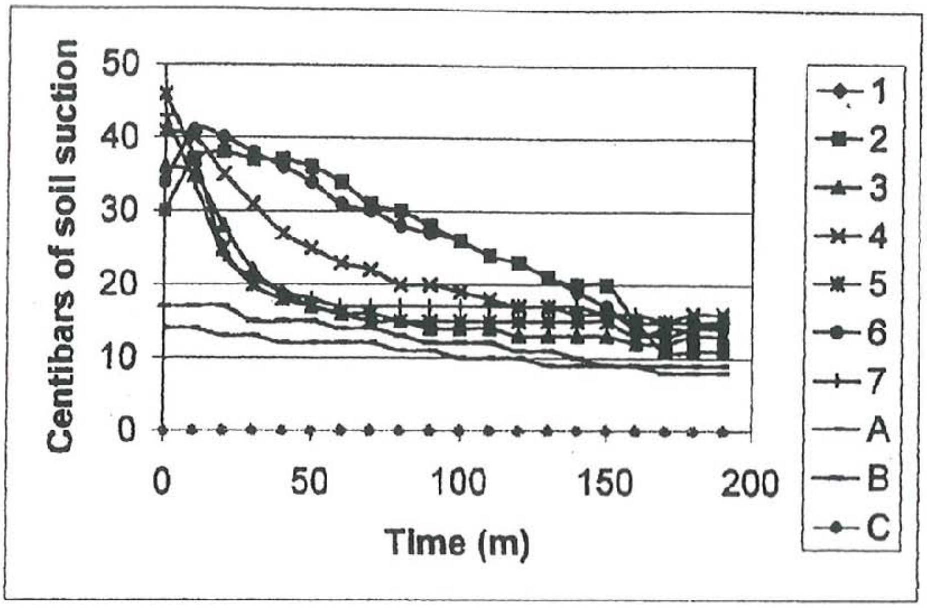


Fig.5 Variation of suction with time for uncovered slope

## 4.0 Conclusions

Slope stability in residual soils is governed by the geologic environment and climatic conditions. The heavy rainfall in tropical areas is largely responsible for many slope failures that occur in steep terrain, rapid infiltration of water occurring because of the high permeability of residual materials. The heterogeneity of the residual profiles and the random nature of the rainfall mean that the application of theoretical methods of stability analysis is problematical.

Generally as the depth increases, matric suction reduces. But, in some circumstances, due to the flux condition, this can be the other way round. High intensity and prolong rainfall may cause instability to slope . Geological features like quartz vein can be significant in slope instability because it increases the rainwater infiltration. When perched water table is formed, it decreases the factor of safety.

## 5.0 References

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