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*Original Article*

# Model Instrument for Capillary Shock Measurement and Description of the Results

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***Abstract*** - *The idea to conduct a study that can measure the capillary shock parameter in the laboratory started from the research team's observations when researching the impact of groundwater pumping on agricultural irrigation and groundwater conservation efforts in Takalar Regency. Researchers found a strange phenomenon in the existence of phreatic groundwater at the beginning of the rainy season. This odd phenomenon is a drastic drop in the groundwater level (phreatic) from the first rain until the fourth or fifth rain. This phenomenon by the research team is termed "capillary shock". The aims of this study are: (1) To describe the relationship between capillary shock parameters and soil media parameters; (2) To describe the relationship between capillary shock parameters and rainfall parameters; (3) To describe the elements of the capillary shock parameters. The stages of implementing this research include: (1) Instrumentation design; (2) Experiment/Instrument Validation; (3) Revision/Improvement of Instruments; (4) Experimental model using granular soil samples, and continued at the Experiment Model stage using finer soil samples.*

***Keywords*** - *Capillary shock, Fine soil, Granular soil, Model instruments, Rainy season.*

## 1. Introduction

The soil layers in the pendular and funicular zones in each dry season experience drying, so the soil pores will enlarge. At the beginning of the rain, the pores in the two zones will shrink again because some of the pores will be filled again with hydroscopic water, which is firmly attached to every soil grain that sucks it. Due to the shrinking of the empty pores in the soil due to being filled with hydroscopic water from rainwater infiltration, the capillary pressure of the soil layer in the capillary zone will increase so that it will suck water from the phreatic zone. Thus the phreatic water level will be degraded because the infiltrated water at the beginning of the rainy season has not yet reached the phreatic zone; but; instead, the phreatic water is sucked into the capillary layer due to the high capillary pressure arising from the shrinking of the soil pores in the soil layer in the funicular and pendular zones. This phenomenon has never been explained either empirically or precisely. The main goal of this research is to uncover and describe behavior that, while appearing as an "anomaly", can be explained empirically through model experiments that will be carried out in this study. Several parameters need to be observed in this study, which is expected to describe the empirical formulation of the relationship between phreatic water degradation, with an increase in capillary pressure, and changes in water content that occur in the pendular and funicular layers, in addition to the parameters that have been disclosed by Terzaghi & Peck before [10]

To obtain these important parameters, the simulation of changes in capillary pressure using this model test must be carefully designed to provide the expected results. Likewise, the preparation of soil samples for testing must be properly conditioned so that all required parameters are measurable. In this case, the measured soil parameters are soil grain size and void ratio (e) of the soil after compaction with controlled energy. This research found that the phenomenon of decreased water level in the early period of the rainy season was triggered by increased capillary pressure due to shrinking pore diameter after water began to infiltrate into the surface soil layer, i.e., the layer of the vadose zone. Increasing capillary pressure caused the attraction of groundwater in the saturated zone to the vertical direction, so the groundwater level decreased significantly. Therefore, this phenomenon was called by the researcher as "capillary shock phenomenon" [3]

Based on the findings of the phenomenon of falling water levels at the beginning of the rainy season, researchers have concluded that the cause is the increase in capillary water pressure, which causes groundwater to be sucked into the phreatic layer above the capillary layer. Researchers term this phenomenon "capillary shock (capillary shock). To empirically formulate the relationship between various parameters related to capillary shock, the research team proposed the implementation of a study entitled: "Measurement of Capillary Shock Pressure Techniques with Simulation Methods (Laboratory Model Test)".

## 2. Materials and Methods

### *2.1. Materials*

The model instruments used in this study will consist of; a transparent tub (glass), a sprayer equipped with a motor, a scaled water bath, and an ambrometer set. Soil compaction aids used a standard froctor mash tool modified with a square cross-section (following the shape of the tub cross section). While the reading aids used to consist of; a measuring cup with a capacity of 5 liters, a magnifying glass, and a long iron ruler. A simple scheme of the model tool designed can be seen in the following figure :

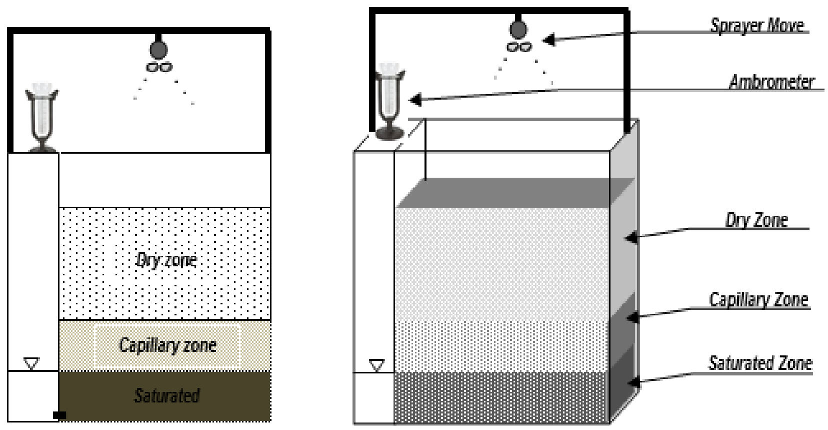


**Fig. 1 Model of Tool Design Schematic**

Starting with the schematic design of the model tool as above, the research team assembles the model equipment that will be used to test the capillary shock phenomenon on a model scale. The model tool used in the laboratory-scale capillary shock test is shown in Figure 2.

From the above instruments, we can observe the process of decreasing the groundwater level, starting at the beginning of the provision of rainfall until the duration of the rain continues to increase, and the groundwater level rises again. In addition to observing the capillary shock parameters, which include the height and time of capillary shock, several soil media parameters can also be observed, such as changes in void ratio (e), housing relative density (Dr), and groundwater seepage parameters.

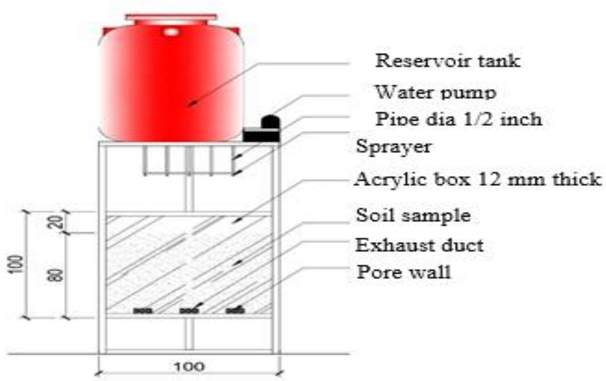


**Fig. 2 Capillary Shock Test Model Tool**

### *2.2. Methods*

In research using experimental laboratory methods, the preparation of model equipment is very important. Besides that, it is also very important to know the description of the soil sample that will be the experimental medium. Therefore, the stages of implementing this research are arranged with the following procedure:

1) The design of the instrument model, with the design results as described above.
2) Making instrument models.
3) Experiments, as well as instrument model validation.
4) Preparation and examination of the characteristics of soil samples as media.
5) Experimental model using granular soil (step-1)
6) Experimental model using finer soil (step-2)
7) Description of capillary shock parameters (capillary shock time and capillary shock height) on various soil types and most of the rainfall intensity.

## 3. Results and Discussion

### *3.1. Results*

From a series of observations made on the test using 5 types of soil as a medium and 5 values of rainfall intensity applied to the soil surface, several graphs are produced as follows:

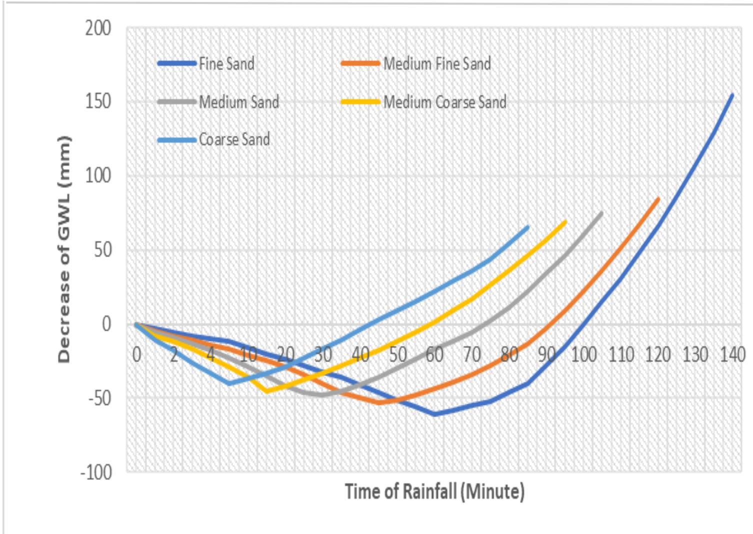


**Fig. 3 Decrease of Groundwater levels VS time of rainfall (5-types of granuler soil)**

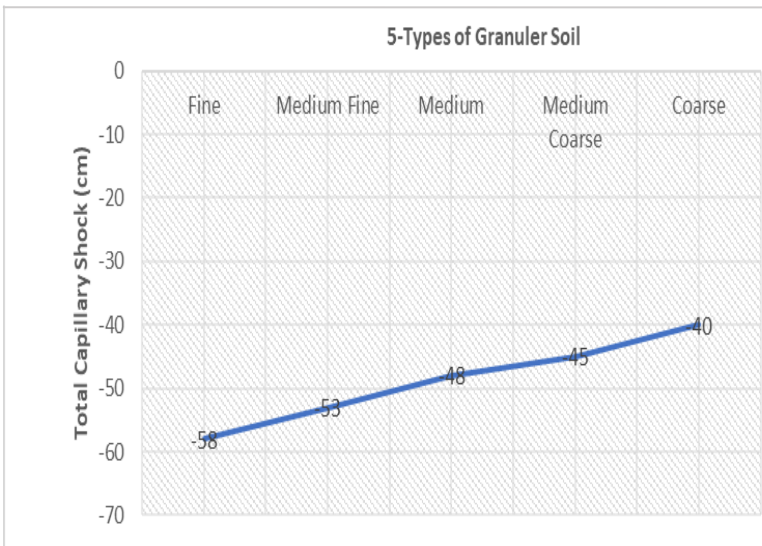


**Fig. 4 Total Capillary Shock in granuler soil (mm)**

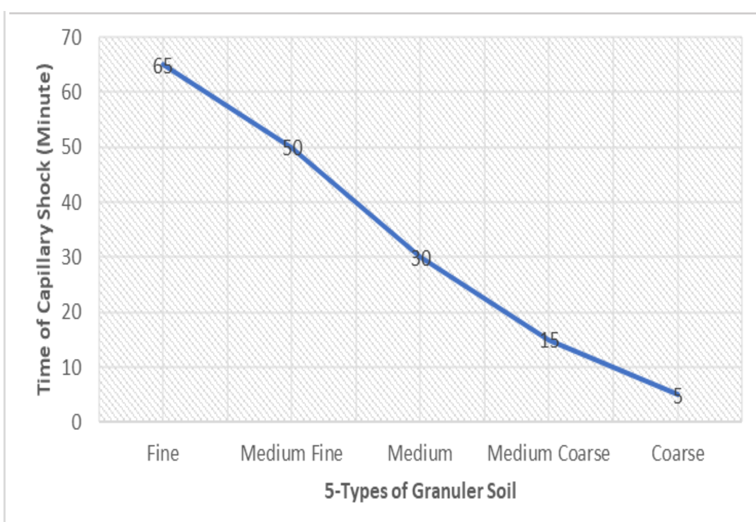


**Fig. 5 Time of Capillary Shock in granuler soil (minute)**

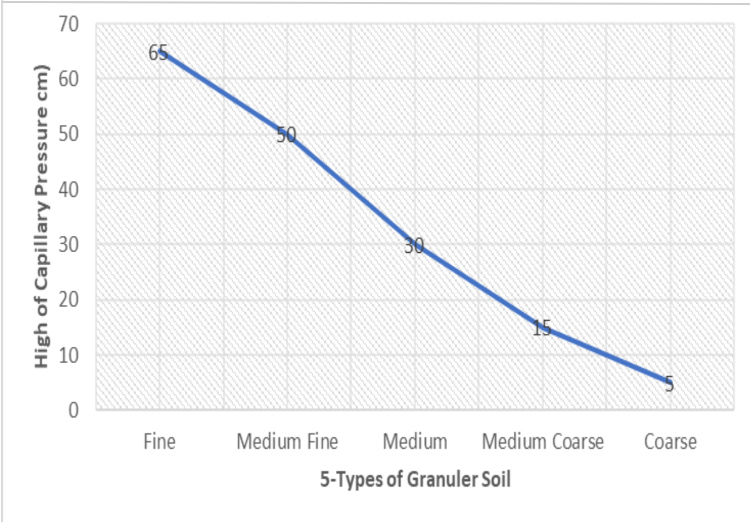


**Fig. 6 High of Capillary Pressure in granuler soil (cm)**

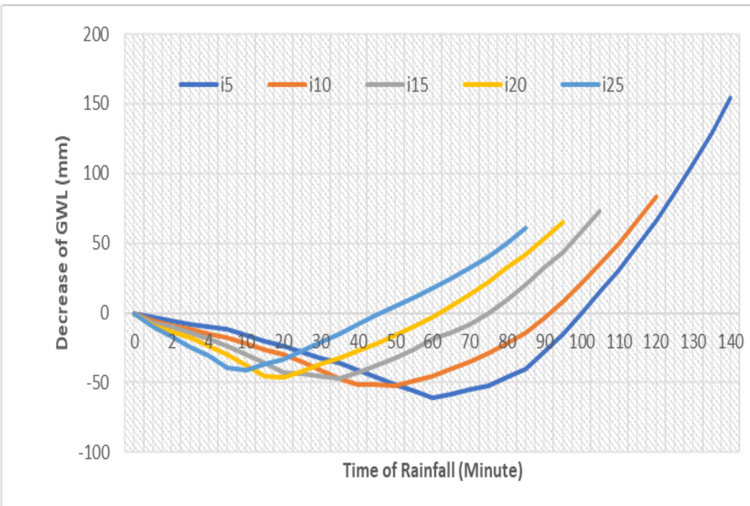


**Fig. 7 Decrease of groundwater levels VS time of rainfall (5-rainfall intensity)**

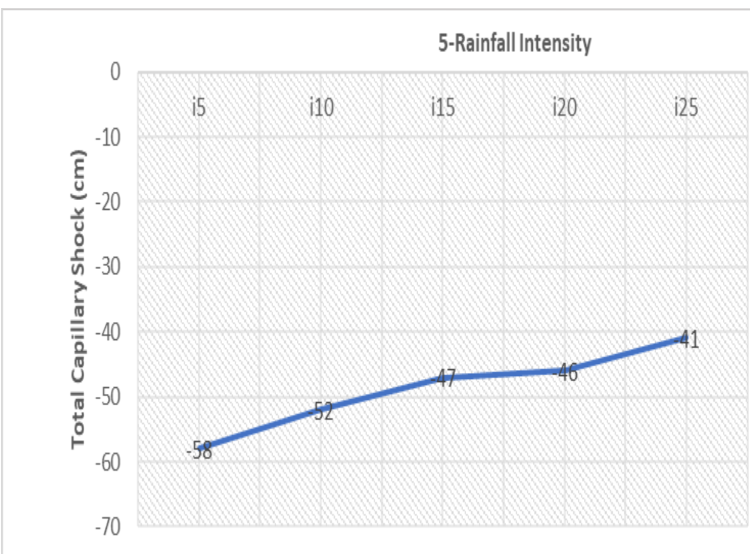


**Fig. 8 Total Capillary Shock on rainfall intensity (mm)**

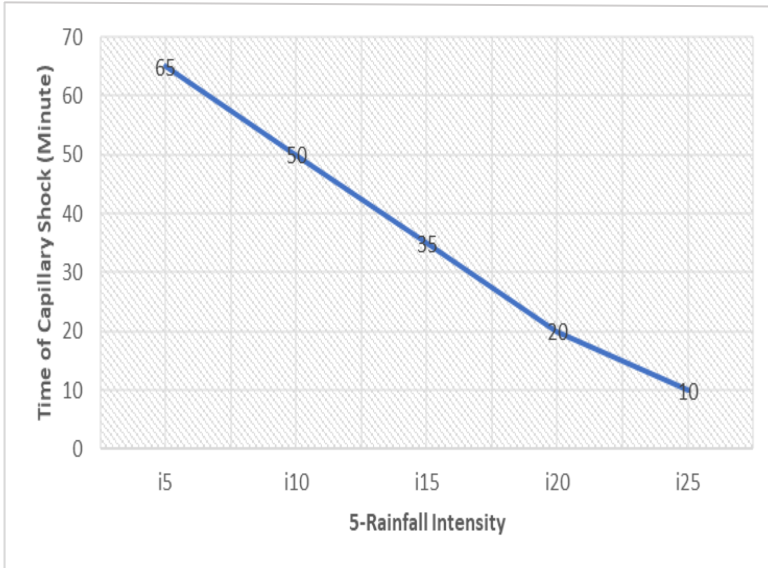


**Fig. 9 Time of Capillary Shock on rainfall intensity (minute)**

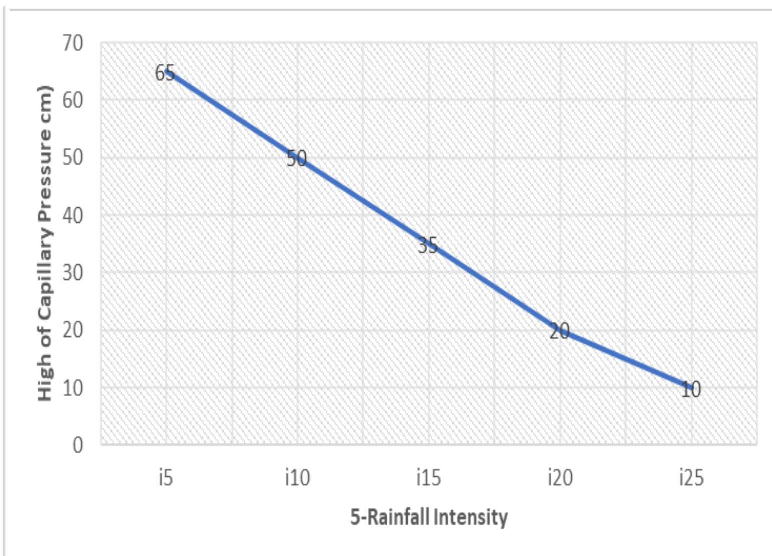


**Fig. 10 High Capillary Pressure on rainfall intensity (cm)**

### *3.2. Discussions*

From the description of the results of this study, several things can be discussed in this article, including:

1. The capillary shock parameter observed in experiments with this model consists of two parameters, namely capillary shock height and capillary shock time. In observing capillary shocks in the field using boreholes, the time of capillary shock is very difficult to observe because observations during rain are disturbed by rainwater falling directly into the wellbore. By the author, the parameter "capillary shock height" is the amount of change in the groundwater level (down) from the beginning of the rainfall on the ground surface until the groundwater level rises again (rises). While the "capillary shock time" is the time calculated from the beginning of the rain falling on the ground surface until the groundwater level rises again (rises).
2. The capillary shock parameter is strongly influenced by the value of the void ratio in the experimental medium soil. The effect of void ratio can affect the capillary shock height and capillary shock time. It can be related to the capillary pressure theory that the smaller the cross-section of the capillary tube, the higher the capillary pressure. If the void ratio is analogous to the diameter of the pipe, the smaller the pore number, the greater the capillary pressure, which will also increase the capillary shock height parameter. Likewise, the capillary shock time will increase if the cross-section of the capillary tube

gets smaller, so the duration of water seeping into the soil will be longer.

3. In addition to media soil parameters, rainfall parameters greatly affect capillary shock parameters, both capillary shock height and capillary shock time. It can be attributed to the existence of run-off, which will be higher if the rainfall intensity is greater. Likewise, the duration of the rain will also affect the run-off height above ground level. This run-off height will affect the capillary shock time and the capillary shock height parameter.

In addition to the three phenomena discussed above, the model instrument used in this study can also be used to measure the velocity of groundwater seepage, both vertical seepage and horizontal seepage. Specifically, to observe seepage parameters using this model instrument, the research team will carry out the next opportunity.

## 4. Conclusion

From the discussion above, both about the ability of the model instrument used and about the description of the correlation between soil media parameters and rainfall with capillary shock parameters, some conclusions can be drawn from this research as follows:

1. The model instrument used in this study can provide 2 values for the capillary shock parameter, namely "capillary shock height" and "capillary shock time". In addition to the capillary shock parameter, it is proven that this instrument model can provide a parameter value for the seepage of water in the soil (seepage).
2. The value of the void ratio of the soil media greatly affects the values of the capillary shock parameters.
3. The intensity of rainfall that falls on the soil surface greatly affects the values of the capillary shock parameters.

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