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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Behavior analysis by model slope experiment of artificial rainfall" *by* M. C. Park

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Anonymous Referee #3

Synopsis: The paper presents the results of a model slope experiment aimed at the analysis of the process of slope failure and seepage under rainfall. The experiment has also been reproduced via numerical modelling, in order to compare the experimental and numerical results.

General comments: In my opinion, physical laboratory modelling can be an extremely useful tool to better understand the mechanisms and conditions that lead to landslide triggering, and so I really appreciate the content of the paper, which is also well struc-

tured and mostly well written. However, although I agree with the use of numerical simulations to verify the experimental results, I am not sure what the purpose of the work is. In other words, modelling is a good thing, but the authors should focus on specific questions regarding slope failure, because the text is fairly vague in this respect.

I also believe that further experiments are needed to make the paper acceptable, as suggested by Referee 1. Currently, the lack of further experiments does not allow to interpret some results: in this sense, the section "Results and discussion" need to be improved, as emphasized by Referee 2. If additional experiments are performed, then the authors will be able to analyse in more detail the investigated process, as well as to test the reproducibility of the experiment, in such a way as to exclude potential errors.

- Answer : The purpose of this study is to reproduce rainfall-induced slope failure through the model experiment and to compare with the unsaturated slope stability analysis and verify it. Various experiments on initial conditions such as slope failure process induced by the rainfall and the unsaturated state of the model slope etc. and boundary conditions such as rainfall etc. can be performed and experimental result can be compared with the numerical analysis results. As I mentioned earlier in an answer about the Referee 1, in addition to the experiment presented in this paper, four experiments with different slope gradient and rainfall conditions were performed. I will further upgrade "Results and Discussion" by adding experimental results.

General comments: Finally, I suggest to perform experiments with different initial and boundary conditions, in order to evaluate their importance (as stated several times in the manuscript). Specific questions for the authors to address and suggestions for improvement are reported in the following paragraphs.

- Answer : It is important to perform an experiment by making initial and boundary conditions be different and evaluate all of these for the quality of the study. However, the

purpose of this study is how to properly evaluate rainfall-induced slope failure with a method of unsaturated slope stability analysis. The design criteria is being presented in order to perform the unsaturated slope stability analysis by limit equilibrium method based on the effective stress of the seepage analysis. Thus, verification of the unsaturated slope stability analysis presented in the design criteria was the primary purpose in this study, there's no point in performing the experiment in all conditions, because rainfall-induced slope failure not occured the model slope with inclination of 50 degrees. Eventually, the rainfall-induced slope failure is caused by rainfall seepage. This can be analyzed in seepage analysis and has already been validated by many scholars. Since little has been known about cases of the comparison between this design method and experimental results, a research about this area was conducted in this study.

Question : p. 4160, line 17. This sentence is a bit generic and needs some references.

- Answer : I'll add references.

Question : Table 1. Modify the table, distinguishing three columns for 1) test type 2) obtained parameter 3) measured value. Use m s-1 for the hydraulic conductivity and kN m-2 for the cohesion. Furthermore, you have to add the call for the table in the text. Figure 1 and Figure 2. You have to add the call in the text also for these two figures, I would say at the beginning of the section "Material and methods".

- Answer : I will modify the units of saturated permeability and cohesion. Also, I will specify Figure 1 and 2 in the text.

Question : p. 4165, line 1. "The artificial rainfall would introduce surface erosion and the formation of gullies". Your statement is correct, but such phenomenon may change the rainfall infiltration process. Is this effect accounted for by the numerical model? If not, I suggest to use a spray nozzle as rainfall simulator, in order to avoid

the mechanical erosion by water.

- Answer : As Referee 3 mentioned, this experimental process will affect the seepage process. However, it does not matter because seepage analysis was also performed in the same boundary conditions in numerical analysis. The rainfall was not reproduced on the inclined plane of the model slope in the model experiment, numerical analysis.

Question : Table 2. Modify the table as suggested for Table 1, distinguishing between soil and crushed stone.

- Answer : Table 1 shows the experimental results about soil of the model slope. The crushed stone layer does not affect the slope failure process, which is formed for drainage of seepage water. Saturated permeability was presented in Table 2.

Question : p. 4165, lines 9-17. This part is a bit out of sequence. I suggest to insert it when you describe the slope stability analysis (P. 4166, line 4).

- Answer : Since the unsaturated slope stability analysis is performed after seepage analysis, it is thought to be appropriate that the process and procedure of the seepage analysis and a description of the unsaturated properties of the soil from the 9∼17th line of page 4165 comes ahead of the limit equilibrium method.

Question : p. 4165, line 15. Replace with "Air entry pressure Ub is"

- Answer : I'll replace it into "Air entry pressure Ub is".

Question : p. 4167, line 21. Sensor F?

- Answer : The word 'Sensor F' is a typing error. I'll delete it.

Question : p. 4167,lines 23-24. Figure 4b and f? Did you mean Figure 4 sensor B?

- Answer : The contents of the sentence means that noise was occurred in the Tensiometer Sensor B and this is a description of the contents shown in Figure 6. Thus, I'll delete 'Figure 4b and f'.

Question : p. 4168, line 9. "However, in the model slope experiment, slope failure occurred later in sensor D" Please rewrite this sentence more clearly.

- Answer : It is a typing error. It is not 'slope failure', but 'seepage behavior'. Thus, I will change it into the sentence like this ; " However, the seepage behavior of the D sensor happend late in the model slope experiment, like Fig. 7(d)."

Question : p. 4168, lines 17-19. I suppose that the time at the start of decrease is similar both for matric suction and water content in the case of sensor A, but it is not clear. Please rewrite this sentence more clearly.

- Answer : In the case of A sensor, the time that matric suction was reduced and its reduction amount was appeared to be similar in the model experiment and numerical analysis.

Question : p. 4168 lines 21-27. This part is a bit confusing: which sensors converge to 0 kPa at 165 min (from the beginning of the rainfall)? Are you sure that slope failure occurred 210 min from the beginning of the event? It doesn't seem so according to Figure 8.

- Answer : It is a description part by comparing the time that matric suction was changed by the rainfall seepage and the time that slope failure happened, but readers might be confused on that sentence, so I'll modify it.

Question : Figure 9. Why phi (the internal friction angle, I suppose) is equal to 33.6? In table 1 and table 2 is 36.9.

- Answer : The internal friction angle of the samples of the slope is 33.6 degrees shown in Figure 9. The most appropriate relative compaction that can reproduce the slope failure with weathered granite soil that is a target sample was set to be 85% by performing direct shear tests according to the relative compaction in the research process. At this time, there was a typing error of 36.9 degrees in the text due to the author's misunderstanding. I'll appreciate it if you understand in this matter.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 3, 4159, 2015.