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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "A theoretical model for the initiation of debris flow in unconsolidated soil under hydrodynamic conditions" *by* C.-X. Guo et al.

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Response to referee 2#

Thanks for your important comments on this manuscript. The authors appreciate the constructive comments. Those comments have been very helpful for the authors to improve this manuscript. The detailed response and revision can be found as follows and Supplement.

*Overall comment Influence of rainfall on the stability of an unconsolidated landslide deposit slope was investigated experimentally by the authors. Findings from the exper-

iments are of great value to interpret mechanism of the debris flow. The manuscript deserves to be published. However, 3 suggestions for its revision are given in the following. An

Response: Thanks for referee's comment. Under rainfall condition, shallow failure soil on the unconsolidated slope with widely graded and loose deposits is the main source for slope debris flow. Meanwhile, shallow failure is an important process before debris-flow initiation. Therefore, shallow failure mechanism and prediction model in this paper provide certain basis for analyzing debris-flow initiation.

Detailed comment 1 It is a little bit difficult to understand debris gradations tabulated in table 2, debris sized 60$\sim$80 could not be traced after experiment. It is therefore suggested that the authors explain this in the manuscript. Moreover, depths of the three layers of the debris deposits need to be specified in order that readers may understand the experiment results easily. Response: Thank you for the referee's suggestion. In table 2, we wanted to illustrate the sample soil which has the particles with size of 60$\sim$80mm. And in the experiment, the particles larger than 60mm are removed for avoiding the scale effect. (See details in Table 1) Additionally, due to our flume requiring a large amount of soil material for each trial, we placed the soil material layer by layer at three times. So the three layer soil may have small difference in grading.

Detailed comment 2 Shear strength of unsaturated debris deposits (in table 3) seems irrelevant. It is suggested that a detailed description for its usage is given. Further, sampling location for the direct shear tests as well as the gradation of the debris should be stated since the strength is closely related to the interlock of the debris, particularly after the process of "coarsening" due to rainfall.

Response: Thanks very much for the referee's comment. In fact, the materials in our experiment contain some clay (Based on the laser-phase Doppler analyzer, the clay percent content is about 5%), therefore the soil exhibits a little cohesion. In the experiment, the superficial fine particle is migrating from surface to slope inside. So the grading of superficial soil has changed. Especially with the clay decreasing, the superficial soil will show a nearly-zero cohesion and lightly reduced internal friction angle. The shear strength of unsaturated debris deposits is used to analyze the slope stabilization in different state. And sample of soil in this manuscript is from Wenjiagou Gully in Qingping area, southwestern China. (See details in Line 172∼178, 77∼78)

Detailed comment 3 It is strongly suggested that writing is re-examined by the authors (and preferably by an English native speaker). Several errors are found in the manuscript, e.g. the line 323 (details are in section 4.2), the line 351 (F should be f), etc. Response: Thank you for the referee pointing our some errors. And we have checked the manuscript again and the detailed revise is as follows: (1) In line 217, the soil surface friction provided by the surface flow f is interpreted as below. The hydrodynamic effect on the soil surface can be simplified into shear stress along the slope surface and dynamic pore water pressure except the hydrostatic pressure. The shear stress analysis of f is shown in Figure 7 and Line 229∼250. According to hydraulics theory, the shear force F that is generated by the surface flow on the slope surface can be calculated as follows:

where is the density of water; l is the slope length; λ is the friction loss factor of the hydraulically open channel, and when the thin water flow is laminar flow (Re<2000, Re is Reynolds number), λ=64/Re; when it is turbulent flow (Re>2000), λ=1/[2lg(3.7R/Δ)2] (Nikuradse empirical formula). R=A/χ is the hydraulic radius of the cross-section; and Δ is the roughness (slope surface sand diameter), which is usually close to 30-60 mm in a pebble river bed. (2) In line 351ïijŇthe shear force ‘F’ should be ‘f’. It has been corrected in the manuscript. (3) The hydrodynamic effect in the soil inside is omitted. And it may be an important force for the soil failure and shallow slide. The detailed analysis has been added in the section 3 (Line 251∼263). Water pressure in the soil is generally divided into hydrostatic and dynamic pressure. Owing to the dynamic pore water pressure always generated by soil contraction or seepage, the superficial widely graded soil doesn't have this effect at saturated state with fine particle lost. However,

the Reynolds stress from turbulent mixing in pore water which can be regarded as dynamic water pressure should not be ignored, although it has a small value (The detailed description is shown in Figure 7). Hotta, et al (2011) constructed a theory formula about Reynolds stress in debris flow. But in soil, this stress has few literatures to analyze. So we proposed an empirical formula to forecast this stress. The formula is as follows: pd=Av2 Where pd is the average Reynolds stress on the cross section of shallow failure layer, kPa; A is empirical constant, called dynamic pore water pressure coefficient. Generally for the pure water, it is 0.5; is the pore fluid density, kg/m3; v is pore fluid veolicity, m/s. Here, the Reynolds stress is in fact the impact stress by pore fluid. (4) The writing of this manuscript has been carefully examined and corrected.

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/2/C1931/2014/nhessd-2-C1931-2014-supplement.zip

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 4487, 2014.