Nat. Hazards Earth Syst. Sci. Discuss., 2, C1939–C1943, 2014
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Natural Hazards and Earth System Sciences
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2, C1939–C1943, 2014

Interactive Comment

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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Received and published: 3 September 2014

I am sorry for the error material for last discussion. The detailed response and revision can be found as follows and Supplement. *Overall comment This paper presented a theoretical model to analyze the initiation of debris flow. This is an old but interesting topic. First the authors summarized the advances in this area. Then they presented a theoretical model based on experimental observation. This paper has some problems should be clarified. Response: Thanks for referee's comment. Based on physical model experiment, present model in this paper is proposed by considering hydrodynamic effect which is usually omitted in current realization. Hence, it is more accurate

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Interactive Discussion

Discussion Paper

to forecast soil failure on the slope with widely graded and unconsolidated soil.

Detailed comment 1 (1) Since in experiments the particles with diameter larger than 60mm excluded, the data of “cumulative ratio” should be modified in Table 2. Response: Thanks very much for the referee’s suggestion. The cumulative ratio of “80mm” has been deleted because the particles with diameter larger than 60mm have been excluded. And Table 2 has been corrected as follows. Table 2 Particle size distribution characteristics of the soil used in the experimental test Grain size(mm) Cumulative ratio (%) First layer Second layer Third layer <60 100 100 100 <40 100 90 82 <20 40 60 72 <5 10 28 40 <2 10 18 10

Detailed comment 2 (2) The description of the experiment should be detailed introduced. How much is the size of flume? How to layout the artificial rainfall apparatus? Were the artificial rainfall and water flow occurred at the same time or rainfall happened first and then water flow happened? The author said that water flow was supplied by an other flume in experiment. But in practice it is most formed by rainfall. So the water is changed with rainfall intensity and duration. To adopt a water flow with stable depth and velocity in analysis is very idealized. At least this point should be an assumption. Actually the change of flow depth has obvious effects on the initiation of debris flow because it can cause excess pore pressure and increasing pore pressure gradient. Response: Thanks for your comment. The detailed flume size and layout of artificial rainfall apparatus and runoff supply have been shown in Figure 1 and Figure 4.

Figure 4. sketch design and actual shape of the flumeïijŽartificial rainfall test equipment for unconsolidated soil (PWP and VWC are the pore water pressure and volumetric water content, respectively) And in section 2.2 and 2.3, experiments with runoff are considering the rainfall alone, and experiments with runoff are considering the runoff meanwhile with rainfall. The detailed condition and layout should be introduced to avoid a confusion, and it has been added in the manuscript (see details in line 72∼75, 115∼117, and Figure 1 in manuscript). In this manuscript, the overland flow is provided by a water tank which can control flux and simulate the superficial flow on the

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slope. Though it can't reach a steady state, whole velocity of this overland flow can be assumed as the same value because of its shallow depth. Additionally, due to the small catchment area in flume experiment which can't simulate the actual thin sheet flow, a water tank is applied to supply the runoff condition. The water depth is sensitive to soil failure and debris flow initiation, so that the runoff is strictly controlled with shallow depth.

Detailed comment 3 (3) Eqs.(12) or (14) can only be used in case of infinite condition or aÂńl. In the experiment (Figs.2,4), the failure is more like a finite model. Other methods such as circular slide method may be more suitable in this case. Response: Thanks for the referee's suggestion. Eqs(12) and (14) in old edition are only used in case of infinite condition or aÂńl. However, in this manuscript, it is suitable for shallow failure because: (a) Though the experiment slope is much smaller than field condition, shallow failure size is smaller comparing with the whole slope. (b) Fine particle migration and blockage effect would form local water perched table which is distributed in layered mode. And this water perched table can be seen as the slide surface for shallow failure. Except the above, circular slide is more suitable for large-scale or deep landslide. And in these conditions, the circular sliding surface is difficult to get accurately, which is always instead by searching critical slip surface. In the shallow failure model, the sliding face is always formed by fine particles migration and accumulation which can be predicted through analyzing the fine particle movement or empirical formula.

Detailed comment 4 (4) Depth of initiation "a" cannot be a factor to analyze the sensitivity. It is a dependent variable determined by independent factors such as rainfall intensity, water flow velocity and parameters of soil layer. Because the material has only 10% of particles with diameter less than 2mm, the cohesion can be ignored. So it can be excluded from Eq. (14) and the sensitivity analysis. Response: Thanks for the referee's comment. The parameter "a" should not a factor for analyzing its sensitivity. And it has been modified in section 3.2 and deleted from sensitivity analysis in section 3.3. And due to the widely graded and unconsolidated soil has little cohesion, the item of cohesion can be ignored and sensitivity analysis (see details in section 3.3 and Line 264∼273, Table 3). The following simplified form of two-phase flow equations will be used (Cheng et al, 2001; Lu and Cui, 2010a, b;). These equations are based on the assumption that the flow is one dimensional and the wall friction and inertia effect may be neglected. Only the simplest form of interaction between sand grains and water, namely Darcy's law, is taken into consideration.

where ε(x, t) stand for the porosity at the depth of x and time of t ; ε0(x, 0) is the initial porosity for soil material; U(t) (unit is cubic meter every second-m3/s) is total flow charge at unit cross-sectional area; t (unit is second-s) is the time; L (unit is meter-m)is the soil thickness; $\lambda$is a small parameter, employed to obtain an asymptotic solution; T and u* are empirical constants.

Detailed comment 5 (5) It'd better provide more experimental results to support the theoretical results. This paper should be carefully revised before publication. Response: Through the current literatures (Tsai, 2008; Gabet & Mudd, 2006; Kean et al, 2013; Gabet, 2003;), we can find that though the flow deph, pore water pressure, even the porosity, the soil strength and failure depth are still difficult to measure for simulation and verification. In this manuscript, similar to Iverson(1997), measured data in the experiment can satisfy the need of computation and verification. Moreover, keeping the variable and parameter values constant except the cohesion, Iverson model (1997), Takahashi model (1991) and presented model are compared in Section 4. The results show that presented model is safer than the other two models with smaller safety factor. Thus, two advantages which are the sliding face forecast and rational assumption considering hydrodynamic effects will be more convenient and simpler to predict shallow failure even the debris flow event. About the model verification, though we repeat our experiment many times with two bed gradient, it is difficult to change the bed gradient with this huge flume for verifying this model. To verify the correction of our model, we will get more field data and small-scale experiment data to improve this model.

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/2/C1939/2014/nhessd-2-C1939-2014-supplement.zip

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

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