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Discussions

Interactive comment on "An evaluation of influential factors on landslide mobility during the 2008 Wenchuan earthquake" *by* D. P. Guo et al.

D. P. Guo et al.

guodeping99@gmail.com

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Dear reviewer,

First of all, thank you so much for your kind comments on our manuscript, entitled " An evaluation of influential factors on landslide mobility during the 2008 Wenchuan earthquake". We will reply your kind comments one by one, as follows:

****P=Page; L=Line****

Comment 1: The authors tried to use and relate some parameters to the landslide mobility through a statistical approach. But this reviewer failed to see the physical meaning of these analyses. If the models were not supported physically, the models

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would be meaningless. Say, the authors tried to conclude that some parameters have a linear relationship with landslide mobility index, but they did not provide the reason, namely, the possible physics behind these phenomena. On the other hand, for this reviewer, it is very difficult to find a linear relationship between those parameters and the mobility index presented in Fig. 4 and Fig. 7. The very low values of R2 make this reviewer doubting reliability of the approach proposed by the authors.

Response: the physical meaning of each influential factor has been discussed in the text, such as:

Slope angle (θ): physical meaning has discussed in P 618 L 24 $\sim$ P 619 L 1-8 Kinetic energy consumed by internal friction has positive correlation to slope angle; meanwhile, the steeper the slope is, the faster the velocity of sliding mass is, the higher the consumption of kinetic energy due to impact at the foot of upper slope. Therefore, the likelihood of high mobilization landslide was relatively low to ocurr on the steep or very steep slope. This general tendency related to the tangent of 5 slope angle of earthquake-induced landslides is consistent with previous studies on non-seismically induced landslides (Okura et al., 2003; Hunter and Fell, 2003; Hattanji and Moriwaki,2009, 2011).

slope transition angle (β): physical meaning has discussed in P 619 L 9-24 slope transition angle represents the changing degree of slope inclination, then the physical meaning of slope transition angle is that the energy consumed by the impact can be represented by slope transition angle.

Slope height (h) is the elevation difference of the sectional slope within the failed part. physical meaning has discussed in P 619 L 29 $\sim$ P 620 L 1-6 slope height implies the potential energy of failed mass and governs the available space to accelerate the failed mass. The higher slope height is, the larger velocity is, then larger velocity will result in a larger amount of kinetic energy loss due to impact, namely, the higher slope is, the larger kenetic energy will be dissipated. When larger kenetic energy is consumed,

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landslide mobility ($1/\mu$) would be lower, hence, the equivalent coeffcient of friction (μ) has a positive 5 correlation with slope height.

The response to the linear assumption is as follows: Because landslide mobility ($1/\mu$) is simultaneously affected by numerous factors, however, the relationship between landslide mobility ($1/\mu$) and each factor in Fig.4, 5,7,8,9,10 is very week, even has no linear relation. In order to explore the empirical model with influential factors, the equivalent coefficient of friction is supposed to be linearly correlated to all of these influential factors and obeys the following model. (Here, some parameters are transformed, such as, volume (V) was transformed to logV)

Based on F tests and t tests, multiple linear regression is implemented and backward elimination approach is applied to obtain optimization model. F-test is used to check and ensure the statistical model has statistical significance, and the t-test is used to check and ensure the regression coefficient of each factor has statistical significance. If an empirical-statistical model satisfy both the F-test and t-test, it suggests the model is reliable.

Comment 2: Some interpretations were based on the authors' images without field evidences or theoretical analysis. For example, the authors failed to see any relationship between the equivalent coefficient of friction and the sine of slope transition angle from Fig.5, but they concluded that these two factors had some relation based on Fig.6. As this reviewer understands, the slope transition angle is the feature of topography before the occurrence of landslide, and Fig.6 can only tell us that more landslides had been triggered on those slopes with slope transition angle being 160-170 degrees. They are basically two different concepts. Nevertheless, the authors concluded that they have some relationship and also tried to explain the reason by guess

Response: The sketch of landslide and its deposit for each parameter definition is shown in following figure.

From Fig.5, we can't find a significant relation between landslide mobility and the sine

of slope transition angle, but the topography definitely has effect on the feature of falling mass, because the falling mass would impact at the foot of the slope change. As result of data limitation, we can't find significant relation in Fig. 5, the effect of slope transition angle was indirectly analyzed by statistical histogram in Fig.6, which shows us that long travel landslide mainly concentrates in the 160-170o slope transition angle group. In order to explain the phenomenon of long travel landslides concentrated in the 160-170o slope transition angle group, we infer that different topography changing degree, namely different slope transition angle, has effect on the movement type of falling mass. Furthermore, from the definition sketch of each parameters in Fig.1 (above), slope have different sections with different inclinations, the slope transition angle is lower than the landslide occurrence section, therefore, the slope transition angle exists not only before the landslide but also during failed mass sliding down.

Comment 3: Figure 7 is in the natural order of things, because the authors plotted H/L against H.

Response: Fig.7 shows the relation between Hmax/Lmax and slope height (h), slope height (h) is the elevation difference of the sectional slope within the failed part. h denotes the accelerating distance from failed part to slope foot, it implies the kinetic energy before impact at the foot of slope.

Comment 4: It is understood that the PGA estimated through equation 1 will be in very low accuracy. It is also expected that PGA would be affected by many site effects (such as bedrock, elevation and topography). Therefore, this reviewer doubts the reliability of the data presented in Fig.8 and then the conclusions made basing on these data.

Response: The equation 1 is for horizontal acceleration attenuation empirical model of hanging wall and footwall sides, the coefficients of determination (R2) are 0.64 and 0.55 on hanging wall and footwall sides, respectively. The significant level of regression is not very high, but it belongs to medium level with statistical meanings. Meanwhile, this result was accepted by other reviewers and published by Engineering Geolgoy,

Vol.152(1), 2013, therefore, the PHA estimated based on equation 1 is acceptable.

Comment 5: Concerning the effect of rock type, this reviewer suggests that the authors make further examination on the data used in the draft. As seen in Fig. 9, the authors selected 12 cases for RT1 and RT2, but 28 cases for RT3 and RT4. If we just selected those cases with H/L being smaller than 0.6, we may have differing conclusion. Namely we may conclude that they had same mobility.

Response: In order to explore the effect of rock type on landslide mobility, considering the feature of travel path of long travel landslides (not considering whether the value of Hmax/Lmax smaller than 0.6) will affect the mobility of landslide, therefore, the criterion of selection of landslides was described in P 617 L 21-24: In this paper, collected landslides travelled over a relatively open slope or partly confined by lateral gentle slope, it is means that those landslides were excluded, which was obstructed by river, valley and relatively large infrastructures or confined by lateral steep slope or travelled over a large deflection path. Based on Chinese Manual of Engineering Geology (Chang et al., 2006), according to rock strength and weathered degree, rock materials are classified into two types and four sub-classes (shown in Table 1), that is, RT1, RT2, RT3 and RT4.

Comment 6: Due to these problems mentioned above, this reviewer doubts the need or reliability of the model as presented by equation 2

Response: Based on one by one qualitative analysis of the general tendencies between equivalent coefficient of friction and 6 influential factors, the results suggests that each influential factor had more or less effect on landslide mobility ($1/\mu$), but the statistical correlation between equivalent coefficient of friction (μ) and each influential factor is very weak, even no correlation, it implies that if only considering one influential factor, it was impossible to obtain a reliable regression model to estimate landslide mobility based on these 46 landslides triggered by the 2008 Wenchuan earthquake; it also implies that landslide mobility was not affected by one main factor but simultaneously

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affected by numerous factors. As a result of numerous influences on landslide mobility, in order to clarify which factor/factors is/are predominant, multivariable analysis would be used to quantitatively explore the effectiveness of each factor on equivalent coefficient of friction by multivariable analysis and backward elimination regression, as shown in Table 4. In order to ensure the regression model has statistical meanings, F-test was used to check the significant level during each backward regression step, meanwhile, t-test was used to ensure the regression coefficient has statistical meaning, otherwise, the parameters without statistical meanings would be deleted and recalculated. If an empirical-statistical model satisfy both the F-test and t-test, it suggests the model is reliable. Furthermore, the comparison shown in Table 5 suggests that the empirical model in this paper not only improved the estimation results but also considered more potentially influential factors on landslide mobility.

Comment 7: Although this reviewer does not think that language should not be a key issue in judging a scientific paper, the English of this draft should be thoroughly sharpened.

Response: Thank you very much for your kind understanding. The English expression has been checked and refined.