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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Assessment of the physical vulnerability of buildings affected by slow-moving landslides" *by* Qin Chen et al.

Qin Chen et al.

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Dear Referee, We would like to thank you for your professional and constructive comments concerning our manuscript entitled "Assessment of the physical vulnerability of buildings affected by slow-moving landslides". These comments are all valuable and helpful for revising and improving our manuscript. We have seriously considered and provided our point-by-point responses, which are listed below.

(1) The abstract should be rearranged and totally rewritten. It cannot be a list of steps followed during the analysis. Authors should mention the problem and the approach followed to get the results.

Response: Thank you for your good comments. We will rearrange and rewritten the

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abstract, which will mention the problem and the approach followed to get the results.

(2) Fig.3, pag.6. Authors should better clarify, for instance with an additional Figure, how the lateral forces impacting the foundation can be associated with ym (that is the inflection under vertical loads). At the moment the concept of im is not clear.

Response: Thank you for your good comments. Figure 3 on page 6 did not clearly express the direction of lateral forces impacting the foundation. We try to express the uniform load applied horizontally, so sorry for the confusing. We will modify this figure as follows.

The concept of im is the threshold value of inclination of buildings. Buildings with inclination exceeding im are dangerous and uninhabitable. In Table 2, we listed out the standard of threshold values for three kinds of buildings with different height. We have supplemented the figure in Fig.2 (see below) to illustrate the concept more clearly.

Fig. 2. Schematic diagram of landslide thrust action on a building.

Fig.3 The simple beam with its foundation affected by landslide thrust.

(3)The sentence (pag.7) referring to Finno et al. (2005) should be better clarified.

Response: Thank you for your good comments. The sentence (Page 7) is: Since cracks on walls are not visible, especially when the building with high stiffness is exceedingly inclined because of the ground deformation, they usually serve as the indicators of damage degree evaluation if the building stiffness is small (Finno et al., 2005)

Sorry for the confused expression in the above sentence. We want to clarify that cracks on building walls are not the only indicator to assess damage degree or vulnerability, especially when the building has a very good stiffness. So, we revised this sentence as follows.

Finno et al. (2005) found that when the buildings with high stiffness are seriously inclined due to the ground deformation, the wall cracking phenomenon is not obvious; On the contrary, if the stiffness of the building is small, the wall cracks seriously. This research indicated that if we only use cracks as indicator for vulnerability assessment, it is unsuitable. Other indicators, such as inclination, should be also taken into consideration.

(4) The Authors identify the damage classification with vulnerability. This aspect deserves further clarifications based on widely shared literature.

Response: Thank you for your good comments. In order to simplify the research work, many researchers directly use damage degree as vulnerability. Tarbotton et al. (2015) defined empirical vulnerability functions as “a continuous curve associating the intensity of the hazard (X-axis) to the damage response of a building (Y-axis)”. Kang et al. (2016) think that the range of damage to the buildings makes it possible to assess the vulnerability using a vulnerability curve that relates the intensity of debris flow with the degree of damage. They use the degree of damage to the buildings to estimate vulnerability.

Reference 1. Tarbotton, C., Dall’osso, F., Dominey-Howes, D., Goff, J. The use of empirical vulnerability functions to assess the response of buildings to tsunami impact: comparative review and summary of best practice. Earth Sci. Rev. 142, 120–134, doi.org/10.1016/j.earscirev.2015.01.002, 2015. 2. Kang, H. sub and Kim, Y. tae: The physical vulnerability of different types of building structure to debris flow events, Natural Hazards, 80(3), 1475–1493, doi:10.1007/s11069-015-2032-z, 2016.

(5) Provide more details on laboratory tests used to gather the values of the shear strength parameters shown in Table 3.

Response: Thank you for your good comments. The shear strength parameters in Table 3 are residual values. According to the report provided by the China Geological Survey (Hunan Institute of Xiangxi Geological Engineering Survey) in 2017, six groups of undisturbed soil samples were collected from the shear zone of the Manjiapo Landslide. Obtained by residual shear tests in the laboratory, the shear strength parameters of slip soils in Table 3 are the average values of these six groups of soil samples.

(6) In Figure 12, it is not clear the range of variation of 1/Fs. Some further comments would be helpful.

Response: thank you very much for the suggestion. Based on the Chinese standard of Code for geological investigation of landslide prevention (GB/T32864ï¡đ2016), the landslide stability state can be classified into three according to the safety factor (Fs) of landslide. Please see more details in the following table.

(7) The comparison shown in Figure 13 is unclear. What is there on x-axis?

Response: thank you very much for the comment. We think you want to comment on Figure 13, which is used to compare the sensitivity of building characteristics on vulnerability. In this figure, the x-axis expresses sample's No. but not means real value. By putting the five parameters together on a single diagram, we can clearly compare and find out which parameter is more sensitive to vulnerability.

(8) Conclusions: please clarify better or add references concerning the calculation of FS just in correspondence of buildings and over large areas. - Exportability should be better supported with clarifications.

Response: thank you very much for the suggestion. We are currently doing the researches on regional scale slow-moving landslide risk assessment in the Three Gorges reservoir area, China, which involves regional scale vulnerability assessment for buildings. The topic in this manuscript is partially new. There are rare references presently concerning Fs of slow-moving landslides and vulnerability of buildings. But the researches about calculation of Fs over large areas can be found from some researches, such as Muntohar AS, Liao HJ (2009), Apip, Takara K, Yamashiki Y, et al (2010), Salciarini (2006) and Sorbino (2010). We are eager to link the intensity of slow-moving landslides with vulnerability of buildings over large areas. Before applying the results from this manuscript, we will do further validation.

Reference 1. Muntohar AS, Liao HJ.: Analysis of rainfall-induced infinite slope failure during typhoon using a hydrological-geotechnical model. Environ Geol 56:1145–1159, 2009 2. Apip, Takara K, Yamashiki Y, et al.: A distributed hydrological-geotechnical model using satellite-derived rainfall estimates for shallow landslide prediction system at a catchment scale. Landslides 7:237–258, 2010 3. Salciarini, D., Godt, J. W., Savage, W. Z., Conversini, P., Baum, R. L. and Michael, J. A.: Modeling regional initiation of rainfall-induced shallow landslides in the eastern Umbria Region of central Italy, Landslides, doi:10.1007/s10346-006-0037-0, 2006. 4. Sorbino, G., Sica, C. and Cascini, L.: Susceptibility analysis of shallow landslides source areas using physically based models, Natural Hazards, doi:10.1007/s11069-0, 2010

We tried our best to improve the manuscript and made changes in the manuscript. We feel great thanks for your professional review work on our article, and hope that the responses will meet with approval.

Sincerely, Lixia Chen

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2019-318/nhess-2019-318-AC2-supplement.pdf

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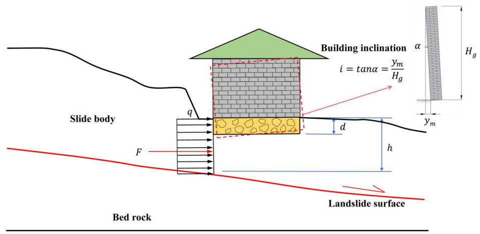

Fig. 2. Schematic diagram of landslide thrust action on a building.

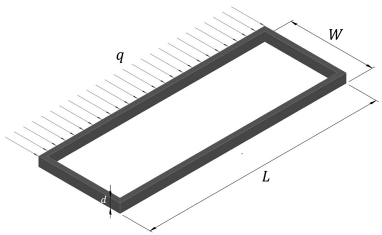

Fig.3 The simple beam with its foundation affected by landslide thrust.

where q denotes the distribution force on the foundation (kN/m), F denotes the horizontal component of landslide residual thrust (P_i) in Eq. (3), and h denotes the vertical distance from sliding surface to the ground surface. i denotes the inclination of the building, which is the ratio of the maximum horizontal deformation y_m to the height H_g of the building calculated from the outdoor ground (Fig.2). L, W, and d denote the length, width and depth of the building foundation (Fig.3).

Fig. 1.

Table . The range of safety factor (F_s) of landslide and its state

The safety factor F_s	$0 < F_s < 1.00$	$1.00 \leq F_s < 1.05$	$F_s \geq 1.05$
$1/F_s$	$1/F_s > 1.00$	$0.95 < 1/F_s \leq 1.00$	$1/Fs \leqslant 0.95$
Stability state of landslide	unstable	Less stable	stable
Description	(1) Many newly expanded cracks on the ground and new deformation on buildings and vegetation. (2) Obvious scratch and displacement on the main scarp. (3)Cracks on the crown of landslide.	(1) Local deformation on the ground. (2) No obvious deformation on the main scarp. (3) No obvious expansion of the cracks on the buildings. (4) Small cracks on the crown of landslide.	(1) No sustained deformation on the ground. (2) No crack expansion on the landslide. And no new deformation on buildings and vegetation on the landslide. (3) No scratch and obvious displacement on the main scarp.

Note: $F_s \neq 0$.

Fig. 2.

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