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Comment

## ***Interactive comment on “The quantitative estimation of the vulnerability of brick and concrete building impacted by debris flow” by J. Zhang et al.***

### **Anonymous Referee #2**

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It is an interesting paper on a full-scale experiment simulating the impact of a mass on a masonry wall. The manuscript is a good contribution to the understanding of failure and vulnerability of masonry walls under mass impacts providing interesting experimental data. The experimental set and the data are presented with certain clarity in a well-structured text however a thorough check of the English language is required. Figures and tables are balanced and providing a good quality information. This work needs a major revision concerning the followed approach for the experimental set-up and specifically the simulation of the debris flow impact as a uniform load on the masonry wall. To simulate debris flow, hydraulic models are used while solid collision

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models are used for the simulation of the boulder impact. The experimental set-up of this study claims simulating a uniform load through the distribution of a concentrated load introduced by an iron sphere on a wall through a board and a rubber cushion. This set up does not guarantee the homogenised and uniform distribution of the iron sphere onto the wall and does have a strong effect on the transmission of the forces from the sphere to wall, affecting the reliability of the results. Additionally the application of a uniform load on the wall, does not take into consideration the hydrostatic characteristics of the debris flow impact, concerning the unequal distribution of stresses along the height of the wall. To this reason the experimental set-up cannot be considered as a debris flow impact simulation with a representative distribution of stresses on the wall. Instead it is rather representative of a boulder impact. Thus the results presented here are limited to the tests carried out and cannot be used for general debris flow vulnerability evaluation. The text and the title of the paper should be changed accordingly. Furthermore, a relevant state of the art on the simulation of debris flow impact forces including for example contributions by Bugnion et al. 2012, Hübl et al. 2009, Canelli et al. 2012, Haugen and Kaynia 2008, Hu et al. 2011, Huang et al. 2007, Scheidl et al. 2012 is missing. No information on the materials and the mechanical characteristics (resistance etc) is provided at all.

Specific comments are: p. 5017, l. 15: References for these models are missing. p. 5018, l. 19: It is not certain that the collapse of the wall will lead directly lead to the collapse of the house. Alternative loading paths for the loading distribution might be followed. p.5019, l.5: The experiment simulates the load-bearing wall but not the whole building. The effect of the transversal walls existing in real structures is not taken in to consideration. p. 5019, l. 24: The cushion and the board do not guarantee the proper simulation of debris flow impact pressure on the building, not the application of a uniform load (see general comments). p. 5020, l. 3 and Figure 1. It is not clear in Fig. 1 whether there is a frame around the masonry wall . Provide information on the support of the masonry wall. p. 5021, l. 3: Expression  $mv=bhv^2$ . These two quantities are not equivalent. The results with reference to this should be recalculated. p. 5021,

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l. 18-19: It is not clear why in particular on the results near the critical number and not on the central numbers are not reliable. p. 5024, l. 7: A comment on the physical interpretation of the vulnerability using the index of Equation (7) is needed. p. 5025, l. 26: If the maximum distance of the wall is 3 m, please explain the formation of a crack of 3216 mm. p. 5026, l. 13: “when the dynamic system...the energy of the sphere” ...This phrase is not clear. p. 5026, l. 11: “the friction of the shaft which should be conquered ...reduce the actual velocity” this effect should be observed for all tests A, B and C. There is not reason for which it should have a special effect only on B results. Lower results for the B tests should be justified better. p. 5026, l. 20: A comparison between the damage presented in Figures 3-5 with the results of Table 4 is missing. For A1, the percentage 18.4% is high for the damage shown at Figure 3. A2 with vulnerability 48% has an almost similar (in terms of area) damage with B2 (31%).A discussion on the representativity of the proposed vulnerability index is missing. p. 5040 and 5041: Figures 3-5. “directly and indirectly attack places” is not defined in the text. p. 5026, l.25: The three lines piecewise function applies only to Figures 7 and 8 and not to Figure 6 (linear curve). p. 5027, Equation (8): Provide more details on the fitting of the curves and the threshold determination for F. p. 5028: The multiplication with  $L=h/2$  to calculate the maximum bending moment assumes the application of the maximum impact force on the mid height of the wall. It is not clearly explained if this is certain at the performed tests.. p.5028, Equation (9): As previously, provide more details on the threshold determination for FL. p.5028, l. 13: There are two bending moments for the wall the vertical and the horizontal, which might be different according to the application point of the maximum impact force. According to the observed crack patterns the out-of-plane bending moment about horizontal plane is crucial for your experiment set up, however this cannot be generalized for other set up geometries. Furthermore as calculated here the maximum bending moment is proportional to the maximum impact force, which contradicts the conclusion that the bending moment is more representative than the maximum impact force. p.5028, 5029 (Discussion section): Please see General comments. Table 2:

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Crack widths from 0 to 0.7 mm are very low. Additionally, for an inclination equal to 2.5, the maximum displacement is  $2.5 \hat{U} / 10 - 3 = 7500$  m for  $H=3$ m! Figure 8: Change the caption to vulnerability curve with maximum impact bending moment.

References Bugnion, L., McArdell, B., Bartelt, P., Wendeler, C., 2012. Measurements of hillslope debris flow impact pressure on obstacles. *Landslides* 9, 179–187. doi:10.1007/s10346-011-0294-4 Hübl, J., Suda, J., Proske, D., Kaitna, R., Scheidl, C., 2009. Debris flow impact estimation, in: Popovska, C., Jovanovski, M. (Eds.), 11th Symposium on Water Management and Hydraulic Engineering. Ohrid, Macedonia, pp. 137–148. Canelli, L., Ferrero, A.M., Migliazza, M., Segalini, A., 2012. Debris flow risk mitigation by the means of rigid and flexible barriers - Experimental tests and impact analysis. *Nat. Hazards Earth Syst. Sci.* 12, 1693–1699.

Haugen, E.D., Kaynia, A.M., 2008. Vulnerability of structures impacted by debris flow, in: Chen, Z. et al. (Ed.), *Landslides and Engineered Slopes*. CRC Press, Xian, China, pp. 381–387.

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Huang, H.P., Yang, K.C., Lai, S.W., 2007. Impact force of debris flow on filter dam. *Geophys. Res. Abstr.* 9, 3218.

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