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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "The effects of cushion's particle size and thickness on coefficient of restitution under the rockfall impacts" *by* Chun Zhu et al.

Anonymous Referee #1

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The research topic of this paper has a strong background in the mining industry as gravel cushion is widely used in open-pit mine for the mitigation of rockfall hazards. When a rock collides with gravel cushion, i.e. a pile of small granules, the kinetic energy of the rock will be absorbed, leading to a smaller run-out zone for the falling rock. To this aspect, the authors performed in-house experiments and investigated the effect of cushion's composition (particle size and thickness) on coefficient of restitution under rockfall impacts. In particular, the energy consumption and the buffer mechanisms of gravel cushion of various compositions were studied using differing impact conditions (i.e. the size of rock and its initial release height were altered). It was found that the thickness of cushion has a significant influence on the reduction of rock energy.

Therefore, this parameter should be carefully considered as a dominating factor for the design of cushion in the mining applications. The paper addressed a seemingly simple but yet important problem in the field of coal mining/rockfall. However, the research results would be more valuable if the following issues can be further clarified (major revision): (1) The English of this paper is not optimal, which prevents a clear understand of the experimental procedures and the physical significance behind observations. The format of the paper needs to be better arranged (e.g. sometimes the figure and the caption are not on the same page). There are also many typo-errors. It is STRONGLY suggested that the authors try to improve the language of the paper through the corrections either from a native English speaker or scientific proofreading & editing services. (2) Section of 'Introduction': It is ideal to include more newly published researches to highlight the importance and uniqueness of the current study. (3) Section of 'Coefficient of restitution': It is better to use the absolute values of the velocities in Equations (1) and (2) since one notices that velocity has a direction. Also it is not clear in e.g. Figures 7-9 that the CORs are calculated based on the velocities of normal direction or tangential direction, or they are calculated based on the kinetic energy? It is necessary to give a clear definition of the normal and tangential directions for a rock-cushion impact. Also the expression 'the COR of cushion' does not seem to be correct since COR is not a physical property of cushion. (4) Section of 'Experimental studies': It should be 'radius' in 'Spherical blocks with diameters of . . .'. It is better to give more details about the experimental procedures. For example, how the rock velocities are calculated from the frames (any calibration or correction of the view distortion)? What is the relative position of the two cameras? If only the vertical velocity of rock is measured, does that mean the view axis of the camera is parallel to the cushion platform? The paragraph below Figure 5 describes how to prepare the cushion platform. However, it is not easy to understand how the platform is established due to the poor English expression. It is suggested that the authors list clearly the experimental parameters in a table so that one sees clearly how the two groups of tests were performed. From Figure 5a it seems that rock has a tangential velocity when it impacts with the cushion platform. However,

the authors used the release height (by changing the inclination of the release path?) as a reference parameter, which influences both the normal and the tangential velocity of rock at impact. Thus it is not clear how the COR is affected by the distribution of kinematic energy between the normal and tangential directions (or the COR is calculated only based on the normal direction?). One wonders whether there still exists boundary effect in experiments, although the authors have tested spherical rocks and cushion platforms of different sizes (or thicknesses). It requires to clearly show that the current results are boundary-effect free. In Figures 8 and 9 the radius of rock and the diameters of particles do not have units. How many experiments are performed for each data points in these figures? One needs to show the uncertainties. How the packing structure of the cushion particles will influence the COR result? This is a topic which is worth discussing because one notices in Figure 4 that the geometry of particles is very regular. Do they form special interlocking structure in the platform? If so how does it affect the rock's impact-rebound behavior? How is the cushion prepared once again after one impact experiment so that the influence of particle packing structure on the next experiment is minimized? It would be great if the author could show the photos of cushion before and after the rock impact experiments. In the discussion part the authors mentioned 'Because the small thickness cushion can be compressed in a very short time . . .'. It needs to be clearly shown or demonstrated. The last paragraph of this section is very difficult to understand. It may be helpful if the important discussions are listed into bullet points so that one gets the ideas more quickly. (5) Section of 'Orthogonal test design': The definition of 'damage depth' should be clearly given. The principle of 'orthogonal test' should be given for the reader who is not familiar with the concept. What is the purpose of doing this test? In Tables 2 and 3 not only the mean value but also the uncertainties should be given. (6) Section of 'Conclusions': It is interesting to see some comments from the authors on non-spherical rocks. In nature the shape of rock is always non-spherical or polyhedral. In addition, treating rocks as non-spherical bodies is nowadays already 'standard' for rockfall simulations such as in RAMMS::ROCKFALL (Leine et al., Simulation of rockfall trajectories with consideration

of rock shape, Multibody System Dynamics, 2014). From the authors' point of view, how will rock geometry influence the conclusions obtained in this work?

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