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Interactive comment on "Risk assessment and management for an extreme accident at a waste slag site" *by* Shuang Liu et al.

Shuang Liu et al.

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Thanks for the comments.That's very helpful.The order of the articles has been adjusted, the unreasonable places have been modified, and the missing parts and figures have been added.

1, Comment "The run-out distance is the strength parameter" Response and changes in the manuscript: this part has been modified.

2, Comment "the hazard of tailing dam failures are analyzed according to the hazard classification of the debris flow"? Response: Because the debris flow intensity proposed by Fiebiger is classified according to the depth of mud and relationship between the maximum flow rate and depth of mud. The debris flow geological hazard is used for reference to risk zoning of tailings dam break-down, and the risk is divided according to its depth and velocity.

3, Comment "Section 2.2, The process of risk analysis – page 4, lines from 25 to 29. The equation(1) is incomplete" Response and changes in the manuscript: The equation (1) has been completed, which is $R = H \times V \times E$.

4, Comment "More details should be provided about the used physical model" Response: The values in the physical model and more details are added in article. A brief introduction to the principles of T-S method simulation is introduced. Changes in the manuscript: Based on the theory of solid and fluid mechanics, the Tsunami squares (T-S) method considers the volume and momentum conservation of the motion process of the flow (sliding) body, and establishes a theoretical model of the energy flow analysis of the flow (sliding) motion process. T-S method is to treat a mass of moving matter as a plane consisting of many small squares of the same size and with a certain thickness and velocity. Based on the continuity equation of Tsunami squares theory (volume conservation and momentum conservation equation), the appropriate calculation time step is chosen, the position, velocity, thickness and acceleration of each small squares movement at each time step is updated, and the motion characteristics of the material that the small squares simulate over time is derived.

5, Comment: "the Authors should make explicit the criterion adopted to distinguish the three hazard levels (High, Moderate; Low)." and "it is not clear if the so-called "mud depth" Response: the different level is distinguished by the product value of the maximum velocity and the mud depth. The mud depth is the depth of the final stop, velocity is the maximum velocity achieved during the movement.

6, Comments: "it seems that the identification of at risk areas precedes the vulnerability estimation. Furthermore, the vulnerability (of either people or buildings) is not defined" and the temporal spatial probability of people at risk is posed equal to 0.6 without any clarification about its estimation" Response and changes in the manuscript: The vulnerability is modified in the article. Vulnerability needs to consider landslide intensity and susceptibility of elements at risk together. The index selection of susceptibility and its value are attached to the text. The susceptibility mainly considers the index of the risk assessment of the single landslide, that is, the structure of buildings, the maintenance of buildings and the service life of buildings. Mixture intensity mainly determines its hazard. The temporal spatial of people at risk (0.6) refers to the time in which people in the area live means the average of persons at risk. The hazard values are 1, 0.7 and 0.4 based on high, moderate and low level. Vulnerability is calculated based on model we have proposed in the article. The formula is listed in the article.

7, Comments: "As a matter of fact, considering people at risk, F represents the cumulative probability (e.g. per year) that N or more lives will be lost; accordingly, F-N curves are usually adopted to evaluate the so-called "societal risk"; "the Authors could fail if the correct definition of F is taken into account." Response and changes in the manuscript: In the original F-N curve, F represents the cumulative probability (e.g. per year) that N or more lives will be lost, at this time the F-N curve is for regional geological hazards, and the case in this article is only the single tailings dam failure, so F represents a single tailings dam failure probability.

8, Comments: "the criterion used to individuate the F-N thresholds – useful to separate the F-N diagram in five zones (see Figure 6) – should be explained." Response and changes in the manuscript: According the consequences of the disaster, and policies and regulations in the area, the standards of acceptable risk are usually determined by expert analysis. Residents need to be assured of the security at these sites, but this cannot be out of a range suggested by experts. Therefore, we propose that the upper (unacceptable) limit could be determined by experts, but that suggestions from residents should be considered for the lower (broadly acceptable) level. The government and mineral companies can act as intermediaries in determining the lower boundary of the acceptable risk. The risk buffer zone, for people and buildings, should be discussed by the multiparty representatives participating in the risk assessment.

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Model	Slope	Materials	Roughness	Burst shape
1	10°	Plywood	Roughness	1/4
2	10°	PVC	Smooth	1/4
3	10°	Plywood	Roughness	1/2
4	20°	Plywood	Roughness	1/2

Fig. 1. Physical model experiment groups

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Hazard level	Mud depth (m)	Relationship	Mud depth(m) and maximum velocity(m/s)	Hazard assignment
High	$H > 2.5$ m	OR	$VH \geq 2.5$	1
Moderate	$0.5 \leq H < 2.5$	AND	$0.5 \leq VH < 2.5$	0.7
Low	$0.0 \leq H < 2.5$	AND	$VH < 0.5$	0.4

Fig. 2. Scheme for dividing the geological environment into hazard zones after a tailings dam failure

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S_{str}	Building structure	S_{mai}	Building maintenance
0.8	Lightweight simple structure	0.1	Good
0.6	Brick-wood structure	0.4	Medium
0.4	Brick concrete structure	0.7	Bad
0.2	Reinforced concrete structure	1	Very bad

S_{ser}	Ratio of service life and design life*
0.05	≤0.1
0.1	0.1~0.4
0.3	0.4~0.6
0.5	0.6~0.8
0.7	0.8~1.0
0.8	1.0~1.2
1	＞1.2

Fig. 3. Susceptibility indexes value of structures

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Vulnerability			Intensity		
			Low	Moderate	High
			0-0.4	0.4-0.7	0.7-1.0
Susceptibility	Low	0-0.5	0-0.35	0.35-0.8	0.8-1
	Moderate	0.5-0.65	0-0.5	0.5-0.85	0.85-1
	Moderate-High	0.65-0.8	0-0.6	0.6-0.87	0.87-1
	High	0.8-1.0	0-0.7	0.7-0.95	0.95-1

*Green, yellow and red zone means the low, moderate， moderate-high and high level of vulnerability

Fig. 4. Vulnerability values of structures in dam failure