Response to Editor and Reviewers

Dear editor,

Thanks very much for the valuable comments of editor and reviewers. This version of our manuscript (revised manuscript of esurf-2020-92) has been revised carefully following the editor's guidance and reviewers' comments. The revised contents have been highlighted in blue. The followings are the point-to-point response for each comment. All the references in this manuscript have been carefully checked to confirm that they are correctly cited. We hope our revision will make the manuscript acceptable for publication.

We would like to express our sincere appreciation to two anonymous reviewers for their great effort to improve the quality of our manuscript.

Best regards,

Xiangang Jiang

Response to the Reviewer 1

General Comments: *The manuscript by Dr. Jiang and colleagues summarizes results of an experiment investigating bar dynamics following breach of a landslide dam. The manuscript appears to be a re-working of results from a similar paper published by the same lead author in 2020 in the journal 'Landslides' (Jiang et al., 2020, cited in the manuscript). The experimental design appears sound, the experiment is well documented, and the results appear different enough from that paper to justify a separate publication. Nonetheless, the current manuscript suffers from a confusion of terminology and formative processes of the primary sedimentary body being investigated (fluvial bars), is lacking in scientific justification, and does not effectively communicate the novel scientific contribution of the experimental results. It is my judgement that the results of the experiment could make a contribution to the scientific community, but the manuscript needs very substantial revision to meet the aims and scope of Earth Surface Dynamics.*

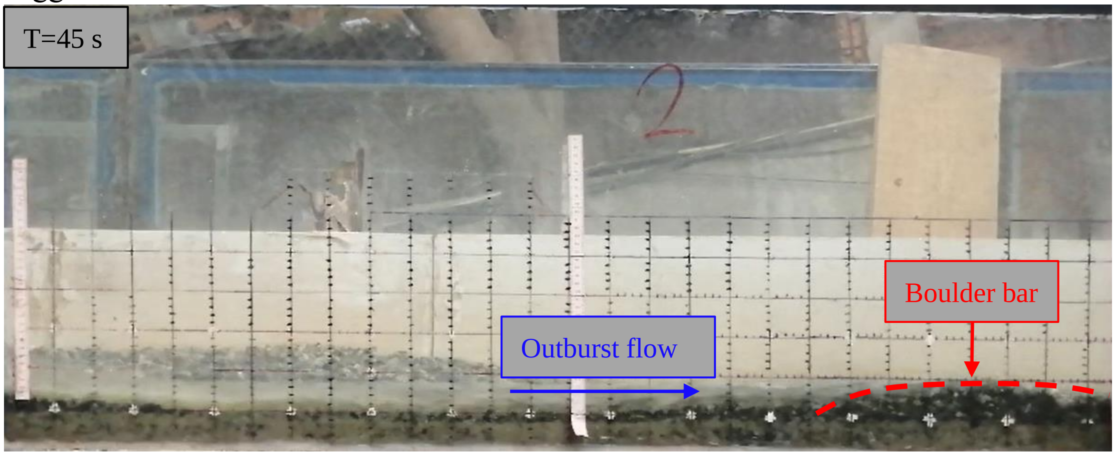
Thanks a lot for the reviewer's comments. In the revised manuscript, we have pointed out this manuscript's contributions to the scientific community. Please see lines 31-33 in the revised manuscript. We also have made other revisions to the manuscript based on the reviewers' comments. Please see the revision.

Specific Comments:

1.The use of the term 'sandbar' is ill-founded. The experiment does, in fact, use a *substrate that is approximately 40 percent sand. However, because of the scale and high Froude conditions (>2), the experiment best represents a canyon, gravel bed system. The formative processes of 'sandbars' in this experimental design are entirely different than the sedimentary bodies described in lines 54 to 108 of the Introduction. In that section, there is extensive review of sedimentary bodies that are not genetically nor stratigraphically related to the sandbodies formed in these experiments which, at the scale of the experiment are gravel alternate bars. The fact that the bars in the experiment migrate in the upstream direction is evidence that the experiments are simulating Froude-supercritical (diffusive) conditions (Shaw and McElroy, 2016), whereas most of the sandbars described in the Introduction (except those formed by landslide dams) are formed by translative depositional processes. I would suggest the authors re-visit the process scaling of the experiments to re-frame and strengthen the experimental justification and basis, and the scientific contributions of the results. Kleinhans et al. (2014) and Shaw and McElroy (2016) provide excellent discussions on linkages between sedimentary processes in flumes and those in rivers.*

Thanks a lot for the reviewer's comments. The authors have discussed this comment and agreed with the reviewer. We reviewed the experimental screen and confirmed that the bars formed in the experiment were boulder bars, which corresponds to the boulder bar in the field (Wu et al., 2020; Turzewski et al., 2019). We have corrected the term "sandbar" to "boulder bar". The introduction has been rewritten focused on boulder bars, the literatures have been recited, and lines 54-108 of the introduction of the original article have been revised by us to ensure accurate description of the boulder bar.

In addition, as the reviewer said, the boulder bar in the experiment is indeed formed by the translational deposition of bedload. As shown in Figure 1, when the discharge is reduced, some gravel will stay on the river bed and hinder the advancement of the upstream flow, and part of the sediment in the flow will be deposited. As time goes by, the accumulation of sediment on the side of the boulder bar increases, and the boulder bar appears to develop upstream. We have added the explanations as the reviewer's suggestion in section 3.2.



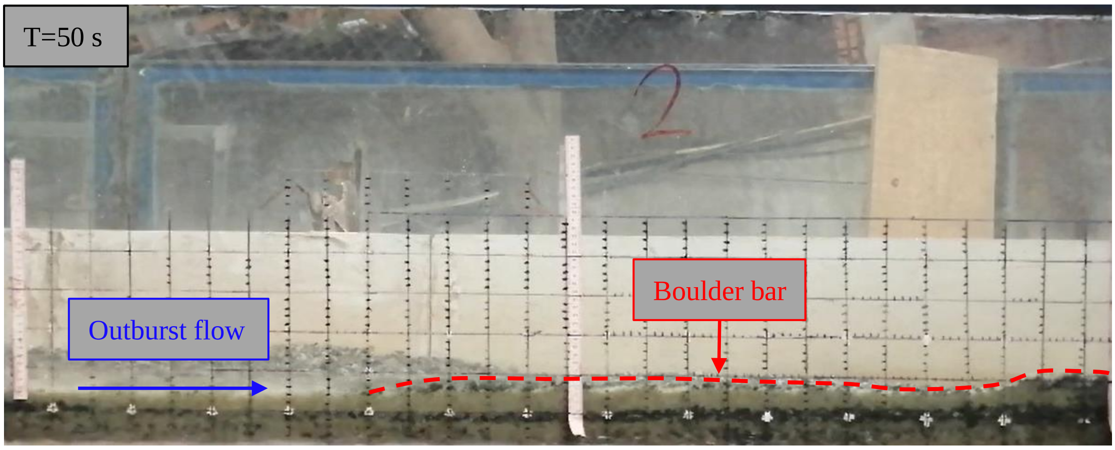


Figure 1. boulder bar obstructs the outburst flow to the river bed lower reaches

Reference:

Wu C.H., Hu, K.H., Liu, W.M., Wang, H., Hu, X.D., and Zhang, X.P.: Morpho-sedimentary and stratigraphic characteristics of the 2000 Yigong River landslide dam outburst flood deposits, eastern Tibetan Plateau, Geomorphology, 107293, https://doi.org/10.1016/j.geomorph.2020.107293, 2020.

Turzewski, M.D., Huntington, K.W., and Leveque, R.J.: The Geomorphic Impact of Outburst Floods: Integrating Observations and Numerical Simulations of the 2000 Yigong Flood, Eastern Himalaya, Journal of Geophysical Research: Earth Surface, 124, 5, https://doi.org/10.1029/2018JF004778, 2019.

2. The authors do not provide a clear basis and justification for the experiments. Neither a hypothesis nor scientific question are presented in the introductory material as a basis for the experiments. Instead, the justification appears to be that 'sandbars are important'. Because the authors appear to have confused sandbars in low-slope, low Froude number rivers with gravel bars from outburst floods, this justification is moot. In line 52 of the Introduction, the author's state "Sandbars are one typical landform formed during the outburst flood evolution (Turzewski et al., 2019; Jiang and Wei, 2020; Wu et al., 2020)." Neither the T urzewski nor Wu papers describe sandbars at all, they describe gravel bars from outburst floods. Only the paper written by Dr. Jiang, which also appears to have confused sandbars with gravel bars, uses the term 'sandbars'. The authors should revisit their results and the literature to provide the reader with a clear justification for the experiments by clearly stating a hypothesis or scientific question addressed

Thank the reviewer very much for the comments. We fully agree with the reviewer's opinion. We have corrected "sandbar" to "boulder bar" in the revision. It was noticed that most researchers focused on distribution characteristics and consisted material characteristics of boulder bars triggered by landslide dam overtopped failure after the dam failure based on field investigations (Wu et al., 2020; Turzewski et al., 2019). However, the boulder bar' formation process and development characteristic during the process of dam failure are still not clear. Therefore, we have proved the formation and development of the boulder bar during the failure process of the landslide dam through the flume experiment. We have pointed out the scientific question and rewritten the introduction section in the revision.

Reference:

Wu C.H., Hu, K.H., Liu, W.M., Wang, H., Hu, X.D., and Zhang, X.P.: Morpho-sedimentary and stratigraphic characteristics of the 2000 Yigong River landslide dam outburst flood deposits, eastern Tibetan Plateau, Geomorphology, 107293, https://doi.org/10.1016/j.geomorph.2020.107293, 2020.

Turzewski, M.D., Huntington, K.W., and Leveque, R.J.: The Geomorphic Impact of Outburst Floods: Integrating Observations and Numerical Simulations of the 2000 Yigong Flood, Eastern Himalaya, Journal of Geophysical Research: Earth Surface, 124, 5, https://doi.org/10.1029/2018JF004778, 2019.

3. The manuscript lacks a clear description or discussion of the scientific contribution. The Results contain very long, detailed descriptions of the spatial-temporal dynamics of bar formation, geometries, and migration processes in the experiments. These descriptions could be shortened, and the scientific community would be better served with a discussion detailing how the results add to our understanding of bar formation from landslide outburst floods. For example, are the final geometries and along-stream scaling of the bars helpful in geologic interpretation of ancient bar deposits? Can they be used to improve interpretation of return frequency of certain outburst floods over recent geologic history? This manuscript simply does not contain any discussion linking the experimental results to the broader scientific literature, nor does it effectively relay the importance of the results to interpretation or prediction of landslide-dam outburst events.

Thanks a lot for the reviewer's comments. We have simplified the description of the position and size characteristics of the boulder bar in the experiment according to the reviewer's suggestions. We study the formation process and growth characteristic of the boulder bar during the landslide dam overtopping failure process. The boulder bar's position and the change characteristics of geometric dimensions in the process of dam failure were carefully discussed. In addition, we have added a new discussion section to compare the experimental results with a field case (Wu et al., 2020; Turzewski et al., 2019). The experimental results and field data are consistent, indicating that the experimental results can provide references for the study of the formation and growth of the boulder bar formed by the outburst flood. Please see the Discussion section.

Reference:

Wu C.H., Hu, K.H., Liu, W.M., Wang, H., Hu, X.D., and Zhang, X.P.: Morpho-sedimentary and stratigraphic characteristics of the 2000 Yigong River landslide dam outburst flood deposits, eastern Tibetan Plateau, Geomorphology, 107293,

https://doi.org/10.1016/j.geomorph.2020.107293, 2020.
Turzewski, M.D., Huntington, K.W., and Leveque, R.J.: The Geomorphic Impact of Outburst Floods: Integrating Observations and Numerical Simulations of the 2000 Yigong Flood, Eastern Himalaya, Journal of Geophysical Research: Earth Surface, 124, 5, https://doi.org/10.1029/2018JF004778, 2019.

Response to the Reviewer 2

Summary:

The authors use a flume study to understand the effects of outburst flooding on downstream sandbar development. Different dam geometries (width and downstream slope angle) and a constant dam height were used. The upstream pool was allowed to fill and then overtop and fail under the same constant flow rate in all experiments. The authors relate bar frequency and volume to different dam geometries, and also note that bars tend to grow upstream during the experiments. The authors proceed to relate their observations to the flow hydraulics and sediment concentrations during the experiment. While the experimental set up seems reasonable, and the general result reproducible, there are several parts of the analysis that are flawed. For example, the "sandbars" are not scaled appropriately, and in fact the median grain size is gravel in the experiment. Instead, these grains are equivalent to very coarse (boulders?) grains in the field scale. The framing of the introduction and paper in general is therefore not appropriate. Further, the Froude numbers during these experiments are all supercritical, leading to spurious correlations between transport capacity and flow depth (for example, I assume that dimensionless shear stress is calculated using subcritical flow assumptions via the depth-slope product embedded in u). Nor is it clear how sediment concentration (figure 8) was calculated with the reference to Laursen given. Later, they use the Meyer Peter-Muller equation to calculate bedload, but, again, not considering the supercritical flow regime of the experiments and the influence on energy slope as far as I can deduce. Therefore, it is difficult to interpret whether any of the results in sections 4 and 5 are valid.*

Thanks a lot for the reviewer's comments. As the reviewer concerned, the bar formed in the experiment was composed of a lot of coarser materials, which should be named "boulder bar". We have corrected this term "sandbar" to "boulder bar" in the revision.

Considering the content of the original manuscript is more, and the sections 4 and 5 have caused the reviewer greater confusion, we have deleted the sections 4 and 5 of the original manuscript after our careful consideration. And in the revised manuscript, the influence of the dam volume and the released flood volume on the growth of the boulder bar was added (section 4 of the revision), and the results of this experiment were compared with the Yigong flood in the Discussion section (section 5 of the revision), which proved the reliability of the results of this experiment. It shows that the research results of this paper can provide reference for the research on the formation and development of the boulder bar formed by the overtopping outburst flood.

General Comment:

Introduction: make it clear how the background information will provide context for the results of the study. For example, the reference to Demirci et al. (2014) does not provide much insight into how these results for a coastal beach will provide context for this study. The authors could use the introduction to describe more precisely how these different previous studies relate to sandbars formed in settings 1, 2, and 3 described on lines 67-70. And then state how the sandbars in this study fit within one of those settings, or whether they are some different phenomenon related to outburst floods (as is implied). Further, the references should be more directly related to the coarse-grained alternate bars that form during the experiment, rather than sandbars.

Thanks a lot for your comments. According to your valuable suggestion, we have corrected the term "sandbar" to "boulder bar" in the revised manuscript. Also, we have rewritten the introduction part of the article and recited references related to the boulder bar to ensure the correct citation of the references.

Section 3: It would be very useful to have some information on grain size on the bars in this section. Much of the sediment in the experiment seems equivalent to boulders in the field case, and the coarse sediment seems to comprise much of the bar material. Even in that case, the grain size of the sediment is going to be a very important factors in depositional patterns and should also be reported.

We fully agree with the reviewer's opinion. We report the material size information of the boulder bar downstream of the river bed (section 5 in the revised manuscript). The material gradation is shown in Figure 2. We found that the farther away from the dam, the smaller the median particle size of the boulder bar material for the boulder bar on the river bed. The experimental results are in good agreement with the Yigong flood (Turzewski et al., 2019). We have added the related descriptions and explanations in the 3th paragraph of section 5.

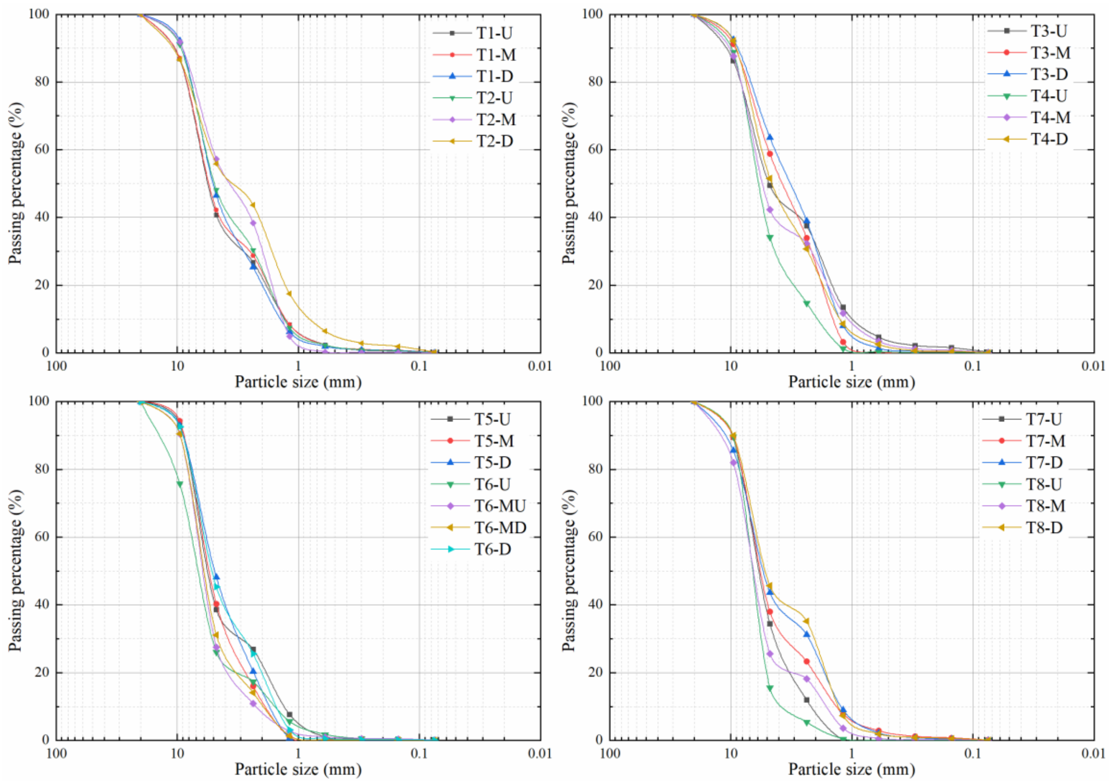


Figure. 2 Gradation curves of the boulder bar materials. Notation: U, M, D, MU, and MD, represent the boulder bar near the upstream reaches, the boulder bar near the middle reaches, the boulder bar near the downstream reaches, the boulder bar near the middle-upstream reaches, and the boulder bar near the middle-downstream reaches, respectively.

Reference:

Turzewski, M.D., Huntington, K.W., and Leveque, R.J.: The Geomorphic Impact of Outburst Floods: Integrating Observations and Numerical Simulations of the 2000 Yigong Flood, Eastern Himalaya, Journal of Geophysical Research: Earth Surface, 124, 5, https://doi.org/10.1029/2018JF004778, 2019.

Section 4: It is confusing that sediment concentration is calculated using a reference to Laursen, with no reference to how this was done or whether we are talking about bed load or suspended load. For true sandbars, it seems that the suspended sediment component would dominate. Later in this section, the MPM formula is used for bed load transport capacity, but how is u defined given the supercritical flow conditions. I don't know if it is appropriate to use MPM without consideration of the effect of Froude number on the energy slope; this may lead to spurious negative correlations between Froude number and transport capacity.*

Thanks a lot for the reviewer's comments. it is difficult to measure the concentration and sediment carrying capacity of outburst flow exactly and timely during experimental process. So, we adopted the calculated methods to obtain the concentration and sediment carrying capacity values in the first version manuscript. But the calculated values may be different with the experimental data. The content of section 4 in the original manuscript may cause confusion to the readers. Therefore, we decided to delete the content of section 4 in the original manuscript(see section 4 of the revised draft for details).

Section 5: given the unknown equation to calculate sediment concentration, and uncertainty in the calculation of sediment transport capacity described above, I don't know how to interpret the results of this section.

Thanks a lot for the reviewer's comments. After our careful discussion, we decided to delete section 5 from the original manuscript. In the revised manuscript, we compared the experimental results with Yigong case and discussed the reliability of experimental results in section 5.

Line Comments:

29: It "is" found. . .

Thanks for the reviewer's guidance. The line 29 in the original manuscript is related to the Froude number. In the revised manuscript, we have deleted the content related to the Froude number. Therefore, this sentence is no longer in the revised manuscript.

35: Exchange "reference the research on" with "can be applied to"

Thanks a lot for the reviewer's comments. We have made corrections in accordance with the reviewer's requirements. See the line 32 of the revised manuscript for details.

41: delete "collapses" and just use "landslides"

Thank the reviewer for this suggestion. We have made corrections in accordance with the reviewer's requirements. See line 38 of the revised manuscript for details.

60: "At present, much research. . ."

Thanks a lot for the reviewer's comments. We have corrected the sentence in the revision.

74: throughout the introduction, I suggest replacing semicolons with periods and starting new sentences.

Thanks very much for the reviewer's comments. We have rewritten the introduction section in the revised manuscript based on your valuable suggestion.

118-131: good concluding paragraph of the introduction

Thanks very much for the reviewer's compliment. We used these sentences in our rewritten Introduction (see lines 77-93 in the revised manuscript).

156: spelling: "gravels"

Thanks a lot for the reviewer's comment. We have revised the spelling of the "gravels" (see line 117 of the revised manuscript).

156-157: Was there any dimensional scaling of the grain size? What would this sediment size correspond to in a field setting?

Thanks a lot for your comments. Although, there was not any dimensional scaling of the grain size, the type of materials used in the tests was similar to the filed, and the materials could ensure the overtopped failure mode happen for the tests. Most of the barrier dams in the field are mixtures of fine particles and coarse particles, therefore, we selected mixtures of sand and gravels as the experimental materials. With reference to Vallejo and Mawby (2000) and Wan and Fell (2008), considering the limitations of the experimental flume space and the size of the dam model, the experimental material adopted a median particle size of 3.8mm mixtures of sand and gravels to improve the possibility of overtopping failure of dam model. Therefore, the selection of dam model and material in this experiment could meet the experimental requirements.

Reference:

Vallejo L. E., Mawby R.: Porosity influence on the shear strength of granular material–clay mixtures, Engineering Geology, 58(2):125-136, https://doi.org/10.1016/S0013-7952(00)00051-X , 2000.

Wan C. F., Fell R.: Assessing the Potential of Internal Instability and Suffusion in Embankment Dams and Their Foundations, Journal of Geotechnical and Geoenvironmental Engineering, 134(3):401-407, https://doi.org/10.1061/(ASCE)1090-0241(2008)134:3(401), 2008,

180: Were the balls buoyant in the flow?

We are honored to be able to answer the reviewer's confusion. The balls used in the experiment have a small mass and can float on the flow surface, and can be used to measure the flow velocity.

188: Are you only able to measure the height along the flume wall? Rather than the average height across the channel?

We are honored to answer the reviewer's questions. We could measure the height along the flume wall timely and conveniently during the dam failure process. Although, the height of other positions maybe different with the section along the flume wall, but the difference is small. So we selected the boulder bar's section along the flume wall as concerned positions of the boulder bar and measured the height of the boulder bar of these positions. Because of the irregular shape of the boulder bar, the height of the boulder bar is different at different position, so we take the average height along the wall of the flume as the representative height value of the boulder bar.

220: Are these sandbars or gravel bars? They look to be dominated by the coarse fraction in the photos.

Thanks a lot for the reviewer's reminder that gravel bars were formed in the river bed during the dam failure in the experiment, which corresponds to the boulder bar formed by the outburst flood in the field. We have also corrected this concept in the revised manuscript.

227-229: This sounds like alternate bar formation, for which there is significant literature that was not discussed in the introduction.

Thanks a lot for the reviewer's comment. As the reviewer mentioned, we have changed the concepts of "sandbar" to "boulder bar". In the revised manuscript we have rewritten the Introduction on "boulder bar".

314-316: I don't understand why a smaller discharge would lead to a larger bar spacing. Please elaborate.

It is a great honor for us to explain this phenomenon to the reviewer. Maybe we did not describe it clearly that the "discharge" is "inflow discharge". We have clarified this term in the revision. Although the inflow discharge in the experiment is small, but the stored water volume behind the dam may be large. When the water volume in front of the dam is large enough, the landslide dam will be over-topped, and the dam will be failure very quickly. Water will be released in a short time, and the outburst discharge may be large (Jiang and Wei, 2020; Carrivick 2010; Jiang and Wei, 2018). We have deleted the confusing sentences. In order to facilitate the readers to understand the degree of amplification of the discharge, we also give the peak discharge of 8 sets of experiments (Figure 3).

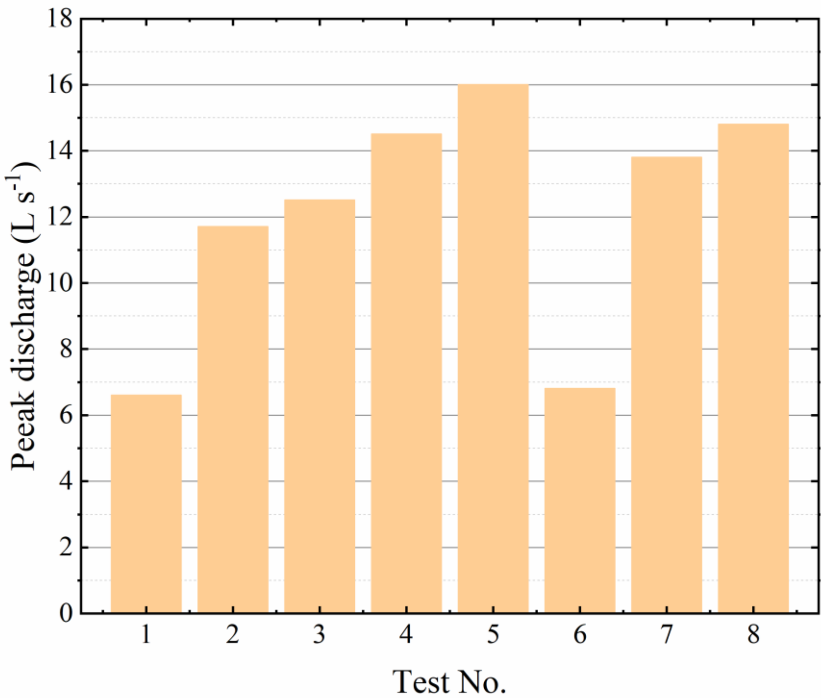


Figure 3. The breaching discharge hydrographs for T1 to T8 tests

Reference:

Carrivick, J. L.: Dam break–outburst flood propagation and transient hydraulics: a geosciences perspective. J Hydrol, 380(3–4):338–355, https://doi.org/10.1016/j.jhydrol.2009.11.009, 2010.

Jiang, X. G. and Wei, Y. W.: Natural dam breaching due to overtopping: effects of initial soil moisture. Bull Eng Geol Environ 78, 4821–4831, https://doi.org/10.1007/s10064-018-01441-7, 2018.

Jiang, X.G., and Wei, Y.W: Erosion characteristics of outburst floods on channel beds under the conditions of different natural dam downstream slope angles, Landslides, 1-12, https://doi.org/10.1007/s10346-020-01381-y, 2020.

297-324: It would be useful to have a table or figure to show these differences between the experiments explicitly, or discuss in the context of Figure 5.

Thanks a lot for the reviewer's advice. We have revised the figure as the reviewer's suggestion. With the new Figure 4 in the revised manuscript, it is easy to understand the characteristic of the position of the boulder bar.

401: Please provide some more on the calculation based on Laursen; bed load? Suspended load?

After careful consideration, we decided to delete the calculation of the concentration in the revised manuscript. There is no more content related to concentration in the revised manuscript.

407-422; Figure 8: I have no basis to judge any of this section because I do not know how the authors calculated these values with the available data. Using the surface velocity in different sections as measured with ball movement? What was the grain size used in the concentration calculation?

After careful consideration, we decided to delete the calculation of the concentration in the revised manuscript. There are no more contents related to concentration in the revised manuscript.

422: Spelling: abdomens? I think a different word was intended.
Thanks a lot for the reviewer's suggestion. We replaced "abdomens" with "waists" in the revised manuscript (see line 259 in the revised manuscript).

444: Were the concentration calculations using Laursen based on bedload as well?

Thank you very much for the comment. After careful consideration, we decided to delete the calculation of the concentration in the revised manuscript. There are no more contents related to concentration in the revised manuscript.

451: equation 4 is not correct – need to square u in the numerator*

Thanks a lot for the reviewer's correction. We have deleted equation 4 in the revised manuscript.

473-477: Not sure I agree with this logic. These Froude numbers are well over 1 in the supercritical regime. The shear stress as calculated is lower at higher Froude numbers because it will be shallower, but the velocity will actually be even greater.

Thanks a lot for the reviewer's comment. This comment is very helpful to us. We all agree with the reviewer's point of view. After our discussion, we have deleted this part in the revised manuscript.

Figure 3: It looks like these are essentially alternate bars forming in a straight flume channel – you state that this is similar to the field setting, but are the bar locations sometimes also controlled by the presence of obstructions?

Thanks a lot for the reviewer's comment. The question raised by the reviewer is very valuable. Boulder bar locations are sometimes controlled by the presence of obstructions. The river bed downstream terrain conditions of the field landslide dam are more complicated. In the lab, we simplified the experimental conditions. For example we simplified the channel shape and omitted the obstacle in the channel. The straight channel used in the tests is a common simplified model (Jiang and Wei, 2020; Chen et al., 2015). It is convenient for us to use the straight channel model to summarize the characteristics of boulder bar's formation and development. When the river bed in the experiment is not of equal width and straight, it is not conducive to drawing a general rule. In addition, the experimental dam model designed according to the method of Zhou et al., (2019) can reflect the actual characteristics of the field landslide dam. And according to the research of Vallejo and Mawby (2000) and Wan and Fell (2008), the materials for this experiment can be meet the experimental requirements.

Reference:

Chen, S. C., Lin, T. W., and Chen, C. Y.: Modeling of natural dam failure modes and downstream riverbed morphological changes with different dam materials in a flume test, Engineering Geology, 188, 148-158, https://doi.org/10.1016/j.enggeo.2015.01.016, 2015.

Jiang, X. G., and Wei, Y. W: Erosion characteristics of outburst floods on channel beds under the conditions of different natural dam downstream slope angles, Landslides, 1-12, https://doi.org/10.1007/s10346-020-01381-y, 2020.

Vallejo L. E., Mawby R.: Porosity influence on the shear strength of granular material–clay mixtures, Engineering Geology, 58(2):125-136, https://doi.org/10.1016/S0013-7952(00)00051-X , 2000.

Wan C. F., Fell R.: Assessing the Potential of Internal Instability and Suffusion in Embankment Dams and Their Foundations, Journal of Geotechnical and Geoenvironmental Engineering, 134(3):401-407, https://doi.org/10.1061/(ASCE)1090-0241(2008)134:3(401), 2008,

Zhou, G. G. D., Zhou, M. J., Shrestha, M. S., Song, D. R., Choi, C. E., Cui, K. F. E., Peng, M., Shi, Z. M., Zhu, X. H., and Chen, H. Y.: Experimental investigation on the longitudinal evolution of landslide dam breaching and outburst floods, Geomorphology, 334, 29-43, https://doi.org/10.1016/j.geomorph.2019.02.035, 2019.

Figure 4: I wonder if this figure could be simplified to focus on the key points in the discussion of the figure that describe the 3 variations of response.

Thanks a lot for the reviewer's comment. Figure 4 in the manuscript shows the change of the position of the boulder bar during the dam failure process. Figure 4 can very intuitively and vividly express the change of the position of the boulder bar over time. Therefore, if possible, we would like to retain the contents of Figure 4.

Figure 5: This is a complex of a figure relative to its discussion in the text; the scale bar doesn't allow us to see much of a trend except for length. There is not consistency in the labeling scheme (dots for length, triangles for width, for example; same colors for the same model runs).

Thanks a lot for the reviewer's comment. According to the reviewer's suggestion, we have modified Figure 5 in the manuscript. We hope that the revised figure can satisfy the reviewer. The revised figure is in the following.

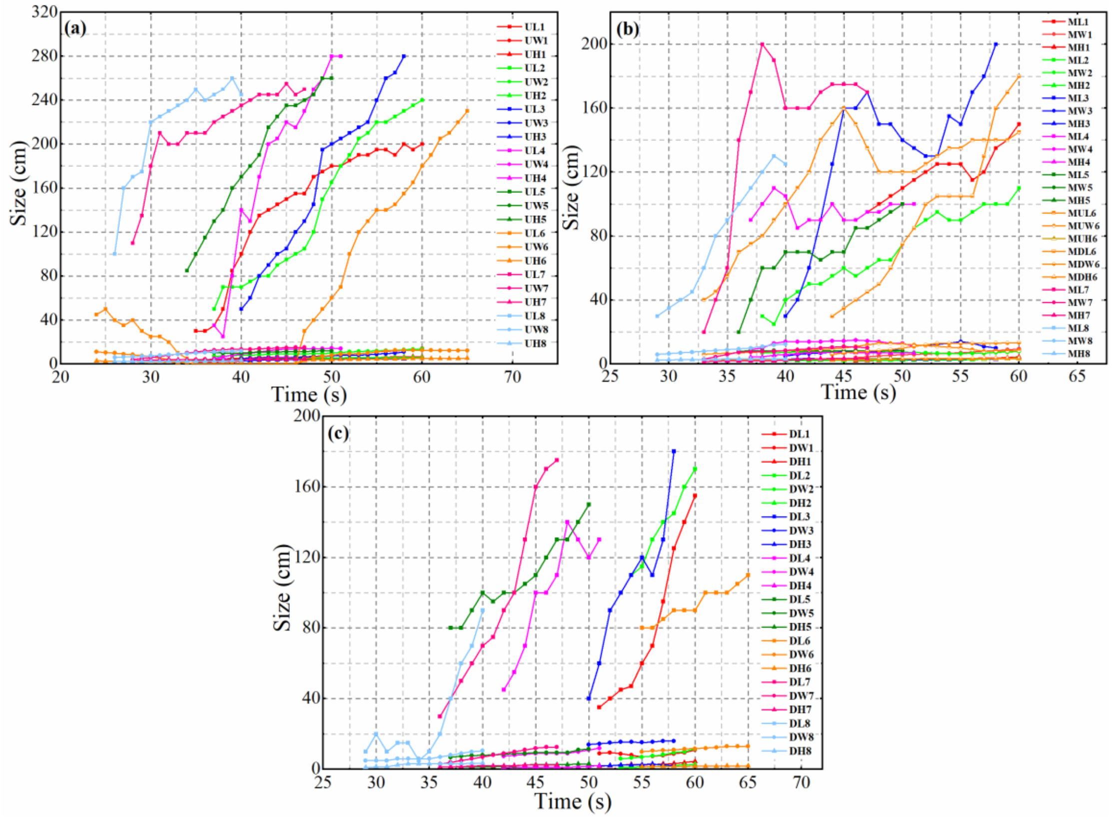


Figure. 5 The lengths, widths, and heights of the boulder bars: (a) sizes of the boulder bars near the upstream reaches; (b) sizes of the boulder bars near the middle reaches; (c) sizes of the boulder bars near the downstream reaches. Notation: L, W, and H represent the length, width, and height of the boulder bar, respectively. i represents the Ti experiment. For example, MUL6 indicates the length of the boulder bar near the middle-upstream reaches for the T1 test.

Figure 6: Same comment as figure 5 with regard

Thanks a lot for the reviewer's comment. This suggestion is very helpful to us. As shown in the figure below, we have modified Figure 6 in the manuscript as suggested by the reviewer.

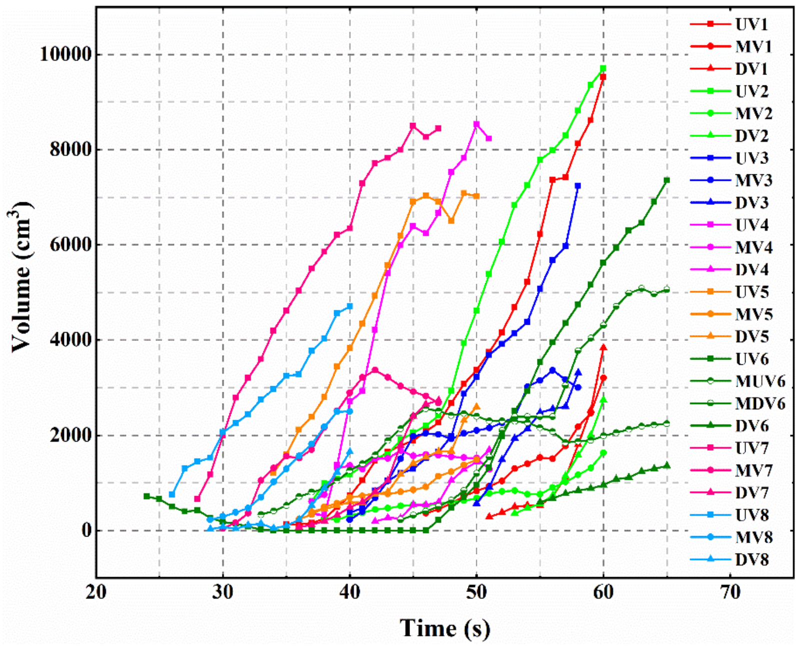


Figure. 6 Volumes of boulder bars. Notation: UVi, MVi, DVi, MUVi, MDVi represent the volume of the boulder bar near the upstream reaches， the boulder bar near the middle reaches, the boulder bar near the downstream reaches, the boulder bar near the middle-upstream reaches, and the boulder bar near the middle-downstream reaches, respectively. For example, UV1 means the boulder bar's volume near the dam toe of the T1 test