We appreciate Dr. Morris for the careful review of our paper and the constructive comments.

Reply to the specific comments

1. Abstract: Why perform these tests in a U shaped flume? If the focus of the work is to understand breach processes, it would be better to avoid the complication of curved approach flow conditions. If the intention was to analyze the effects of curved approach flow, then a closer analysis of these aspects should be performed.

Re：The work is mainly focused on the levee breach processes and the experiments should have been done in a straight channel to avoid complicated flow conditions.

We performed the tests in a U shaped flume on the consideration that levees on the concave bank are more likely to be breached by overflow than that at convex bank or straight channels because the water surface at the concave bank is higher than that at the convex bank in a bend. So this kind of breach has more research value. And in the experiment, the transverse water-surface gradient of the bend flow make the river flow enter into the land region easily.

2. Ln 14 - why choose a 2D depth averaged model? Flow through breach is 3D and whilst it may be approximated to 2DV or 2DH for different aspects, any simplification will have an effect.

Re: Compared to 3D models, simplified 2D averaged models can improve the computation efficiency effectively. Obviously, for this curved and irregular calculating area, 2D width-averaged is not appropriate. The 2D shallow water equations, discretized based on Riemman solvers have been widely used to simulate flows with discontinuities such as dam-break flow and can get satisfactory results. This is the reason why we choose a 2D depth-averaged model.

3. Ln 16 - choosing a fixed discharge coefficient for a weir shape that changes during the erosion process, and for which

Re: In Fig. 15, almost all the data are selected from the headcut retreat stage. So most of the weir height is larger than zero. Although the discharge coefficient varies with the ratio of the weir height to the overflow depth, its variation is in a limited range and the deduced discharge coefficient is in an average meaning. So there exist deviation between the scattered points and the fitting line.

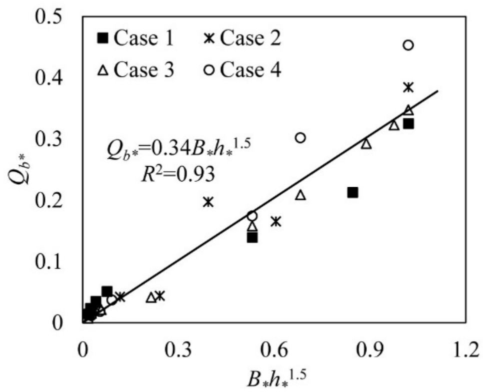


Figure 15 Fitting relation of Q_{b*} and $B_*h_*^{1.5}$

4. Ln 19 - I don't understand the phrase "Levees, as one form of embankments" – what other forms are there which are not levees? I would choose one term (levee or embankment) and stay with it.

Re: Sorry for this misleading expression and thank you for your suggestions. According to Wikipedia and other references, embankment structures include dams, levees, dikes, barriers and other similar structures. And a levee is an artificial bank raised above the immediately surrounding land to redirect or prevent flooding by a river, lake or sea. In this paper, we focused on river levees, which are constructed parallel to the river flow. And in the introduction part, the researches on the embankment constructed normal to flow were summarized first and then those on river levees were introduced.

There indeed exist some misleading expressions in the introduction part. Combined with the fifth question about non-cohesive and cohesive embankment, the introduction part has been reorganized as follows:

"River levees, as a kind of embankment structure, are constructed around rivers and parallel to the main flow to constrain flow and protect local residents from flooding disasters (Schmocker and Hager, 2009). …

Many researches have been performed on the overtopping breaching of embankments constructed normal to river flow and quite a few of these are for embankments constructed with non-cohesive materials. For example, Coleman et al. (2004) found that the breach channel of overtopped embankments under constant water level has a curved shape and the breach development obeyed the minimum energy dissipation rate rule for streams. …

Many studies on the cohesive ones have also been conducted. Compared to non-cohesive embankments, overtopping breaching of cohesive embankments is a more complex phenomenon involving impinging jet flows, reverse roller structures and headcut erosion (Zhu, 2006)…

However, researches on the overtopping breaching of river levees parallel to the main flow are limited. Kakinuma and Shimizu (2014) conducted large-scale experiments on breaching of river levees at the floodway of an actual river channel. …

River levee breach is quite different from the breach of embankment constructed normal to the flow in morphology, hydraulics and inflow variation characteristics (Kakinuma and Shimizu, 2014). Moreover, measured data of cohesive levee breach have not been reported until now. Thus, four groups of experiments on cohesive levee breach were performed in a bend flume with varied inflow discharge, soil water content and porosity. In these experiments, levees were constructed in the flume with an initial breach. Different stages of levee breach process and flow characteristics near the breach were analyzed. The levee breaching flow rates process, simulated by a depth averaged 2-D flow model, was also studied with detail."

The complete version of this part is in the revised paper.

5. Ln 26 and numerous other references - you state a number of times that most studies look at non cohesives or cohesives. I would not agree. There are various researchers who have investigated both cohesive and non cohesive breach processes. In terms of large scale tests (ie. 1.5 - 2m high) tests, the most rigorous work on cohesive breach processes has been done by Hanson at HERU, USDA Stillwater. I'm not aware of similar scale and magnitude of tests on non cohesives, although there are plenty of smaller scale analyses. In conclusion, I would avoid suggesting any bias to one or the other.

Re: This is our fault in expression. The introduction part has been reorganized shown in the previous question.

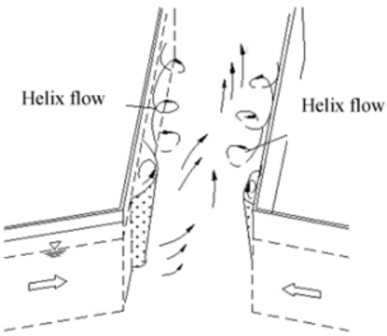
6. Ln 38 - No - many of the processes listed also occur with non cohesives (eg. Vortex flow, soil mass failure etc).

Re: This is our fault in expression. We have reorganized the sentence in Ln 40-42 as:

Compared to non-cohesive embankments, overtopping breaching of cohesive embankments is a more complex phenomenon involving impinging jet flows, reverse roller structures and headcut erosion (Zhu, 2006).

7. Ln 47 - you mean vortex rather than spiral flow?

Re: Here the spiral flow indicates the helix flow shown in the following figure. The author (Zhang et al, 2009) found that the upstream of the breach is bell-shaped, and helix flows exist on both sides of the breach. This kind of flow pattern could be considered as the convergence of three currents: the left bend flow, central straight flow, and the right bend flow.



Helix flow in dam break processes

8. Ln 89 - THIN FILMS - this is the only reference to thin films made in the paper. What is this referring to? It may be associated with trying to limit seepage through the test section before starting the test? If so, this is a key issue since the internal pore pressure conditions will affect how the test section performs (erodes) and this is subject to scale effects. How was this aspect dealt with in your tests?

Re: It should be stated in the previous context. The sentence "Before experiments began, the levee surface in the river region was covered with thin films to prevent infiltration." is added in Ln 94.

As for the internal pore pressure, I think you mean the minus pore water pressure (matric suction) in unsaturated soil. Indeed, the pore water pressure affect the soil erodibility. Here we did not consider it because the saturability of the levee is quite large, about 75.67% to 81.82%, calculated according to the porosity, dry density and the water content of the soil. And so the water infiltrates slowly into the soil and only affects the pore water pressure of a small part of the soil.

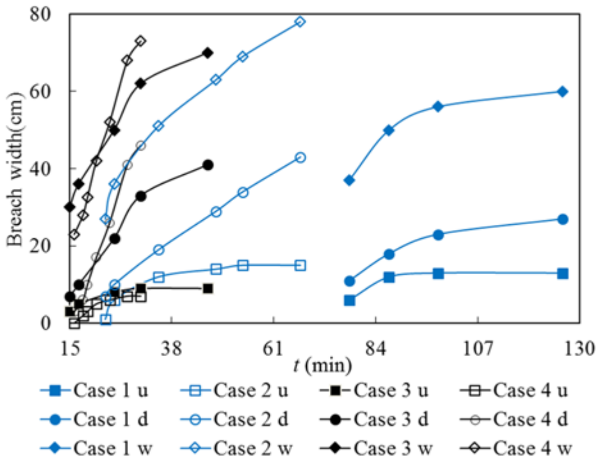
9. Ln 138 - 144 - in practice you are referring here to the soil erodibility. How the erodibility varies affects the headcut / erosion process. The soil state and parameters affect the erodibility and hence the breach process. A clearer analysis and understanding of these aspects is needed to place breaching processes in context for different levees, materials and material states. In your case, it should be recognised that the test results reflect a certain, specific soil type and state and hence some observed and calculated processes may vary as these parameters change.

Re: Thank you for your suggestion. Here I refer to the effect of soil water content and soil porosity on the soil erodibility and then the breaching process. Could you please tell me your specific suggestion? Do you suggest me declare that my analysis is confined to only a small range or reanalyze it?

10. Ln 148-150 - the approach flow conditions offer a whole area of research in relation to breach formation that could be / should be analysed!

Re: Thank you very much for your suggestion. This part has been reorganized as follows in Ln 156-162:

The breach widening process is shown in Fig. 7. It can be seen that initially, the migration rate of the upstream and downstream side slope of the breach was similar. But afterwards, the downstream side was eroded faster. This can be explained by the flow structures shown in Fig. 3f. The main breaching flow concentrates near the downstream side slope and eroded its toe. Fig. 8 shows the calculated flow field near the breach of Case 2 when the breach width is about 40 cm using the following 2D depth-averaged numerical model. The flow velocity near the downstream side is larger than that near the upstream side. Meanwhile, around the downstream side, the flow velocity near the toe of the land region is larger than that of the river region. The flow structure corresponds well with the final breach form shown in Fig. 9.



‘u’ represents the upstream slope. ‘d’ represents the downstream. ‘w’ represents the breach width

Figure 7 Breach widening process

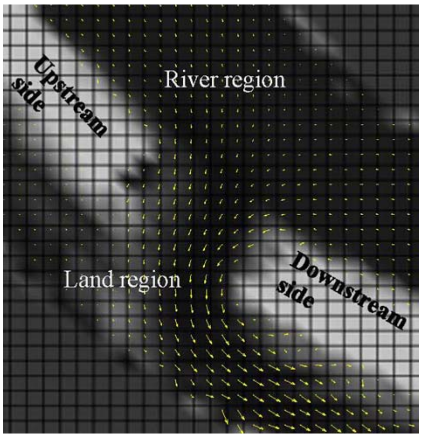


Figure 8 Flow field of Case 2 (*B*=40cm)

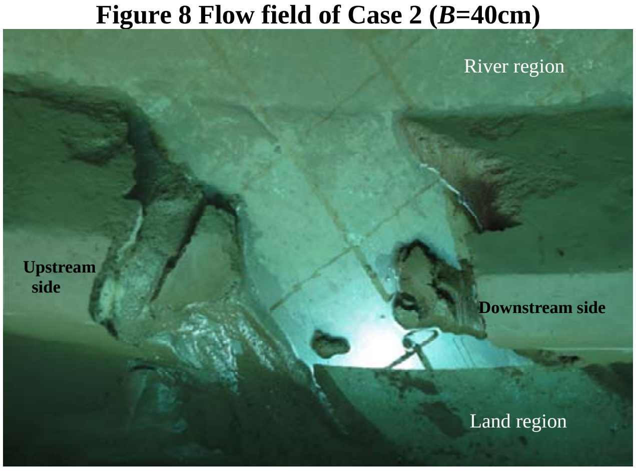


Figure 9 Final breach form

11. Ln 168-170 - analysis of cantilever lengths. Whilst I agree with the observed process, and the approach to calculation is logical, there is considerable uncertainty in the ‘rule of thumb’ tensile strength value, as well as soil homogeneity - which means that the true strength in situ will vary unpredictably, so affecting the observed cantilever lengths.

Re: I agree with the view that the tensile strength varies unpredictably in situ. And that is may be the reason why the calculated cantilever length does not match exactly with the observed value. But the observed critical cantilever length is the average of all the fractured cantilevers in a test case. This may weaken the effect of non-homogeneity.

12. Ln 261-265 - flow calculation: would have expected a closer fit between estimated and modelled values. maybe a closer look at the geometry of the flow control section would offer a means to reduce the uncertainty?

Re: Thank you for your suggestion. Here we take use of the measured data of Case 2. For Case 2, the velocity monitoring point is located at the middle of the breach and the flow direction there was directly toward the land region. And the measured velocity can represent the average breaching flow velocity. In Table 3, we list the breach geometry parameters (the breach width B and the breach height H), the hydraulic parameters (the water head above the breach crest h' and the measured velocity U), the estimated breach discharge Q_{bm} (calculated by $Q_{bm} = Bh'U$) and the numerically calculated breach discharge Q_b. It can be seen that the numerically calculated breach discharge matches well with the estimated values overall. The above modifications have been made in Ln 270-276.

Table 3 Numerically calculated breach discharge and estimated values

t (min)	H (cm)	B (cm)	h' (cm)	U (m/s)	Q_{bm} (L/s)	Q_b (L/s)
10	15.7	20	1.8	0.193	0.695	0.655
17	15.5	20	2	0.198	0.792	0.964
19	15	20	2.5	0.207	1.035	1.416
21	13	20	4.5	0.324	2.916	1.922
22	5	20	12.5	0.499	12.475	11.601
23	0	20	16.9	0.579	19.57	18.744
25	0	36	13.3	0.407	19.487	18.292
28	0	43	13	0.318	17.776	15.551

13. Ln 294 - what does "...increase of soil content..." mean? Suggest reword.

Re: There is a mistake here. It should be "...increase of soil water content..." in Ln 320.

14. Fig 3a - you show a scour hole. Was there also seepage through the test material, and / or between the material and flume base?

Re: There may exist feeble seepage between the materials and the flume bottom, but we did not observe obvious seepage, when the overtopping was suspended temporarily. This may be due to the reason that the material and the flume bottom were tightly bounded together by the beating of soils with a hammer. The scour hole indeed appeared after the overtopping began and the feeble seepage through the interface, if there is, is one of the reasons that the scour hole usually appear at the slope toe initially.

The soil is cohesive and the levee was constructed by gradually adding soil and compacting layer by layer and the levee surface was carefully smoothened by the plastering trowel. These can all decrease the permeability of the levee. And before the breaching process, seepage prevention measures (thin films were placed at the river-side slope) was applied. So the flow upstream may not permeate through the test material during the overtopping process with very small seepage flow velocity.

Reply to typos

(1) Ln 12 - mechanisms

Re: “mechanism” has been changed into “mechanisms” in Ln 12.

(2) Ln 24 - "...flood propagation processes..."

Re: “flood propagation process” has been changed into “flood propagation processes” in Ln 24.

(3) Ln 119 - "...the overflow departs from the headcut surface..."

Re: “the overflow will be departed from the headcut surface” has been changed into “the overflow departs from the headcut surface” in Ln127.

(4) Ln 146 - should read Fig 3f not 5f.

Re: “Fig. 5f” has been changed into “Fig. 3f” in Ln 154.

(5) Ln 292 - "...single step..."

Re: “singe” has been changed into “single” in Ln 318.