Application of embankment breaching model to simulate dam-break floods of barrier lakes

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Introduction

The barrier lake refers to the lake formed by large-scale landslides or mudslides blocking the river. The so-formed dam is a kind of natural embankment prone to breaching. There are currently relatively few studies specifically focused on natural embankment breaching simulation. Application of an embankment breaching model previously developed to simulate the dam-break floods of two high-risk barrier lakes are summarized.
The two barrier lakes (or natural embankments) are shown in Fig. 1 and Fig. 2, and summarized in Table 1.

Fig. 1 Tangjiashan embankment

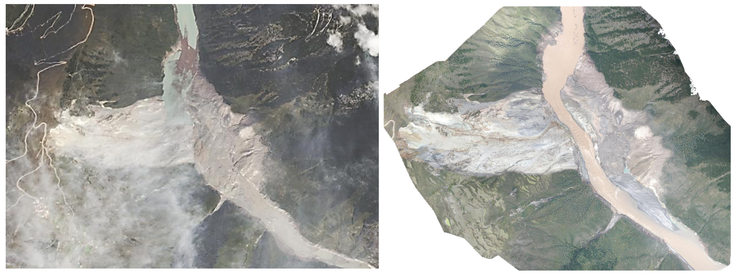

Fig. 2 "10.10" Baige embankment before and after breaching

Table 1 Summary of the two barrier lakes (natural embankments)

Natural embankment	Length river direction (m)	Width valley direction (m)	Height (m)	Volume embankment (10^6 m^3)	Volume water stored (10^8 m^3)
Tangjiashan	803	611	82-124	20.4	2.5
"10.10" Baige	2000	450-700	61-100	25	2.9

Model

The embankment breaching model is previously developed based on the mechanism of breach erosion as observed in various laboratory or field tests and prototype cases. The model mainly simulates the coupling process of embankment failure, such as reservoir water balance, embankment-breaching flow change, embankment-breaching morphology development and embankment body erosion. For details readers are referred to Zhu (2006) and Zhu et al. (2008).
The main difference between barrier embankment and artificial embankment is that the material grading of barrier embankment is wider and looser, and the embankment body along the river is thicker. However, in terms of failure, the barrier embankment and artificial embankment still have similar failure process and hydraulic characteristics, and similar failure mechanism as well. Since the embankment body is thicker in the river direction, the characteristics of headcut erosion of the failure of the barrier embankment are more prominent.

Results

(1) Model applications during emergency response phase
According to the continuous accumulated and updated measured or inferred data transmitted from the sites, over 100 possible scenarios of the dam-break floods have been simulated for the two barrier lakes (see e.g. Table 2 and Fig. 3), providing important basis for the emergency evacuation of the population at risk.
(2) Model applications to the back analysis
For the Tangjiashan Barrier Lake, it was artificially breached by a manual excavated drainage channel about one month later after its formation. The model was also applied to back analyze the drainage process of the barrier lake. The modeled results agree well with the available measurements (see Fig. 4).

Table 2 Some of the calculation conditions and results of the"10.10" Baige Barrier Lake

No.	Corresponding lake storage (10^8 m^3)	Breach size	Breach duration (hr)	Calculated flood peak (m^3/s)
1	3.0	1/2 dam body	3	21600
2	3.0	1/2 dam body	6	15600
3	3.0	1/2 dam body	12	9500
4	3.0	1/3 dam body	3	9500
5	3.0	1/3 dam body	6	8500
6	3.0	1/3 dam body	12	6900

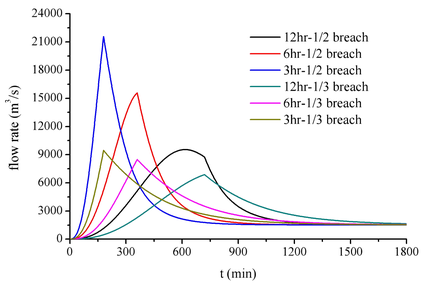

Fig. 3 Predicted breach flow rates of the "10.10" Baige Barrier Lake

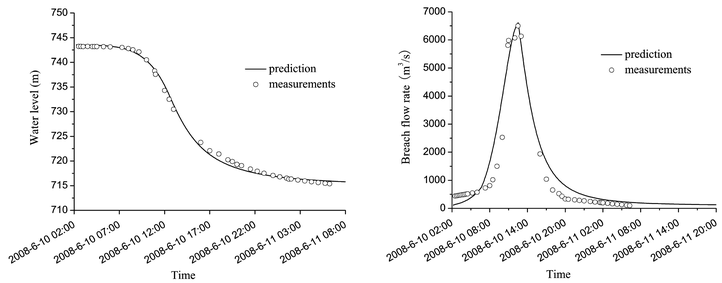

Fig. 4 Predictions vs. measurements for the Tangjiashan Barrier Lake (left: lake level, right: breach flow rate)

Conclusions

- Non-engineering measures are the main means for emergency rescue and disposal of barrier lakes.
- The most basic requirement for the calculation of dam-break flood risk for the emergency treatment of barrier lakes is simple and fast.
- Due to the lack of data and the urgency of time, many assumptions usually have to be adopted in the flood simulation and prediction during emergency treatment of barrier lakes, so it is feasible to borrow embankment breaching model at this time.

References
Zhu, 2006. *Breach growth in clay-dikes*. Delft: Delft University of Technology.
Zhu et al., 2008. Dam break flood analysis and discharge scour simulation of the Tangjiashan Barrier Lake. *Yangtze River*. 39(22): 79-82.

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