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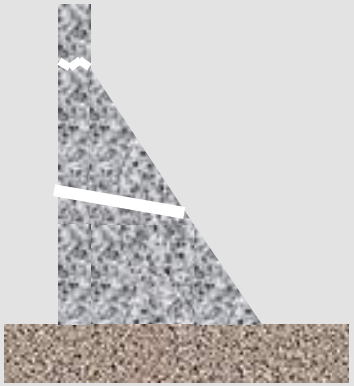
Bending failure of a concrete gravity dam subjected to underwater explosion

Key words:

Centrifuge test; Numerical simulation; Concrete gravity dam; Underwater explosion; Bending failure



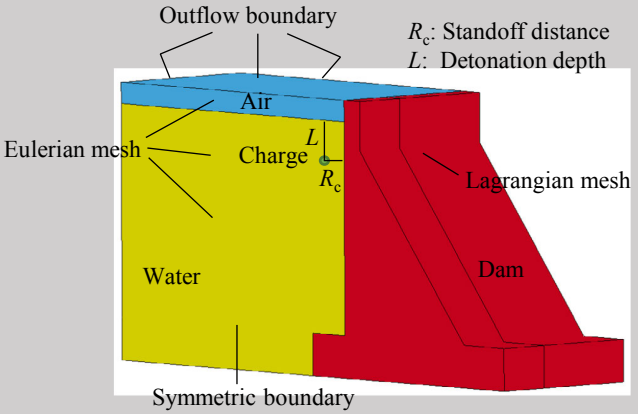
Comparative study

Centrifuge tests

- Detailed configurations: TNT equivalent of the industrial detonator; dam geometry; water depth, detonation depth, standoff distance.
- Pressure data; strain data

Numerical simulations

- Full coupled Lagrangian–Eulerian method
- Analysis of the underlying mechanics of the dam failure

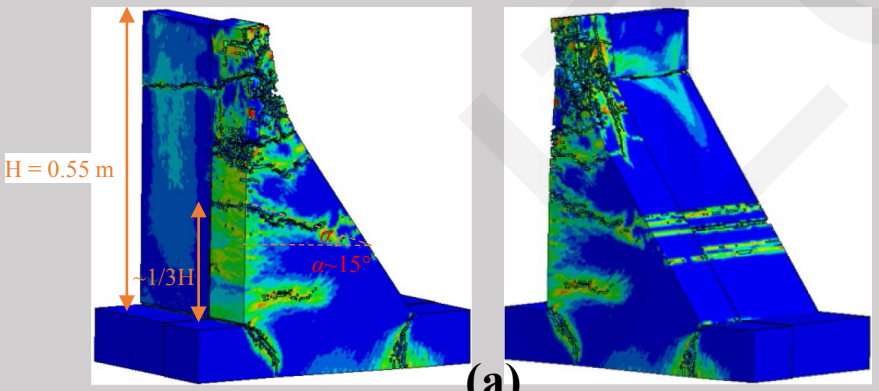


Dam failure

(a) (b)

The first fracture in the upper part is at the change in the downstream slope, and is normal to the upstream face.

Fig. 1 Dam failures from the centrifuge test UE-04: (a) upstream face; (b) downstream face



(a)

(b)

The second fracture is in the lower part at around one third the height of the dam. This fracture is no longer normal to the upstream face, as there is a horizontal angle with a measured value of about 15°.

Fig. 2 Dam failures from numerical simulations (a) and centrifuge test UE-04 (b)

Conclusive remarks

Centrifuge tests and numerical simulations were performed in this study to investigate the failure of a concrete gravity dam subjected to a near-field underwater explosion. Results of the centrifuge tests and numerical simulations were in good agreement. There were two tensile fractures inside the dam: one in the upper part and another in the lower part of the dam. Our conclusions can be summarized as follows:

(1) The thin upper part of a concrete gravity dam is vulnerable. A horizontal tensile fracture was observed at the break of the downstream slope.

(2) A tensile fracture was also observed in the lower part at around one third of the height of the dam, and at a horizontal angle of about 15° . This fracture was produced mainly by the bending tensile stress in the upstream face, causing the fracture to propagate in a downstream direction.

(3) Some dam failures produced in historical wars shared a similar failure mode, generally a breach of variable depth in the upper part of the dam. This failure mode is consistent with the results presented in this study. The position of the tensile fracture in the lower part internally determines the depth of the breach for a dam subjected to underwater explosion.