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Simulation analysis of the characteristics of the truncated projectile entering the water

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Abstract. In order to explore the influence of the bevel angle of the projectile on the vertical velocity attenuation characteristics and cavitation of the projectile after it enters the water vertically, this paper uses numerical simulation to analyze the bevel angles by series of projectiles. At the same time, the high-speed camera is used to study the vertical penetration of the projectile with a 45 degress bevel angle to verify the simulation model. The research results show that the vertical velocity decays exponentially, and the trajectory of the truncated projectile is bent after entering the water so that an asymmetric open cavitation occurs. The bevel angle will affect the degree of trajectory curvature, velocity attenuation and the shape of the cavity. The larger the bevel angle, the greater the degree of trajectory curvature; the smaller the bevel angle, the slenderer the cavity and the smaller the asymmetry.

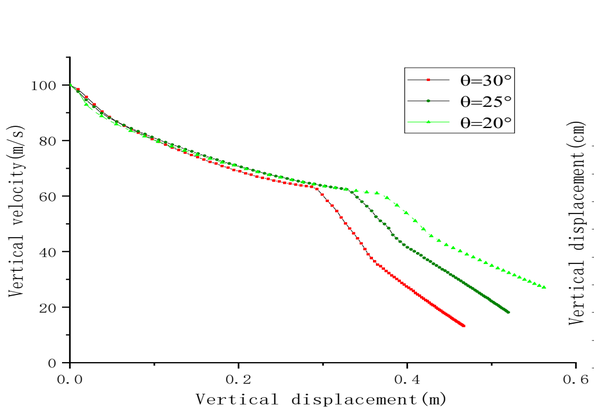
Numerical Simulation

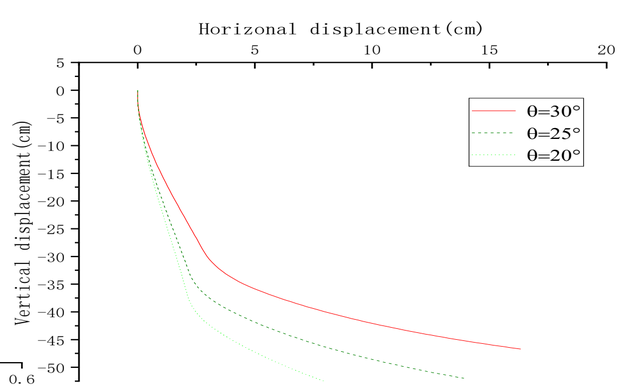
Water-entry is a fluid-structure coupling problem. The fluid-structure coupling algorithm used in this article is the ALE algorithm in the LS-DYNA program. Elements are allowed to move and distort which minimizes advection. This minimizes energy dissipation and speeds up run time.

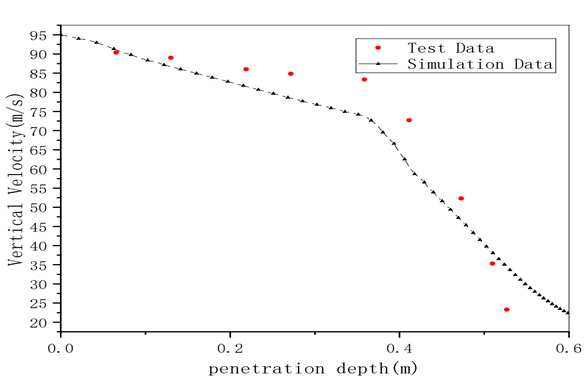
Experimental validation

Water-entry is a fluid-structure coupling problem. The fluid-structure coupling algorithm used in this article is the ALE algorithm in the LS-DYNA program. Elements are allowed to move and distort which minimizes advection. This minimizes energy dissipation and speeds up run time. The experimental projectile and water tank are as follows.

Results and Discussion







Conclusion

This paper uses LS-DYNA to simulate and analyze the vertical entry process of three different truncated projectiles, and the test results is used to prove the reliability of the model. Through the data fitting of simulation results, it can be found that the attenuation of the vertical velocity of the projectile with the penetration depth conforms to the exponential attenuation law $v_y/v_0 = e^{cy^2+by+a}$, and the bevel angle has little effect on the attenuation at the initial stage. It would be better to verify the law experimentally in the subsequent research. When the tail of the projectile touches the wall of the cavity, as the bevel angle increases, the velocity of the projectile in the vertical direction decays faster.

The projectile deflects when it enters the water. The larger the bevel angle, the greater the angle of deflection of the projectile at the same penetration depth. Also, the open cavity is asymmetrical, and the smaller the bevel angle is, the more slender the cavity is.