Violent breaking wave impacts. Part 3. Effects of scale and aeration

The effects of scale and aeration on violent breaking wave impacts with trapped and entrained air are investigated both analytically and numerically. By dimensional analysis we show that the impact pressures for Froude scaled conditions prior to the impact depend on the scale and aeration level. The Bagnold-Mitsuyasu scaling law for the compression of an air pocket by a piston of incompressible water is rederived and generalised to 3D air pockets of arbitrary shape. Numerical results for wall pressure, force and impulse are then presented for a flip-through impact, a low-aeration impact and a high-aeration impact, for nine scales and five levels of initial aeration. Two of these impact types trap a pocket of air at the wall. Among the findings of the paper is that for fixed initial aeration, impact pressures from the flip-through impact broadly follow Froude scaling. This is also the case for the two impact types with trapped air pockets for impact pressures below 318 kPa, while impact pressures above this value broadly follow the Bagnold-Mitsuyasu scaling law with full-scale pressures greater than those predicted by the Froude law. For all impact types, the effect of aeration is found to reduce the maximum impact pressure, maximum force and impulse. Good agreement with the asymptotic model of Peregrine & Thais (J. Fluid Mech., vol. 325, 1996, pp. 377-397) is found for the flip-through impact pressure and a fair agreement is found for the low- and high-aeration impacts. Based on the numerical results, a modified scaling curve that combines Froude scaling and the Bagnold-Mitsuyasu law is suggested. The practical implications of the findings are discussed and attention is drawn to the limitations of physical model tests.