

Punching shear failure due to impact loading

The Dutch Safety Requirements specifies that newly build nuclear reactors shall provide suitable protection measures in the event of an accidental aircraft crash. Usually this is done with a so-called aircraft protection shell (APS) made from reinforced concrete which protects vital safety systems inside the reactor.

An aircraft impact causes an extreme load in a short time period, which depends mostly on the speed and the mass of the projectile (the aircraft). The response of the target (APS) is highly non-linear and difficult to predict. Therefore analysis for impact loading is usually done with explicit FEM packages.

Several experiments have been carried out to study the behaviour of concrete walls under impact loading. The interaction between the projectile and the target defines the load as either "hard impact" or "soft impact", both with their own failure mechanisms. For hard impact, the dominant failure mechanism is punching shear failure, where the kinetic energy impacted by the projectile is entirely absorbed by the deformation of the target.

A hard impact experiment is modelled in DIANA to verify the analysis of aircraft impact on the APS. Two methods are used, one with a force-time load and one with an explicit projectile with a predefined speed. In both cases the target is modelled with solid elements. The exact behaviour of the experiment is hard to reproduce, but an indication of punching shear failure is noticeable.