# Experimental Investigation and Numerical Analyses of Reinforced Concrete Structures Subjected to External Missile Impact

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Aircraft impact on protective reinforced concrete (RC) building structures is a relevant loading case. Numerical tools like ANSYS AUTODYN used for the assessment are validated on the basis of tests.

Impact test facility at VTT of intermediate scale
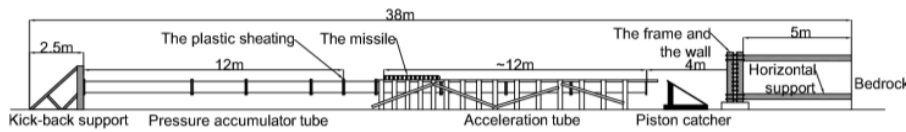
- International project IMPACT (10 partners)
- Missile mass ~50 kg, $v_{0,maximum}$ =165 m/s
- Soft, hard and water filled missiles
- Target: RC slab edge length 2.1-2.3 m, thickness 0.15-0.25 m or force plate system
- Enhancements of facility scheduled for fall 2013 to test larger structures at higher velocities

Punching failure of RC slabs (hard impact)

Test parameters to study punching capacity:
- Impact velocity
- Amount and type of shear reinforcement
- Amount of bending reinforcement
- Pre-stressing of concrete
- Effect of a steel-liner

Open questions
- Influence of slab thickness

IRIS* Punching Test   Simulation

Lagrange   SPH**

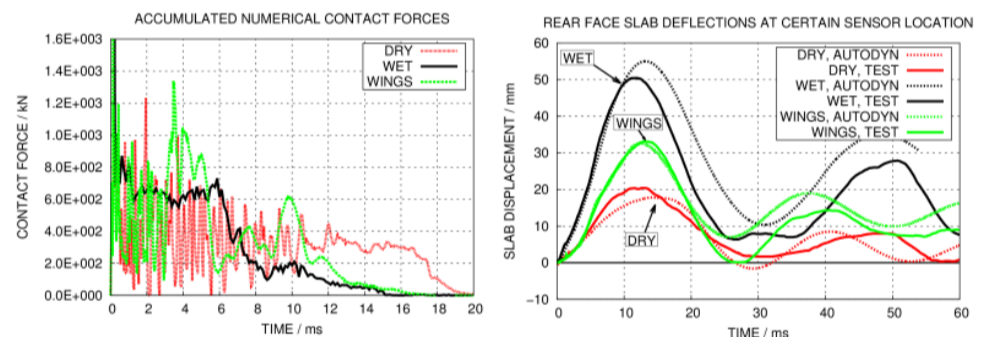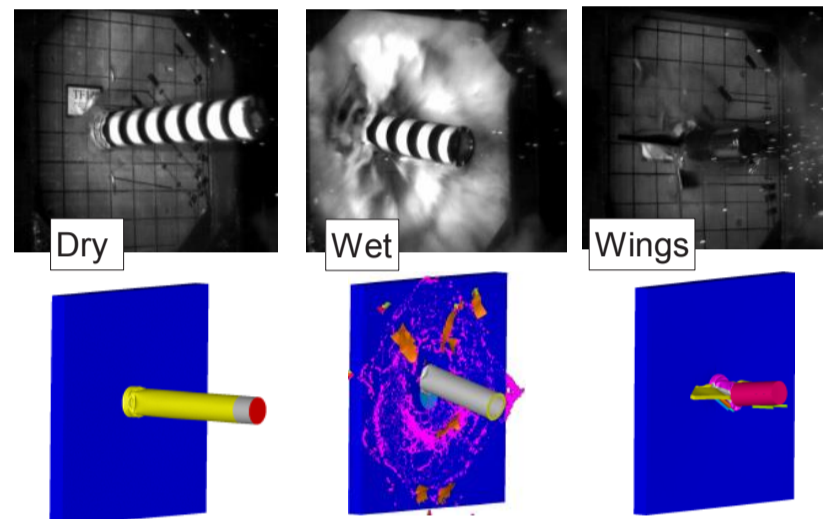RESULTS FOR PLAIN WALL (BENDING REINFORCEMENT ONLY)
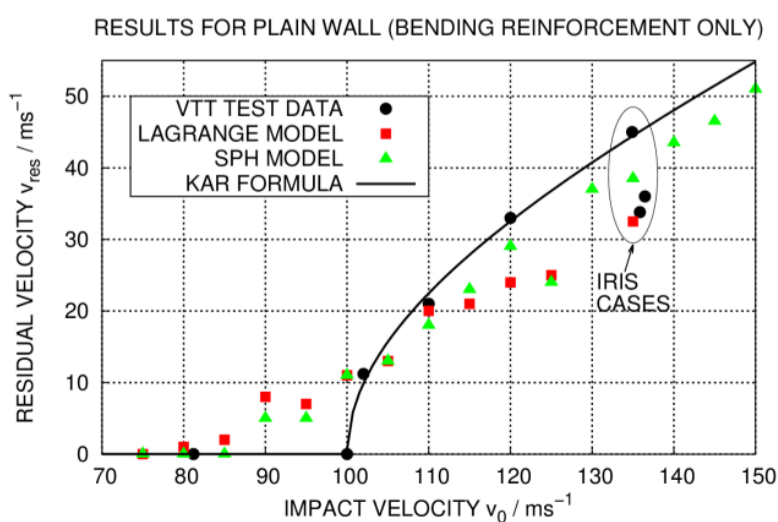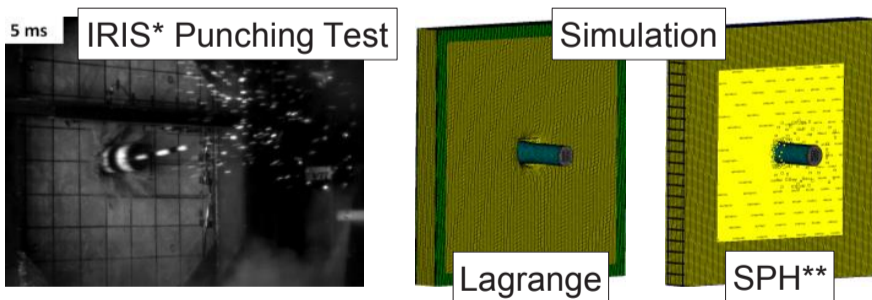
Bending failure of RC slabs (soft impact)

Test parameters to study flexural behaviour:
- Missile design (soft, water-filled, wings)
- Impact velocity (110-160 m/s)
- Support conditions (1-way, 2-way)

Open questions:
- Effect of partially water filled tanks (sloshing)
- Variation of span-width (2.1 m → 3.5 m)
- Simulation of maximum reinforcement strains

Dry   Wet   Wings

ACCUMULATED NUMERICAL CONTACT FORCES

REAR FACE SLAB DEFLECTIONS AT CERTAIN SENSOR LOCATION

Slab deflections are sensitive to features of load time function. Water infill yields higher average loading and two times larger deflections.

Ongoing activities

- IRIS* benchmark activities hosted by OECD/NEA with some 28 participants, duration 2010-2014
- VTT IMPACT PHASE III, duration 2012-2014
- Application of methodology to integrity-assessment of real containment structures loaded by aircraft impact

Frame from Sandia

SANDIA FULL SCALE TEST (F4–PHANTOM, v_0=215 m/s, M=19 t)
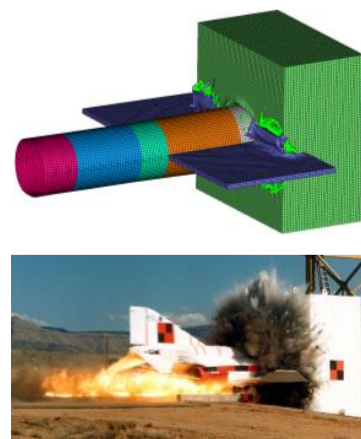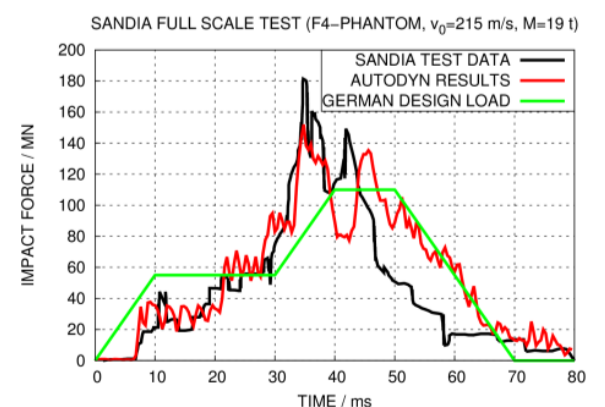
* **I**mproving **R**obustness Assessment Methodologies for Structures **I**mpacted by Missile**s** ** Smoothed Particle Hydrodynamics