Half scale experiments with rig for measuring structural deformation and impulse transfer from land mines

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Cooperation during 2007-2008 between:

BAE Systems Hägglunds AB
FOI, Swedish Defence Research Agency

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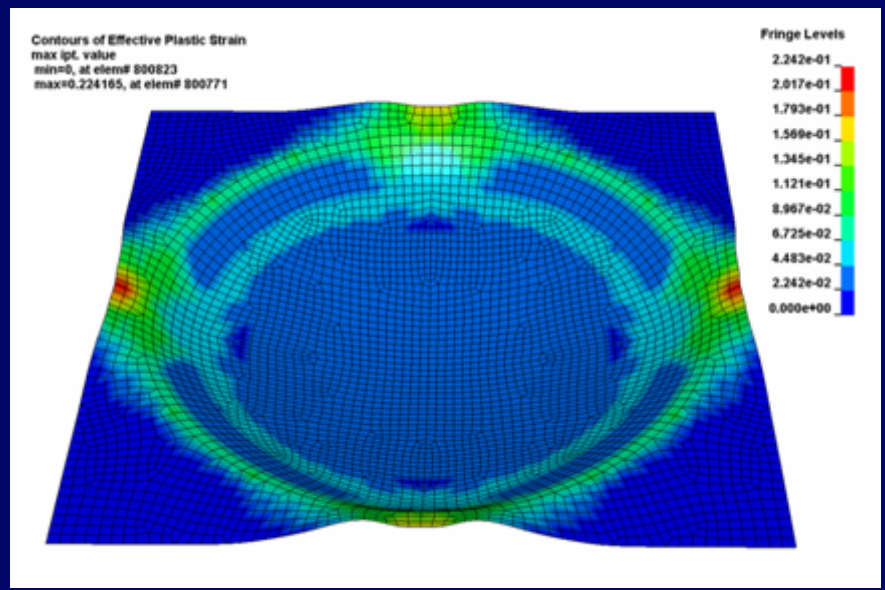
PhD-project PROTECT

In collaboration between :

BAE Systems Hägglunds
Luleå University of Technology

Björn Zakrisson



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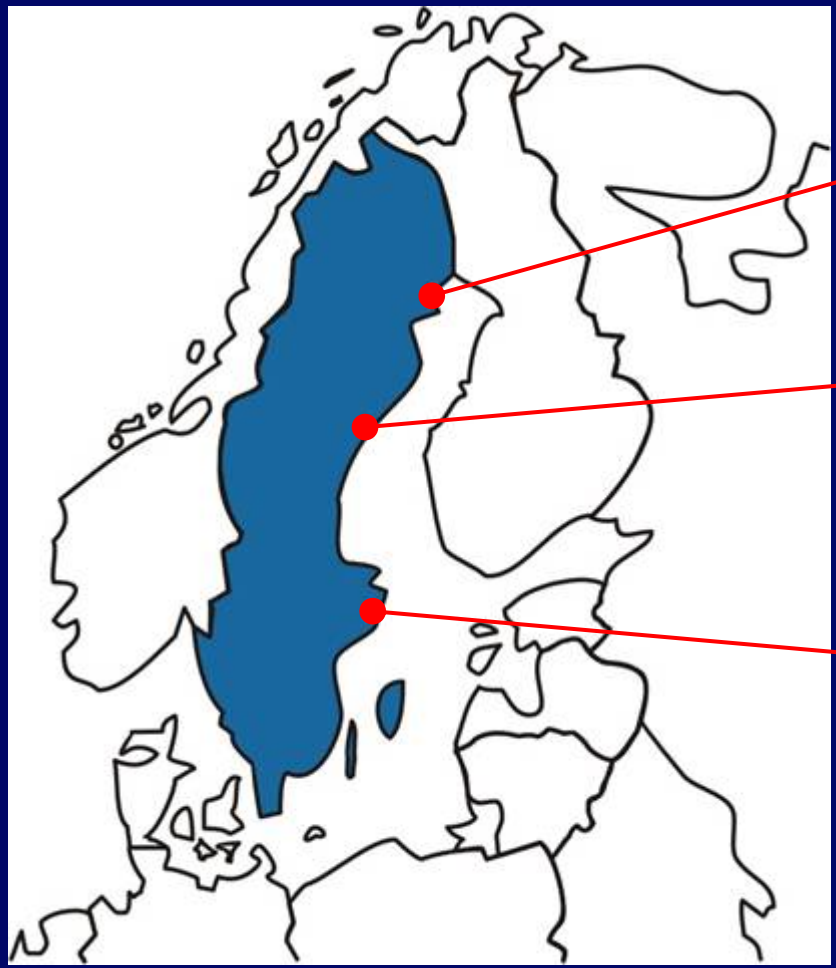

Luleå University of Technology

BAE Systems Hägglunds AB
(Örnsköldsvik, Sweden)

FOI
Swedish Defence Research Agency
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Scope of work

- Experiments with land mine buried in ground
  - Performed in half scale
- Test parameters:
  - Explosive placed in steel pot or sand
  - Depth of Burial (DOB) in sand 0, 50 och 150 mm
  - Wet or dry sand
- Conditions:
  - Swedish military plastic explosive m/46
    - 86 % PETN 14 % fuel oil
    - Cylindrical with Diameter to Height ratio 3
    - 0.750 kg
  - 0.25 m stand-off distance
- Objective:
  - Detect effects of different test parameters
  - Use test results for validation of numerical model

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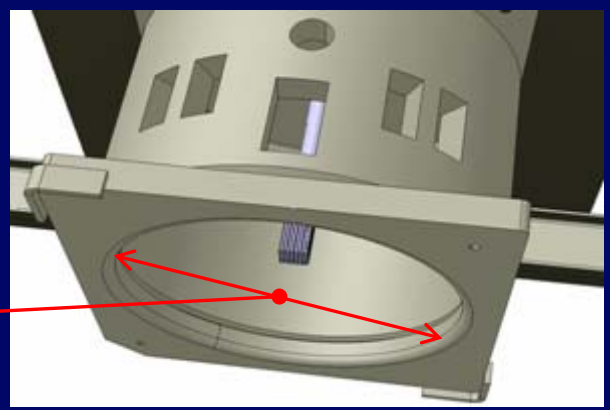
Experimental Setup

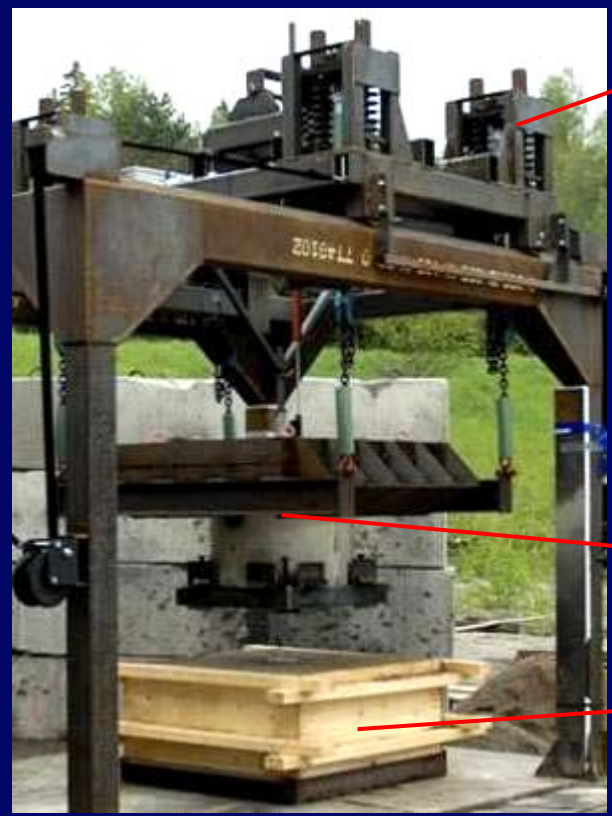
Test module viewed from underneath

Plate holder

Weldox 700E
600x600 mm
t=8mm



Diameter
500 mm



Spring-damper system

Test module

Sand box / Steel pot

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Measurements

- Maximum vertical jump of the test module
  - Impulse transfer to test module

$$I = m \cdot v_{\max} \approx m \cdot \sqrt{2 \cdot g \cdot z_{\max}}$$

- Maximum dynamic plate deformation
- Residual plate deformation

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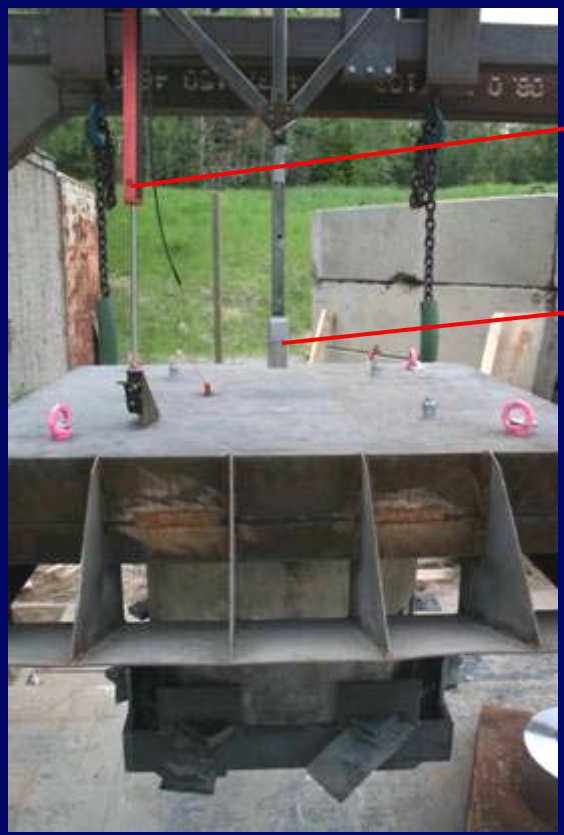
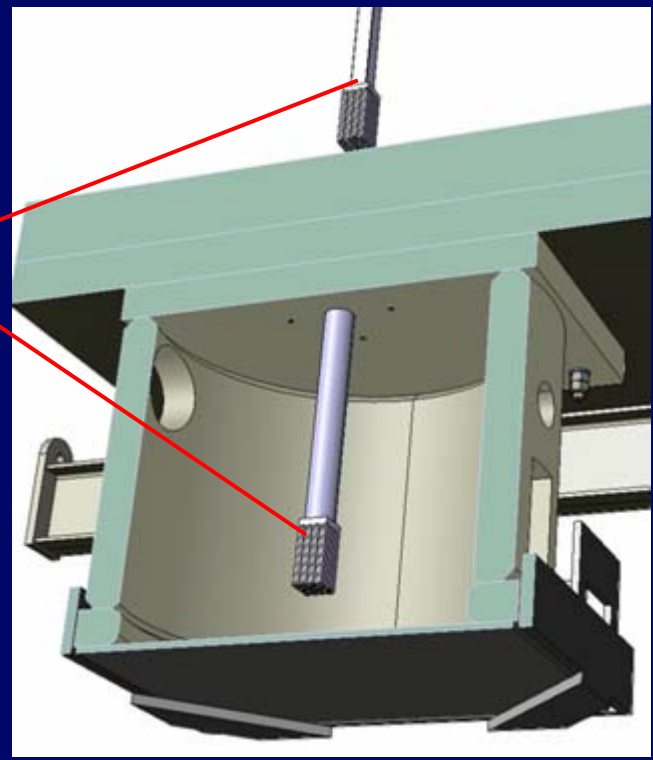
Measurements (cont.)



Position sensor

Aluminum Honeycomb

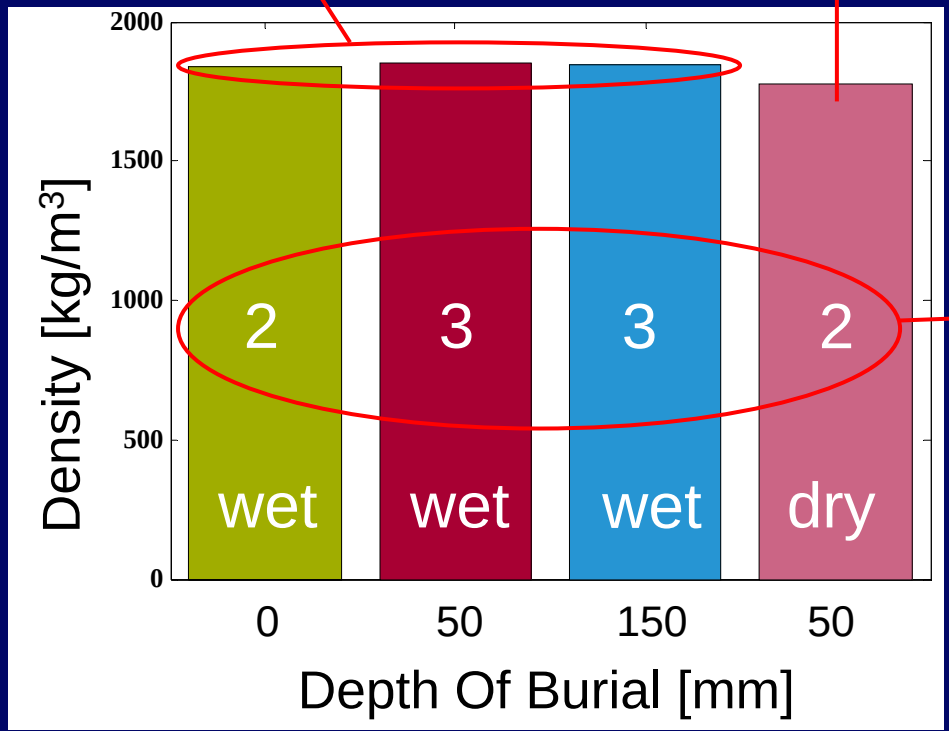


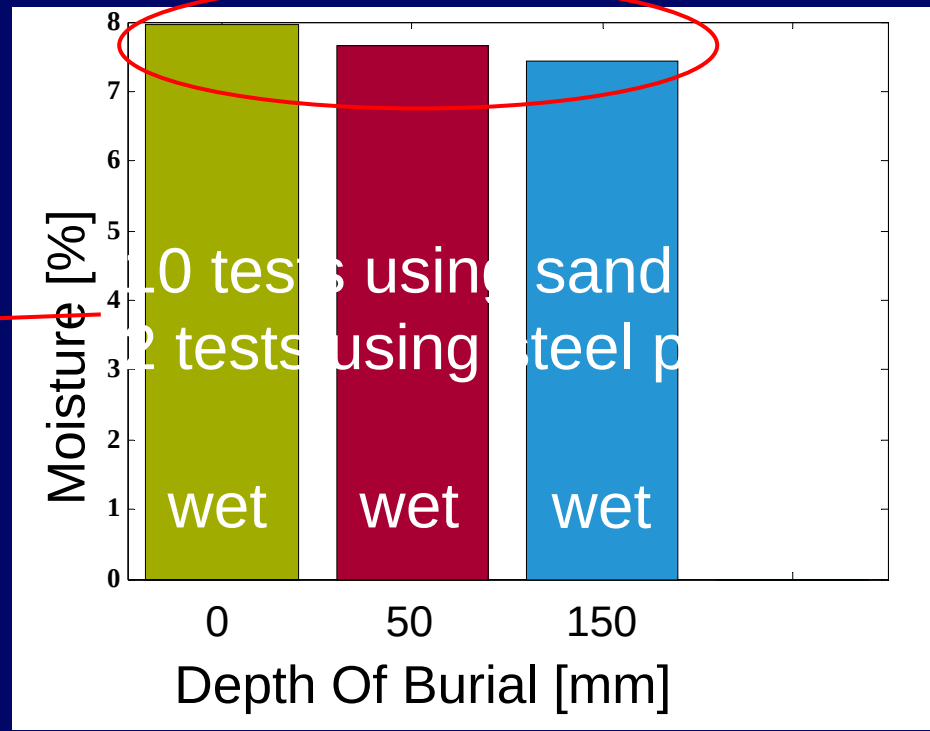
Sand properties

Mean ”wet” density 1845 kg/m^3

Dry density 1771 kg/m^3

Mean moisture 7.7 %





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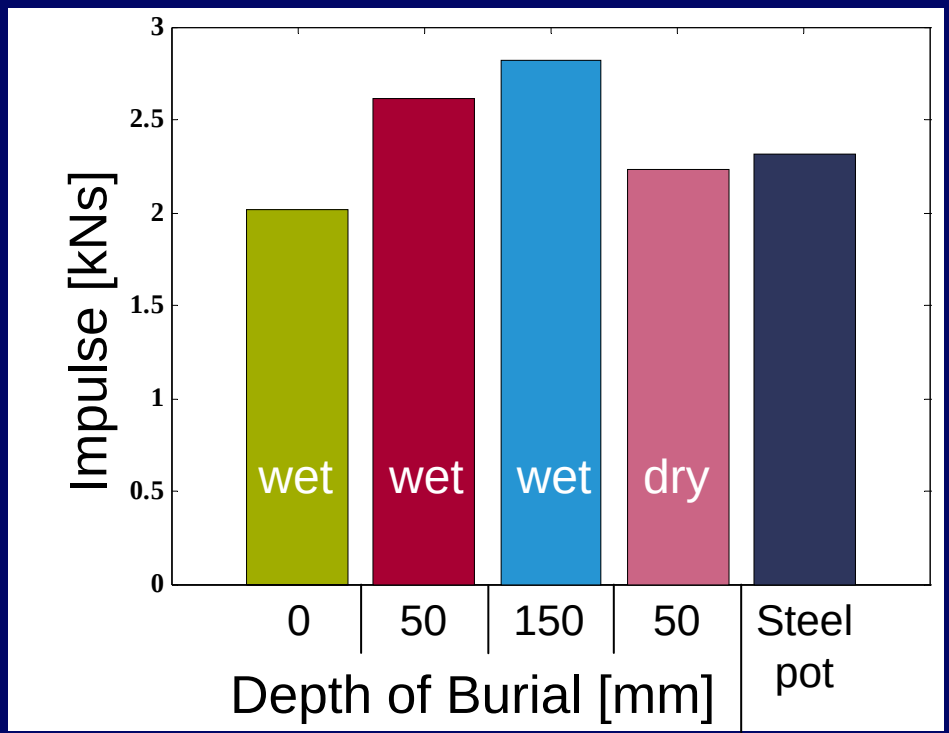
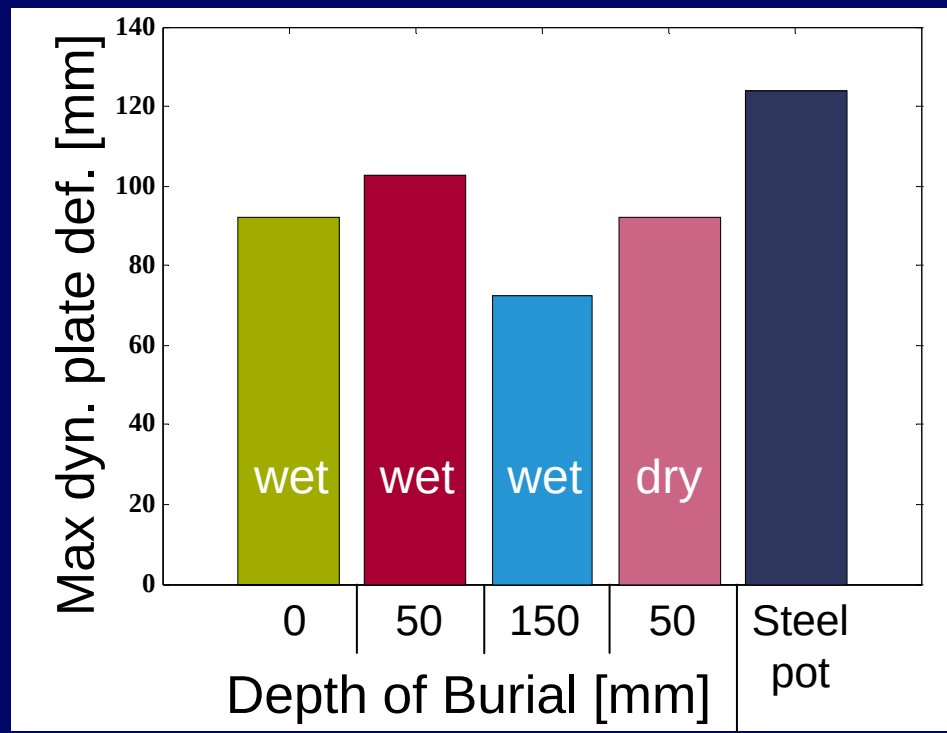
Experimental Results

Impulse transfer to test module



Maximum dynamic plate deformation



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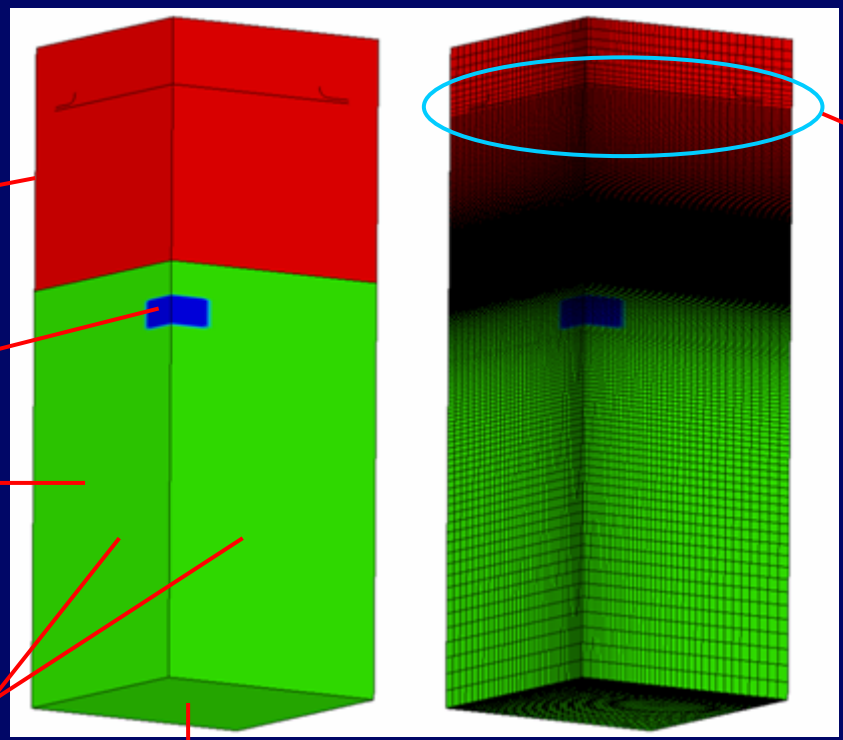
Numerical model
LS-DYNA



- Symmetry model 1/4
- Sand, Air and Explosive modeled with ~536000 Euler elements
- Fluid Structure Interaction couple state variables from gas to structure

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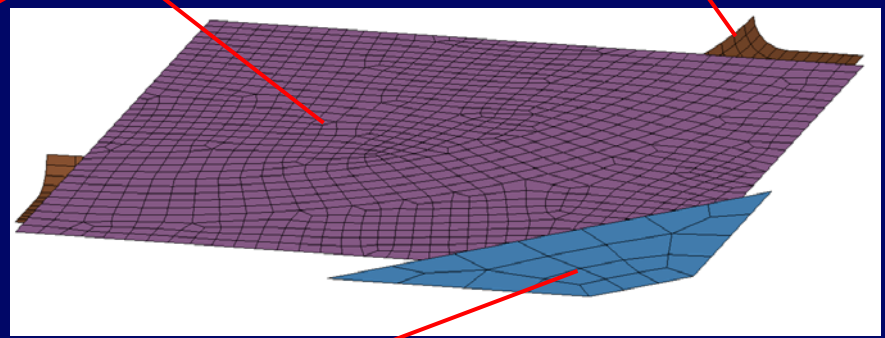
Numerical model (cont.)
LS-DYNA



Fixed rig

Plate

Plate holder

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Numerical model (cont.)
Materials

Sand

- Properties presented by Laine and Sandvik
  - Moisture content 6.57%
  - *Laine L., Sandvik A., "Derivation of mechanical properties for sand", 4th Silos, CI-Premier LTD, p 361-367.*

- Material model
  - Mohr-Coulomb yield surface
  - Tabulated Equation of State
    - ✓ Gives pressure-density relation
  - Initial density set to 1835 kg/m^3

Steel Weldox 700E

- Johnson-Cook model

Explosive m/46

- High Explosive material
  - Equation of state JWL (Jones-Wilkins-Lee)

Air

- Ideal gas

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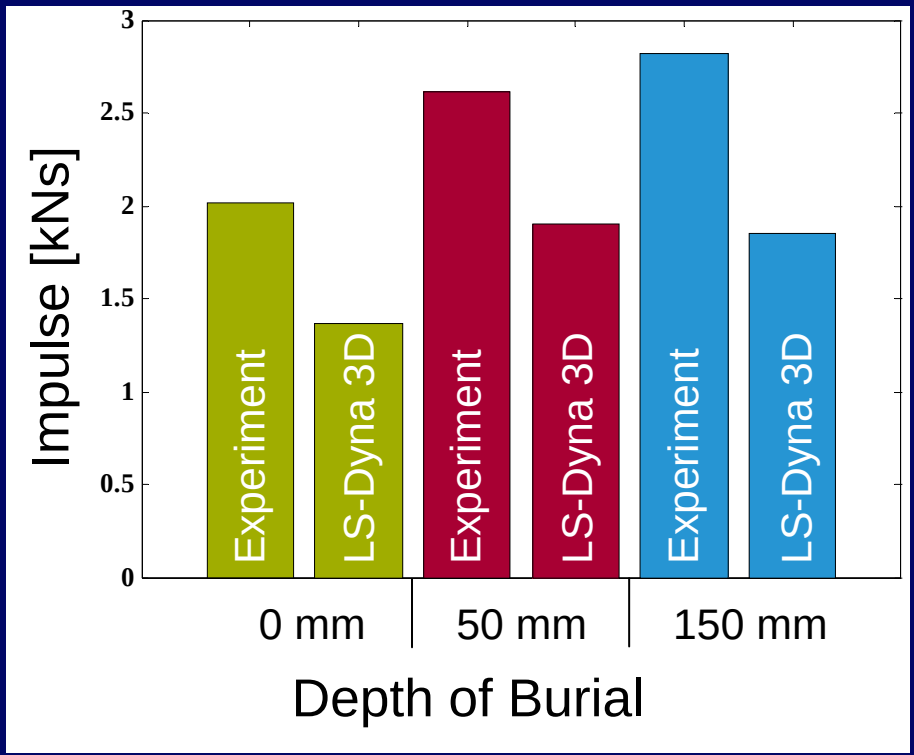
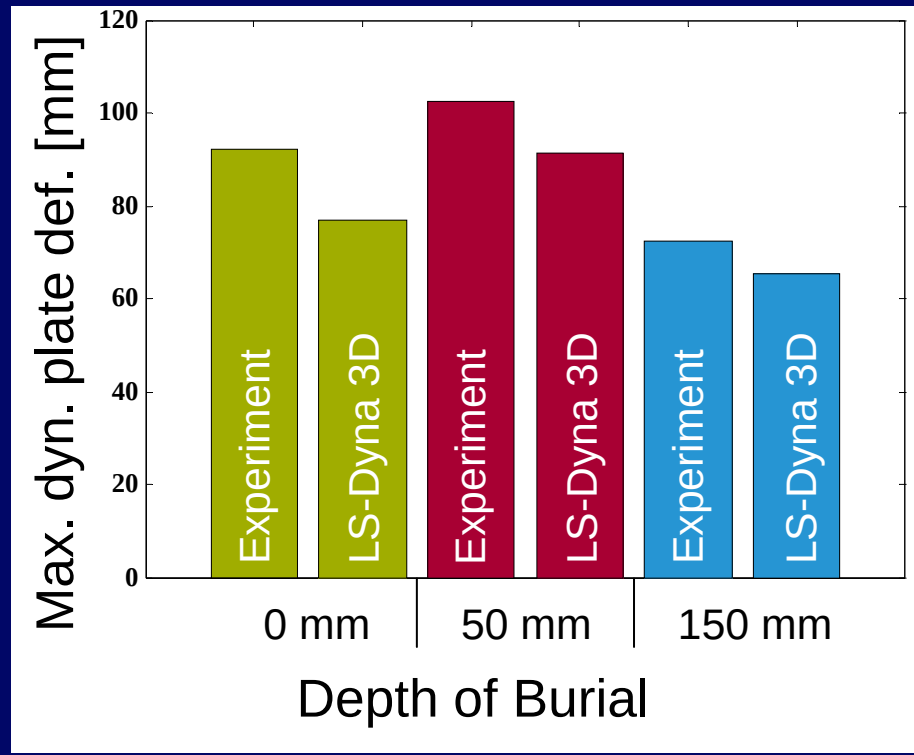
Numerical Results

Impulse transfer to test module



Maximum dynamic plate deformation



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Conclusions

- Transferred impulse increases with the tested DOB in sand
- Measurement methods for test module jump give comparable results
- Wet sand results in larger impulse and plate deformation than dry sand
- Plate deformation increases with DOB up to a limit, decays thereafter
  - Indicates load localization
- Plate deformation largest when using steel pot
- Numerical simulations describe measured trends
  - General underestimation relative measurements
  - Further refinement and investigation needed

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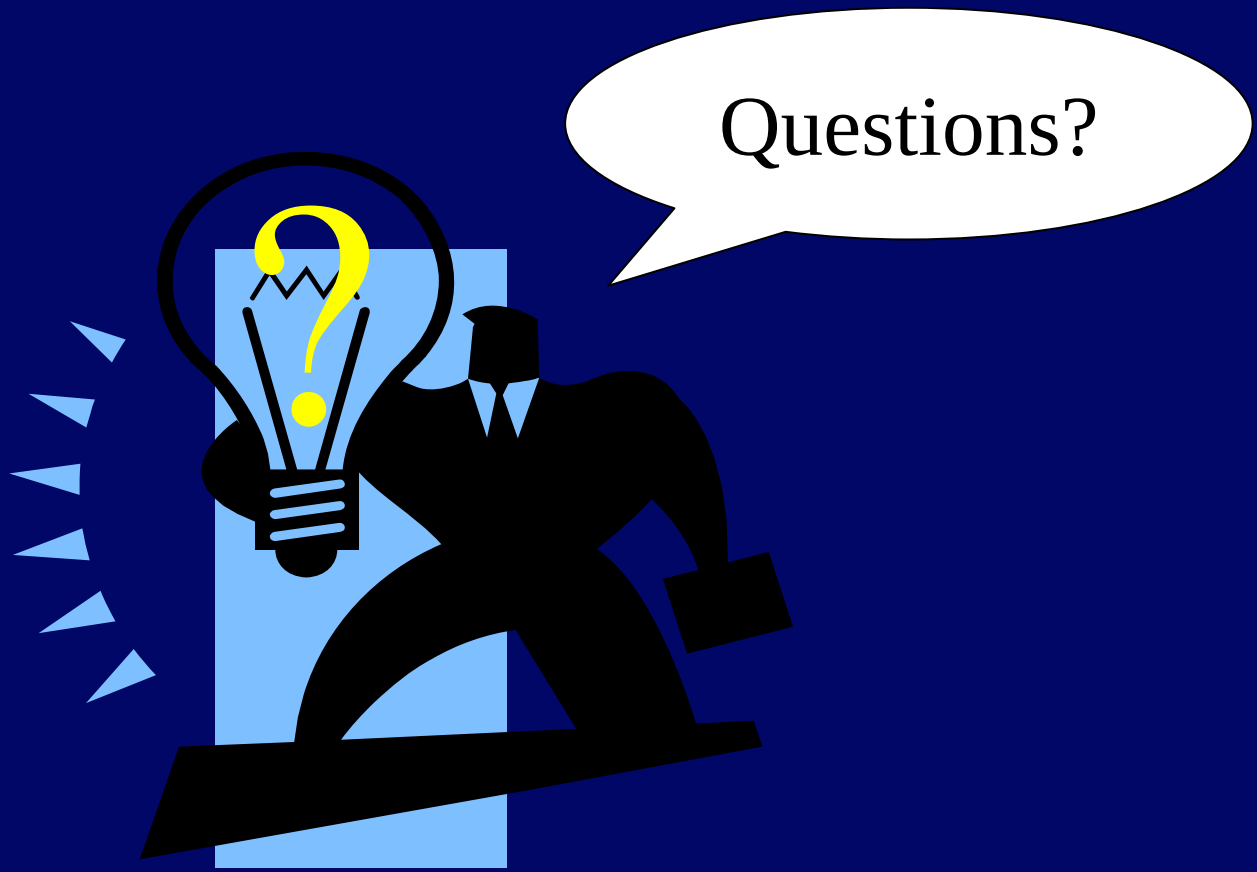

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