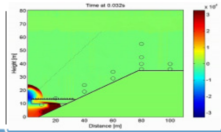


Strasbourg - 2012
XI EPNM

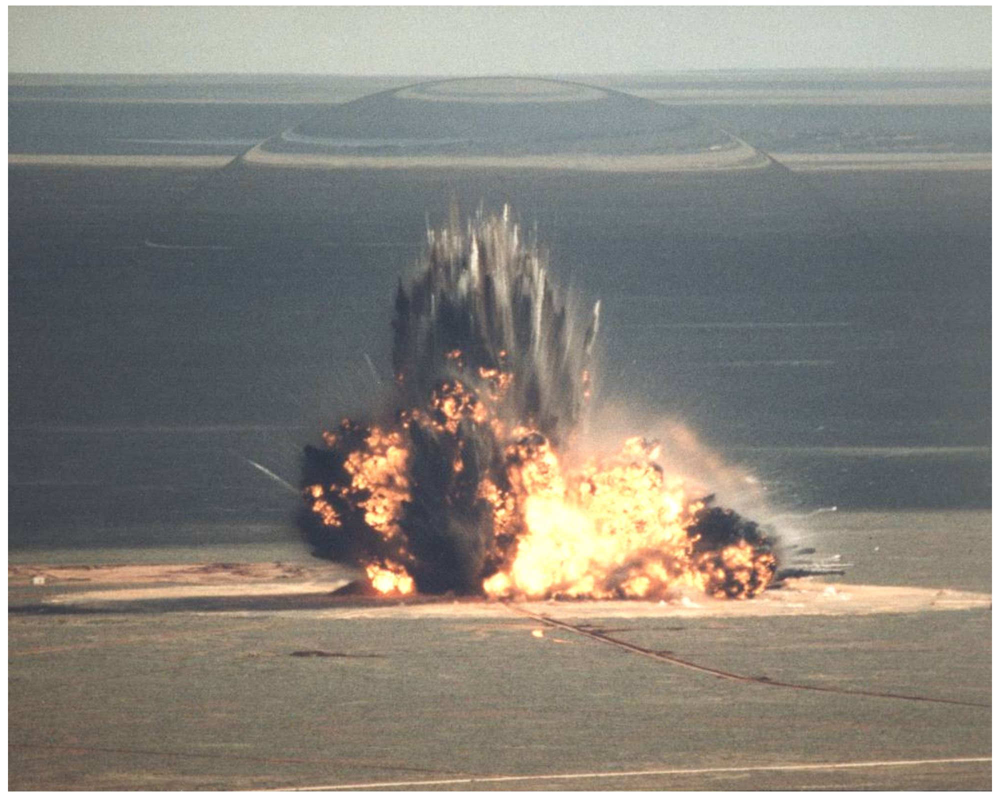
TNO innovation for life

Noise mitigation measures to be used for the explosive cladding in open air

Erik Carton

Frank van den Berg

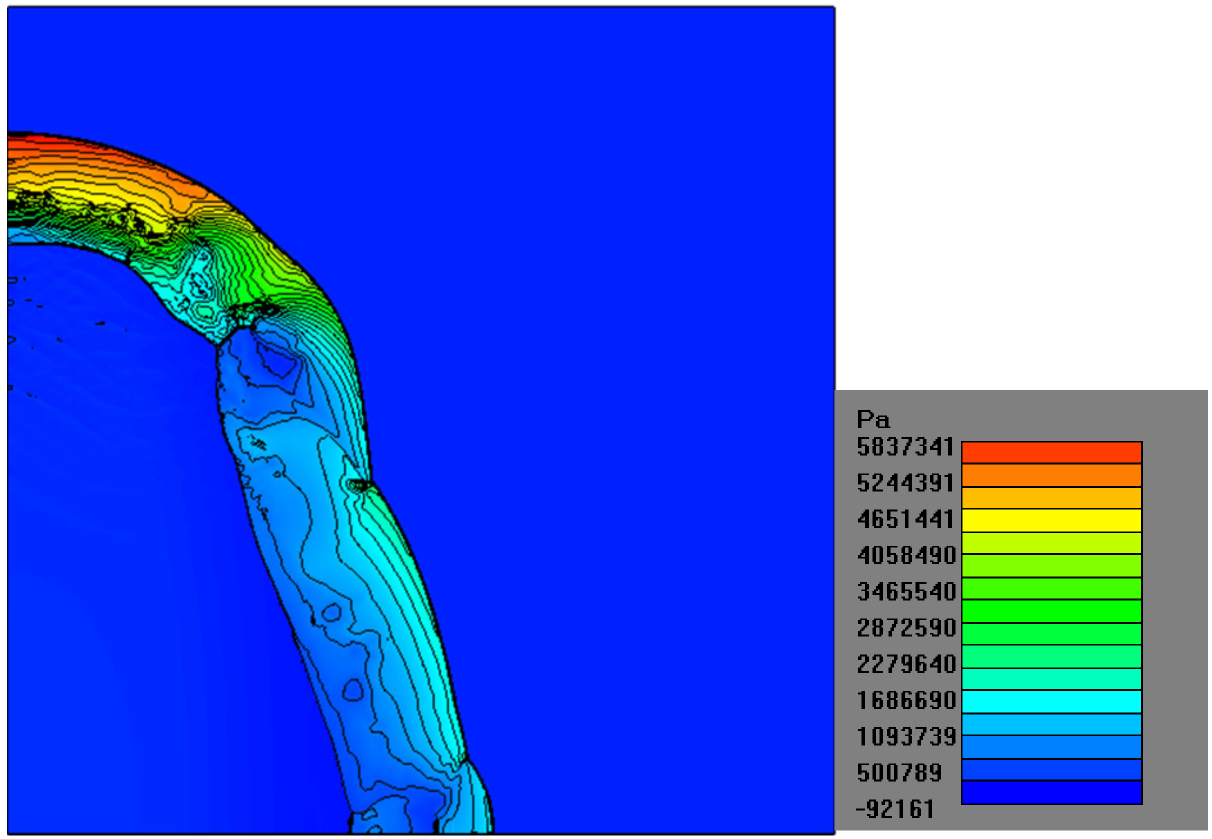
Frits van der Eerden



1 Mei 2012

Simulation of the blast wave shape

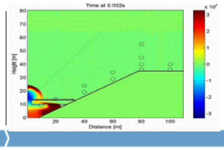
Ø 2 m plate of detonating TNT (0.1 m thick)



Video images of detonation of 50 kg cladding explosive without (left) and with water foam

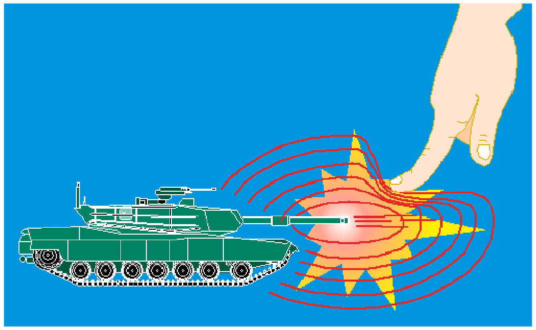

Foam:

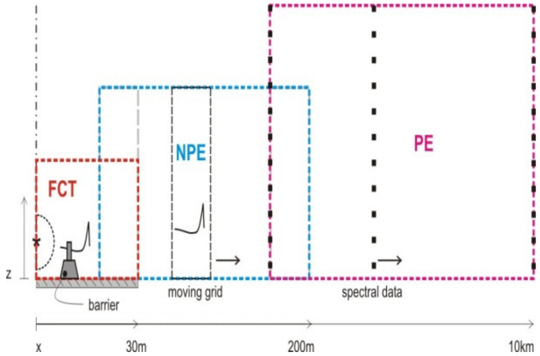
- Reduction in peak pressure 28%
- Reduction in impulse 22%

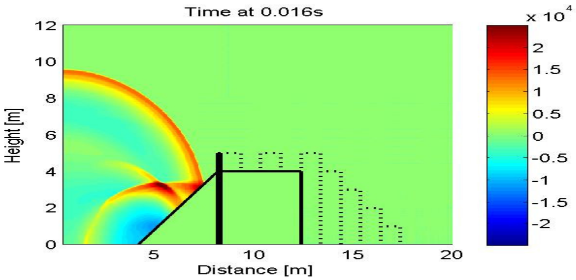


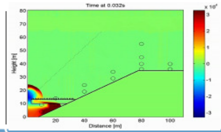
Overview of presentation

- Objective
- Numerical techniques & Validation
- Muzzle blast mitigation (Ministry of Defense)
- Mitigations of open air explosions
- Conclusions



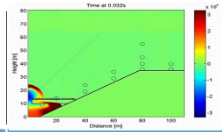




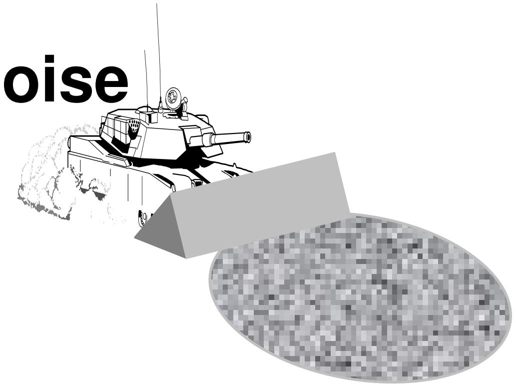


Objective: Reduction of blast noise from explosive cladding in open air

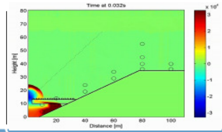
- Open air explosions burden for people in the surroundings
- Comparable with problems military training area
- Common approach not applicable:
  - Shielding measures (like for traffic) do not work
  - Sound propagation different due to high noise levels (non-linear effects)



Background: Reduction of “blast” noise

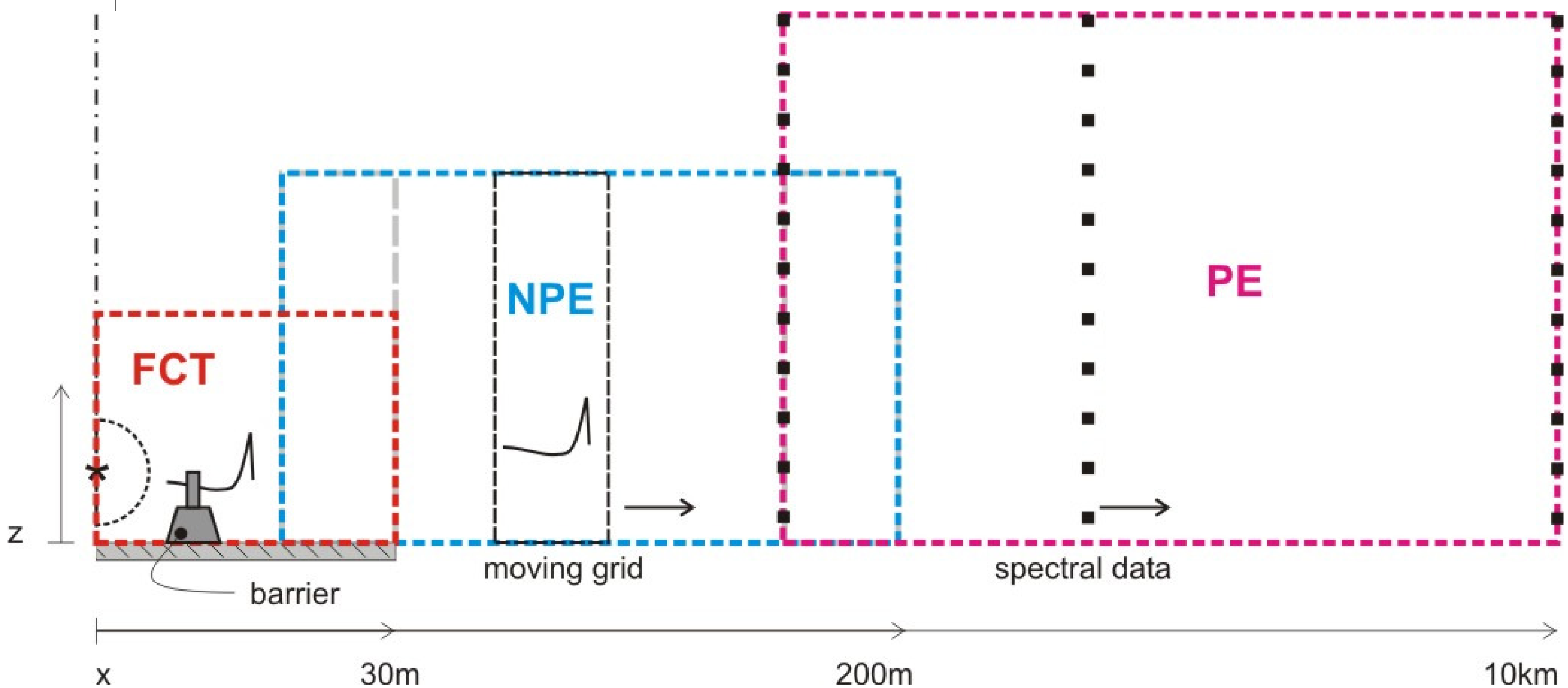


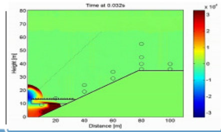
- Initialized by:
  - US-Army
  - the Netherlands Ministry of Defense
- Objective: Mitigation of blast noise from large weapons (armor, artillary)
  - Propagation over large distances
  - By means of barriers and sound absorbing material
  - Close to the source (non-linear acoustics)



Numerical hybrid model: FCT – NPE – PE

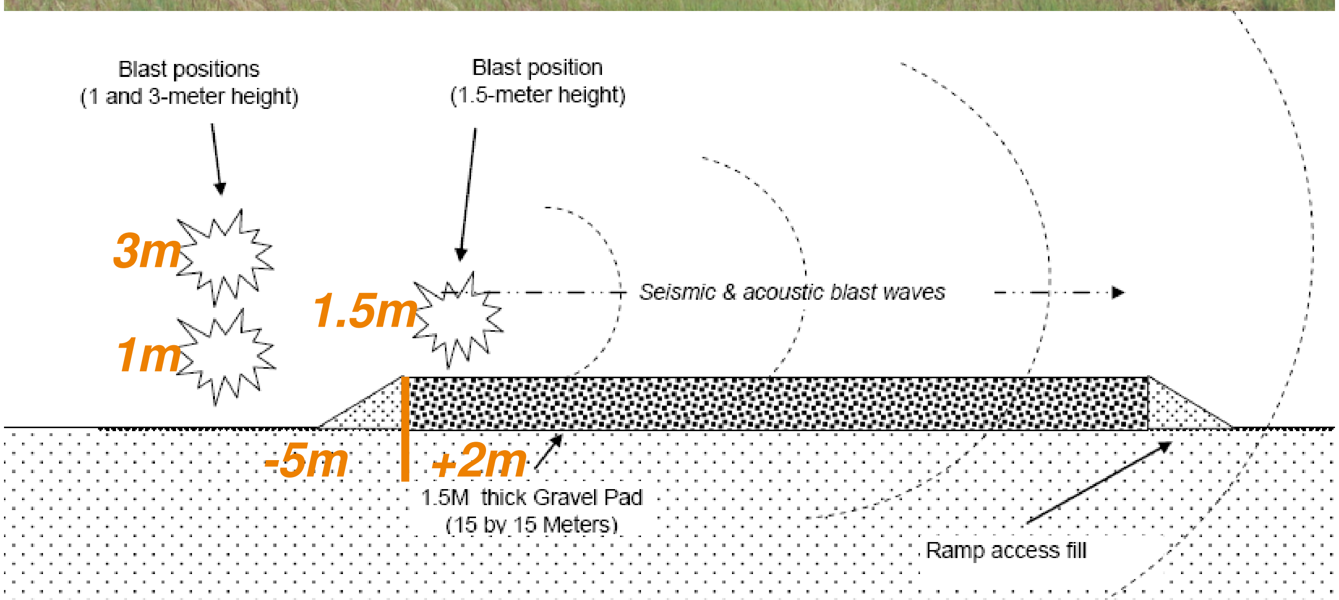
- FCT: “Flux-Corrected Transport technique” → strong shock wave
- NPE: “Non-linear progressive wave equation” → weak shock wave
- PE: “Parabolic Equation” → linear acoustic

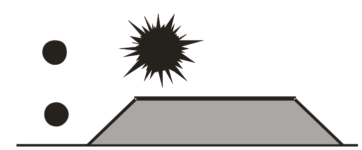




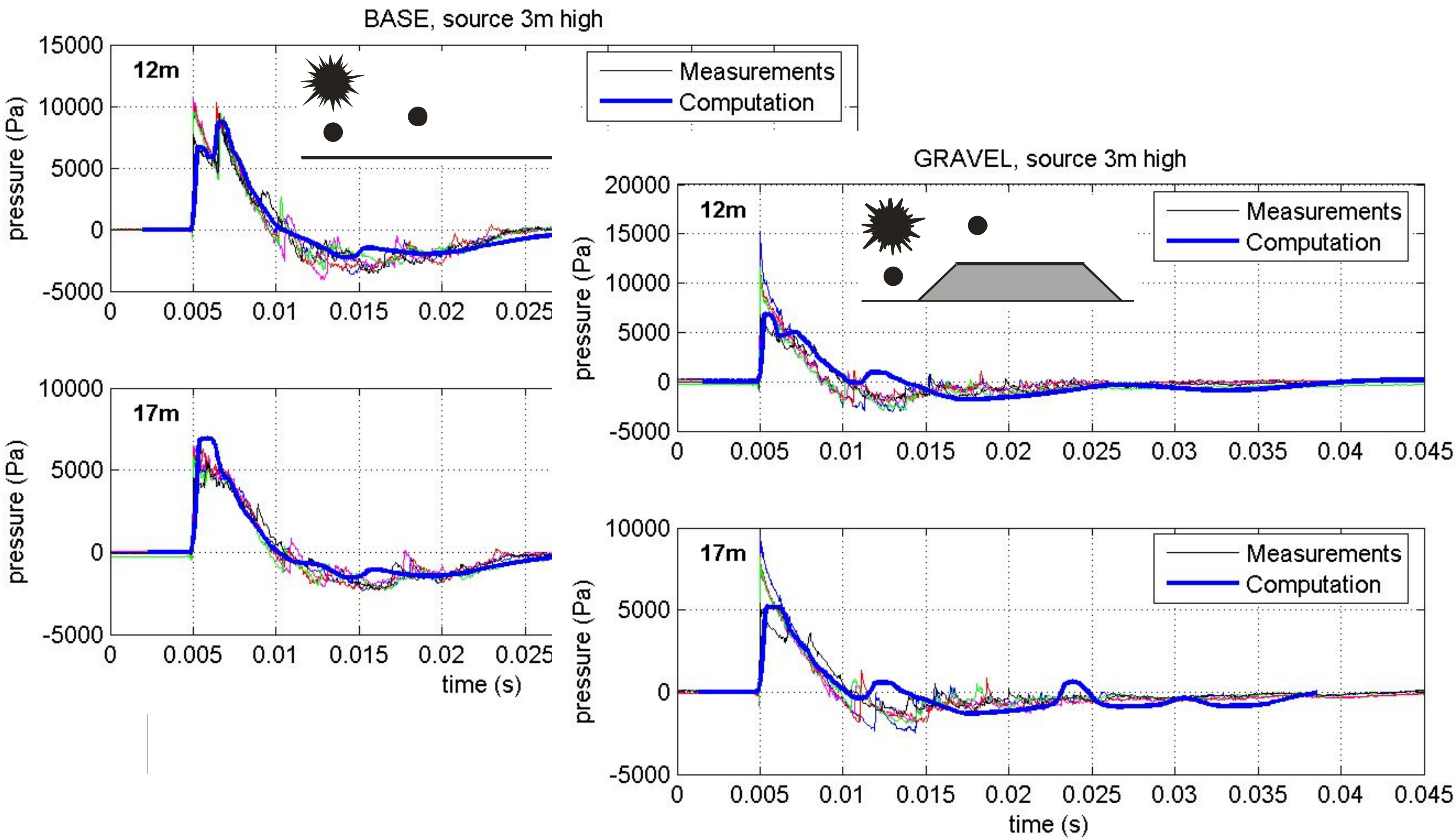
Validated at Aberdeen Test Centre, MD, USA

- A large pile of gravel 15x15 m2, 1.5m high, coarse gravel (3cm)
- Three source locations, C-4 bricks (0.57 kg) → 32 … 63 Hz

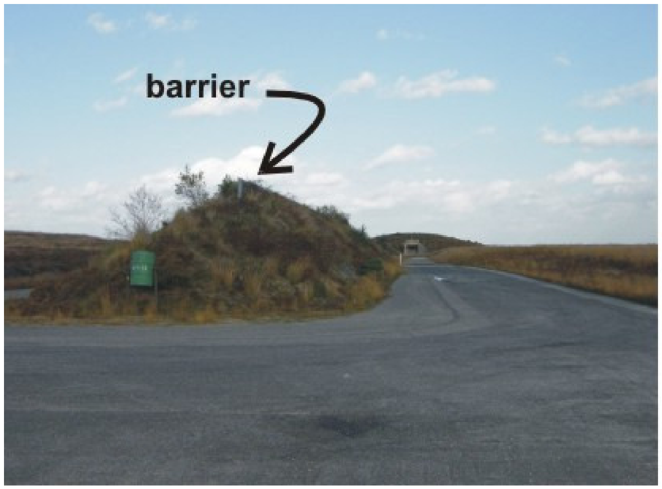


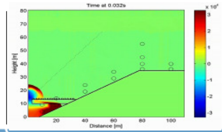


Numerical FCT results (compared to measurements)



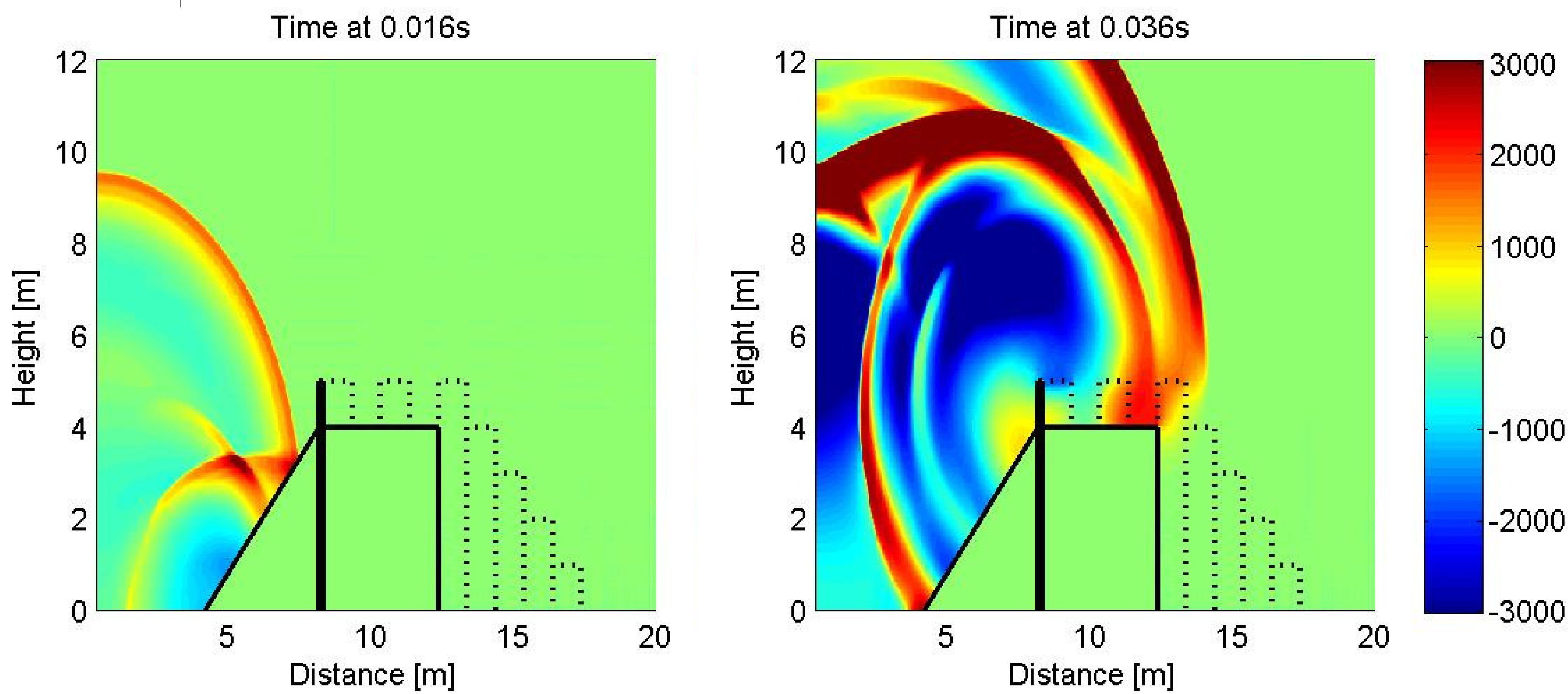
Case study: Shielding Howitzer blast noise

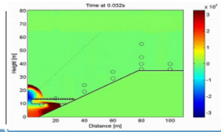




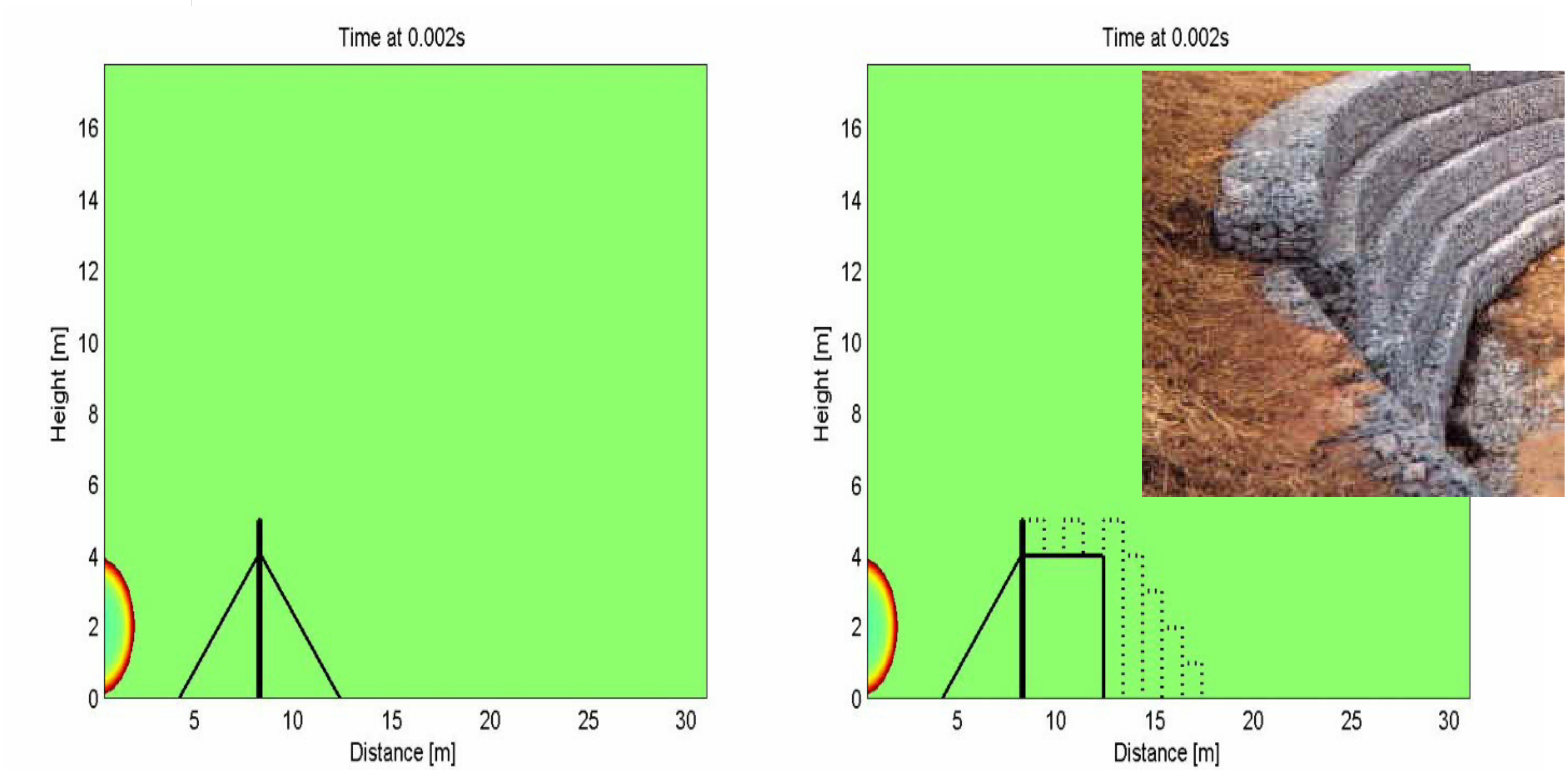
Case study: Barrier with absorption added

- Gravel filled gabions/bastions (1 m^3):
  - absorb shock wave energy
  - suppress ground reflection (behind barrier)



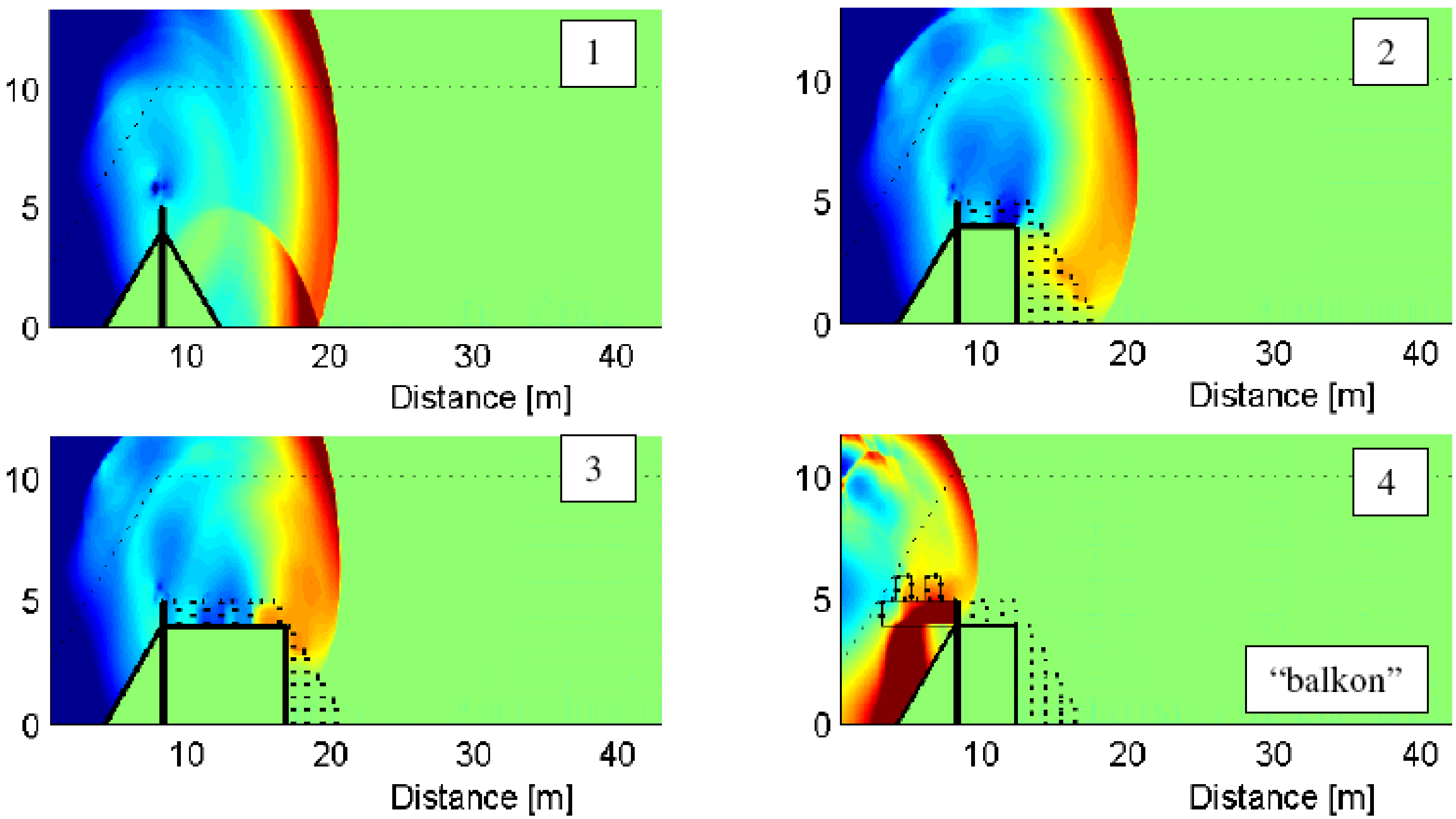


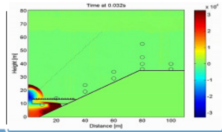
Case study: Barrier with absorption added



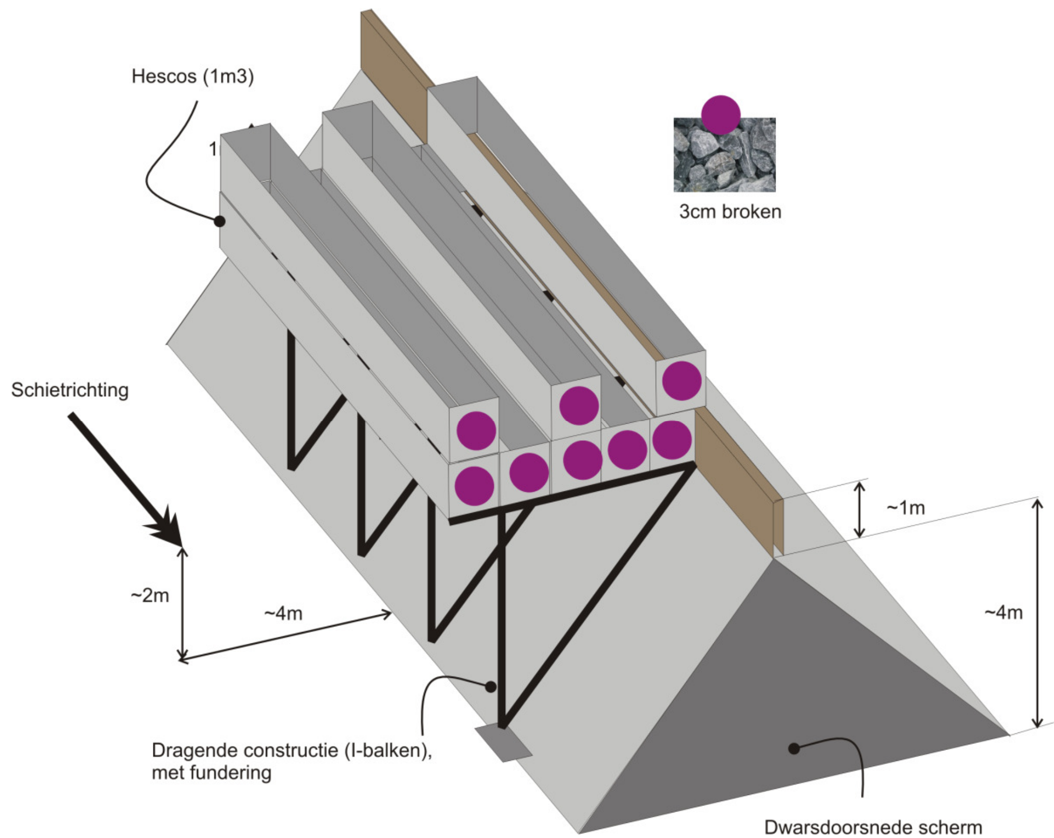
Two movies: blast mitigation behind barrier

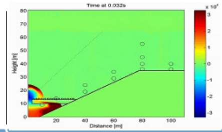
Calculation results for different configurations





A balcony construction for increased reduction





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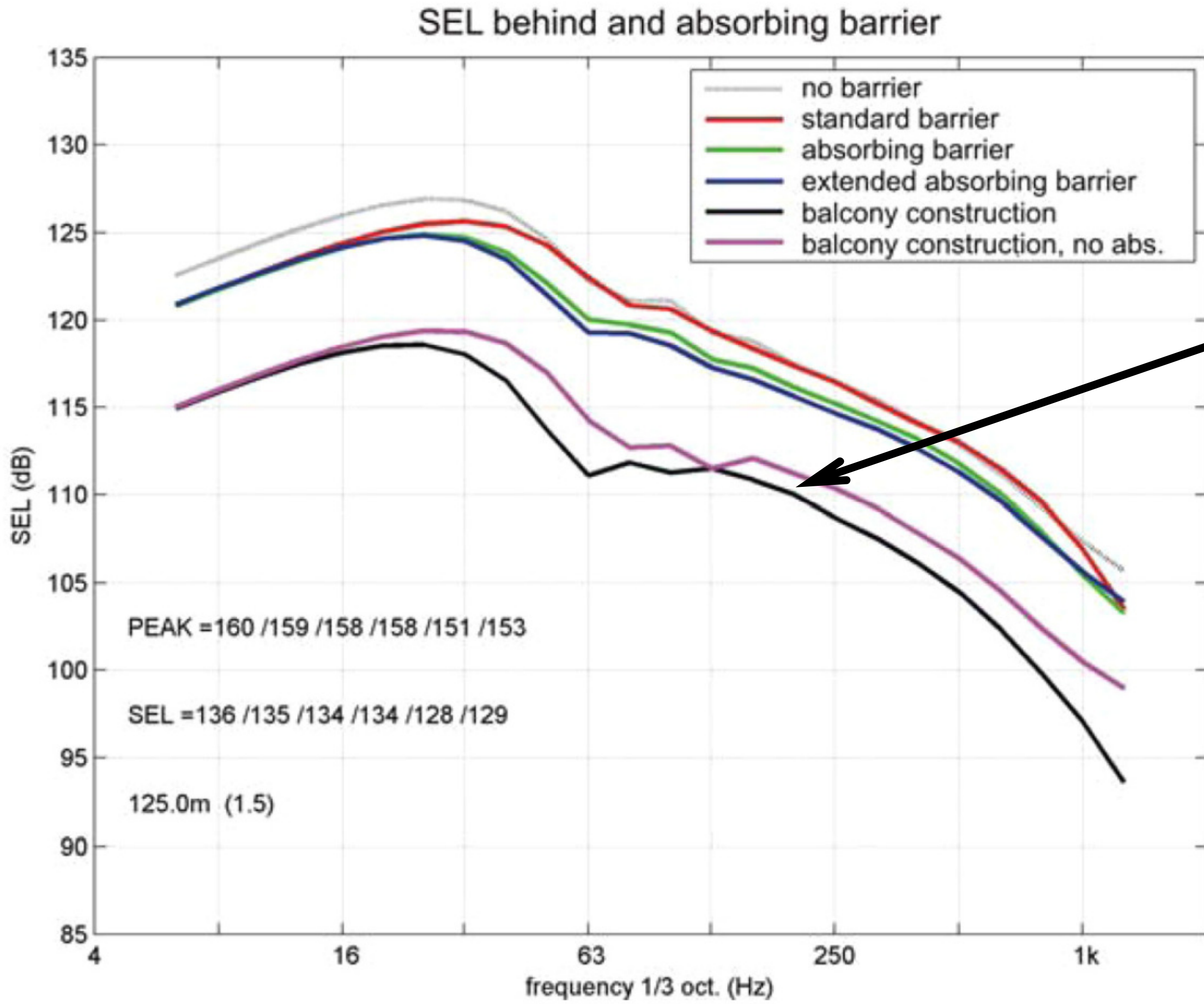
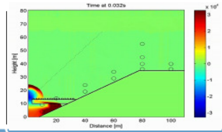
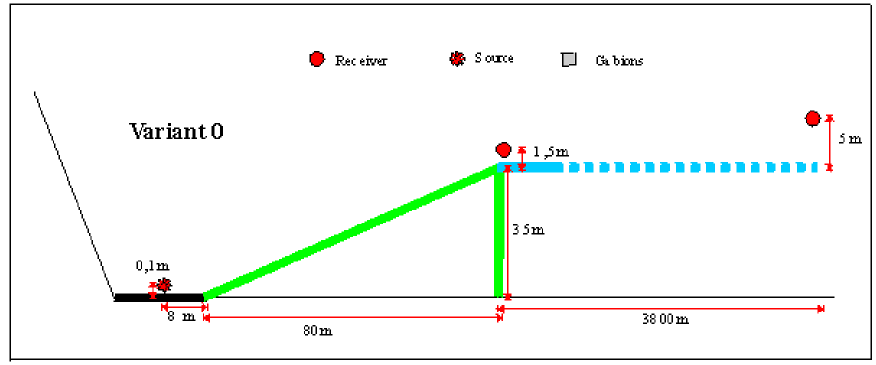
Numerical results (sound exposure level, in dB)

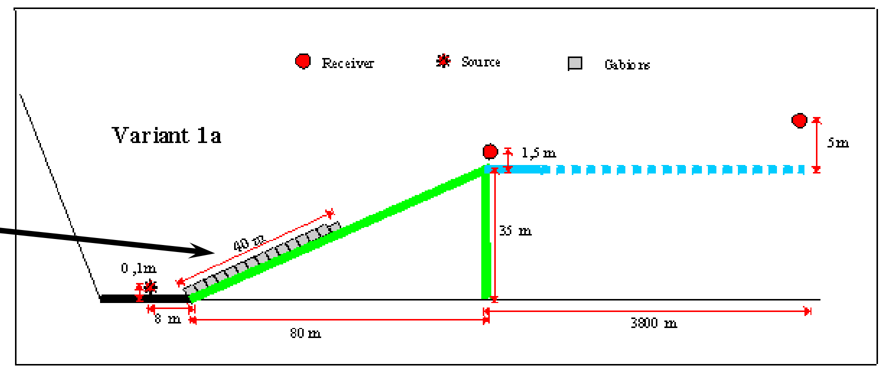


With balcony

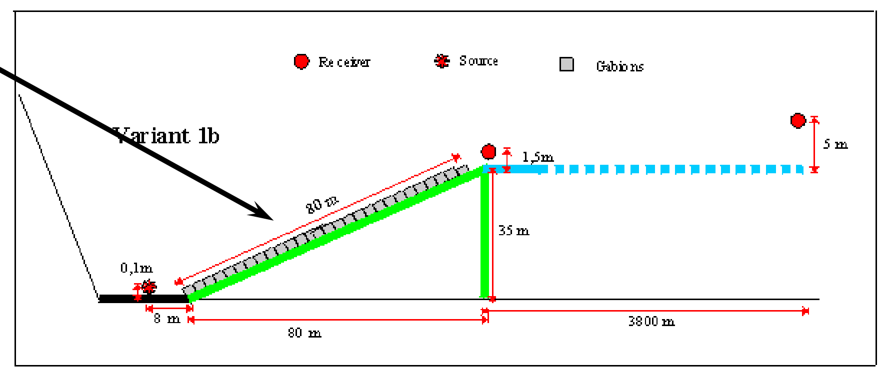


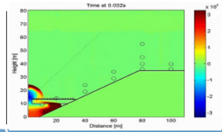
Study to reduce open air explosions from cladding



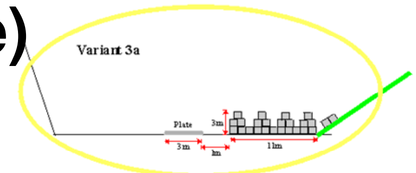


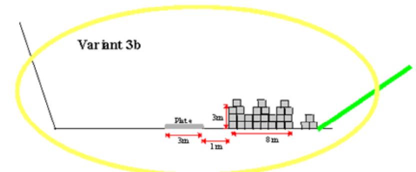
"Absorbing" material
(broken stones)





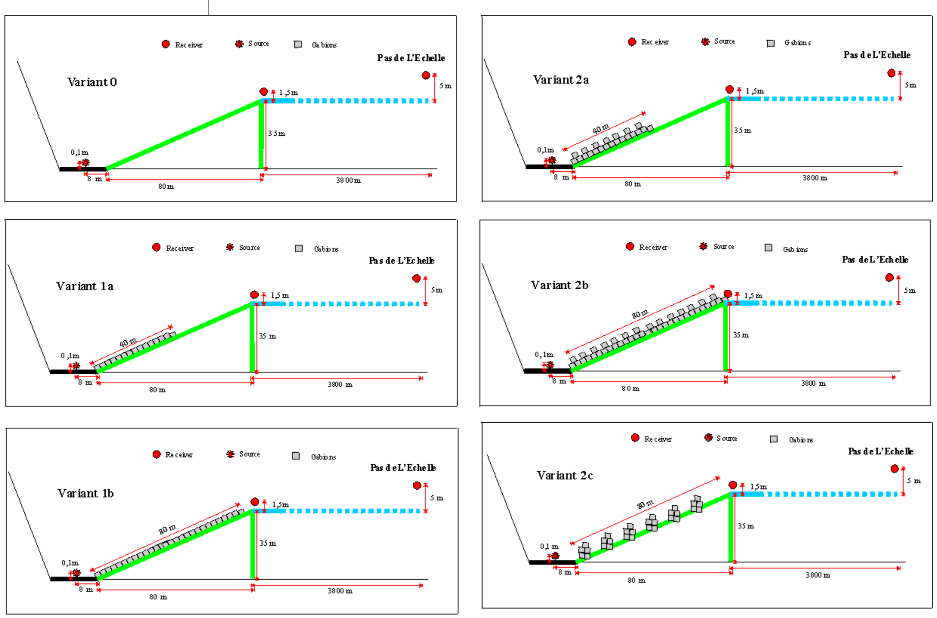
Simulations: 8 variants (500 kg source)

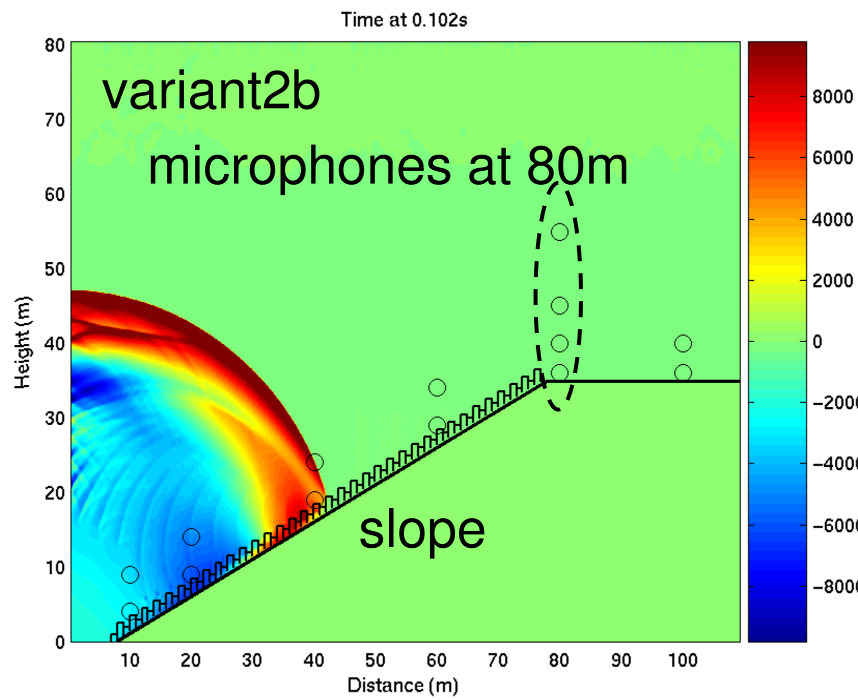


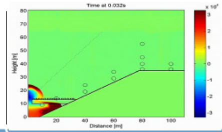


Variant 4: combination from 1or 2 and 3a or 3b.

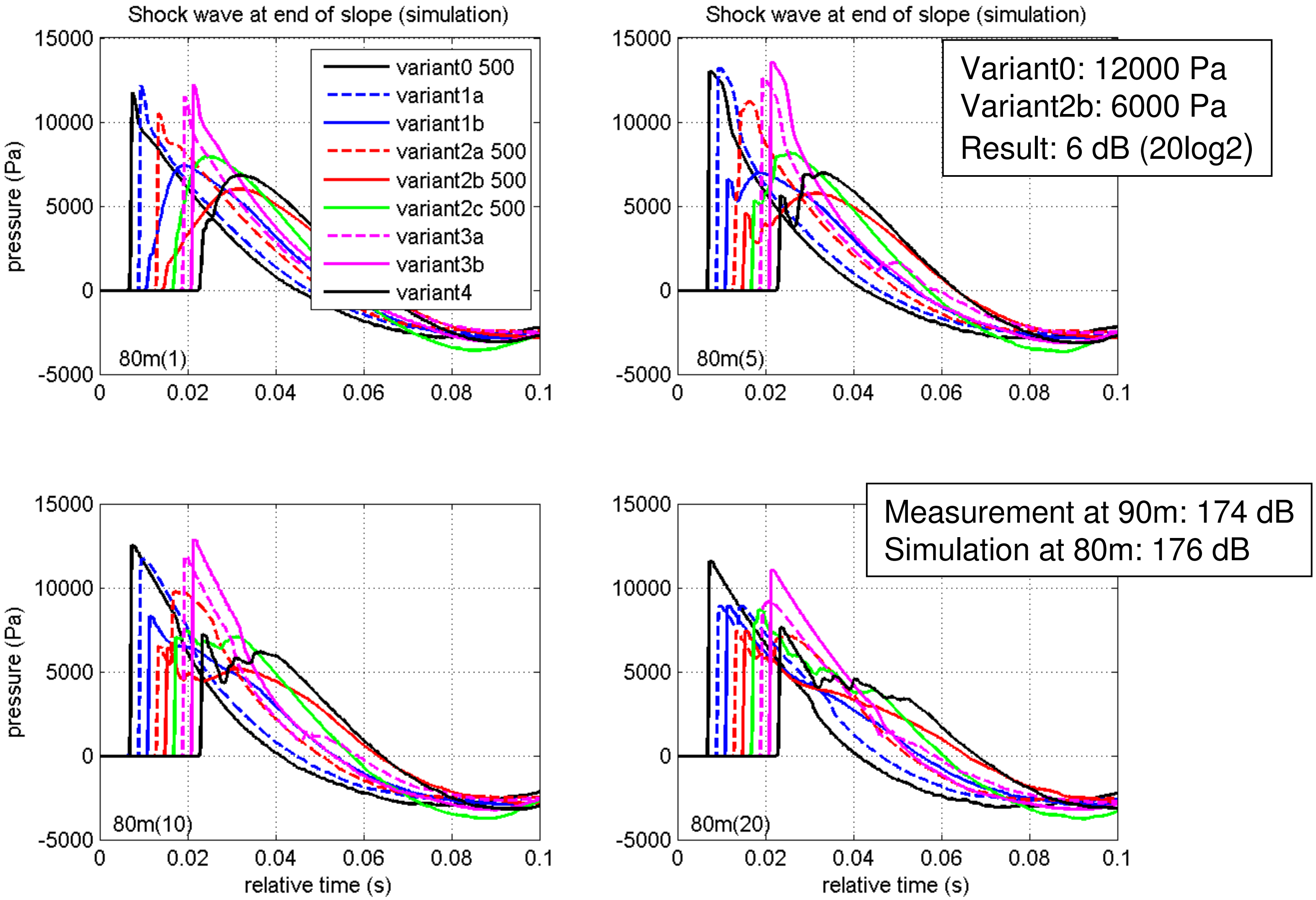
- Variant 0 = slope without gabions
- Variant 1a, 1b = slope with 1m high gabions
- Variant 2a,2b,2c = slope with 2m or 3m high gabior
- Variant 3a,3b = barrier in front of slope
- Variant 4, combination 3b & 2c

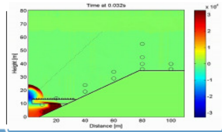




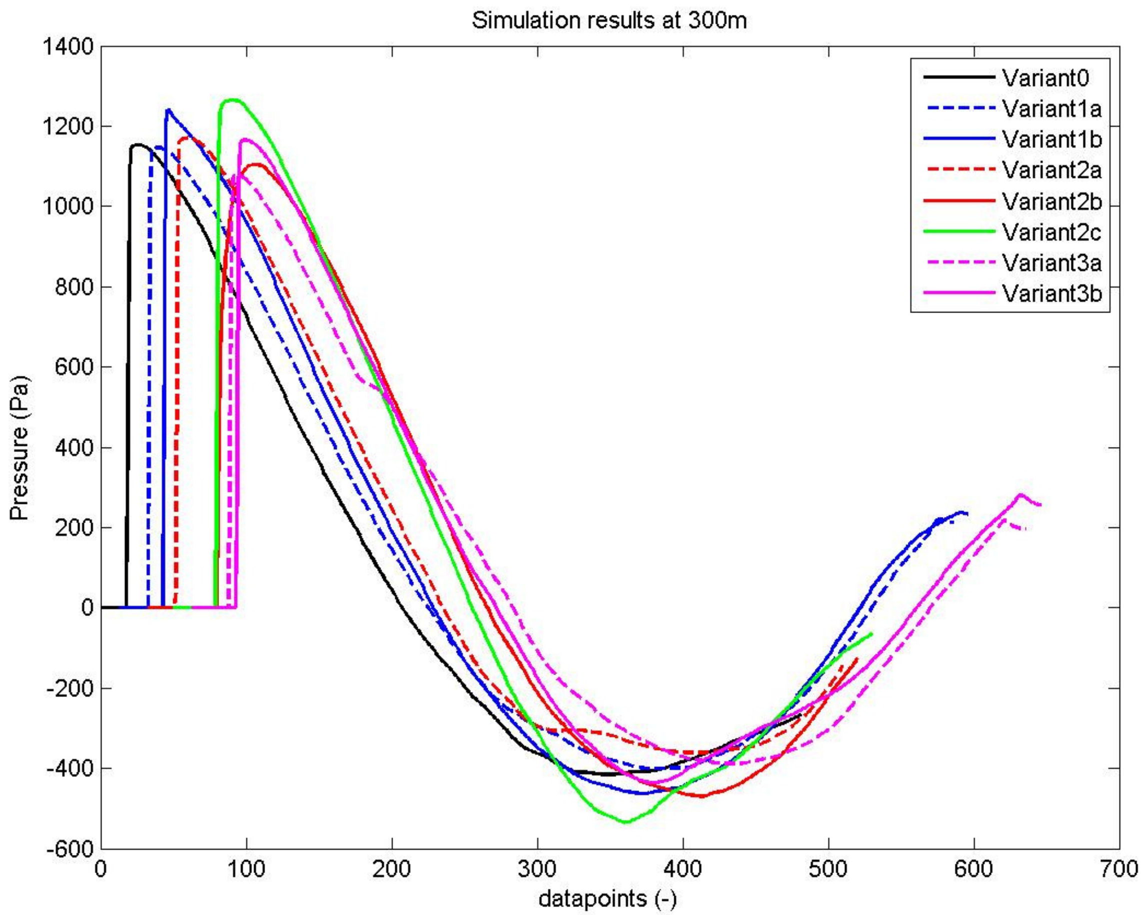


Levels at end of slope (at 80m, 1/5/10/20m high)

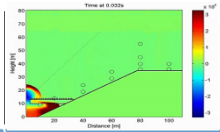


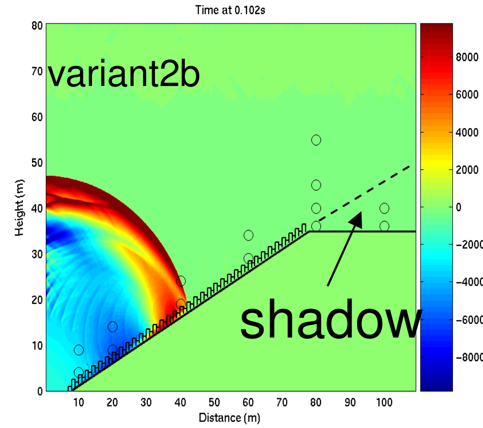


Levels at 300m (beyond slope)



→ No noticable effect of mitigation measures





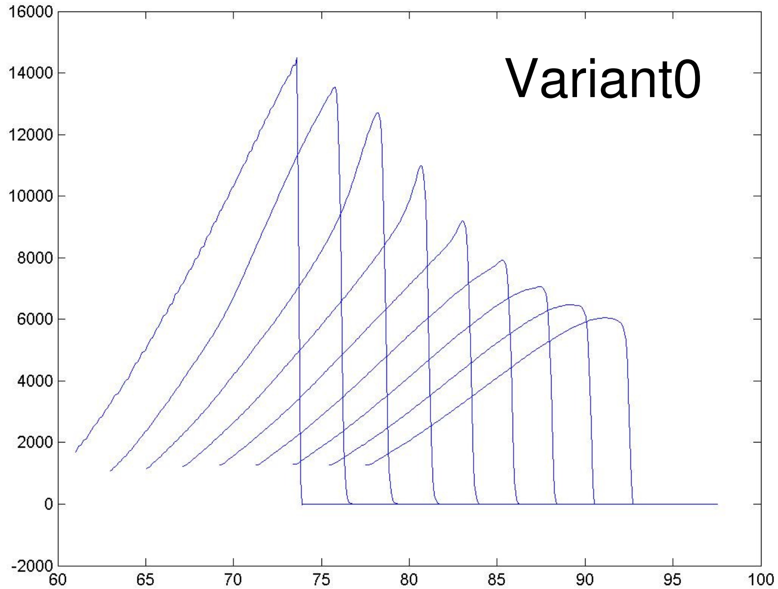
Explanation

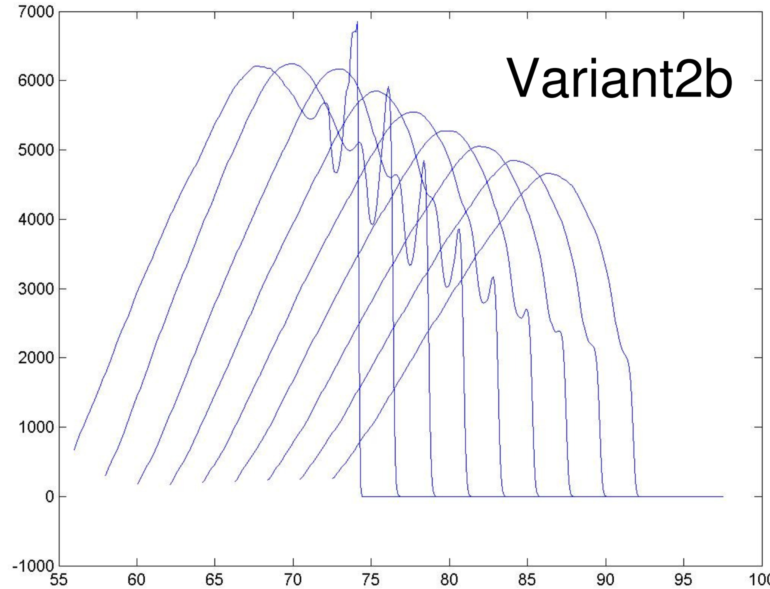
- At 80m: variant0 12000 Pa, variant2b 6000 Pa
- At 90m: variant0 6000 Pa, variant2b 5000 Pa

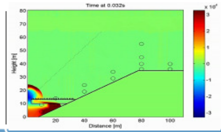
→ propagation into "shadow zone", easy for low frequencies

variant2b, already smooth wave with low-frequency content (higher freq's are damped)

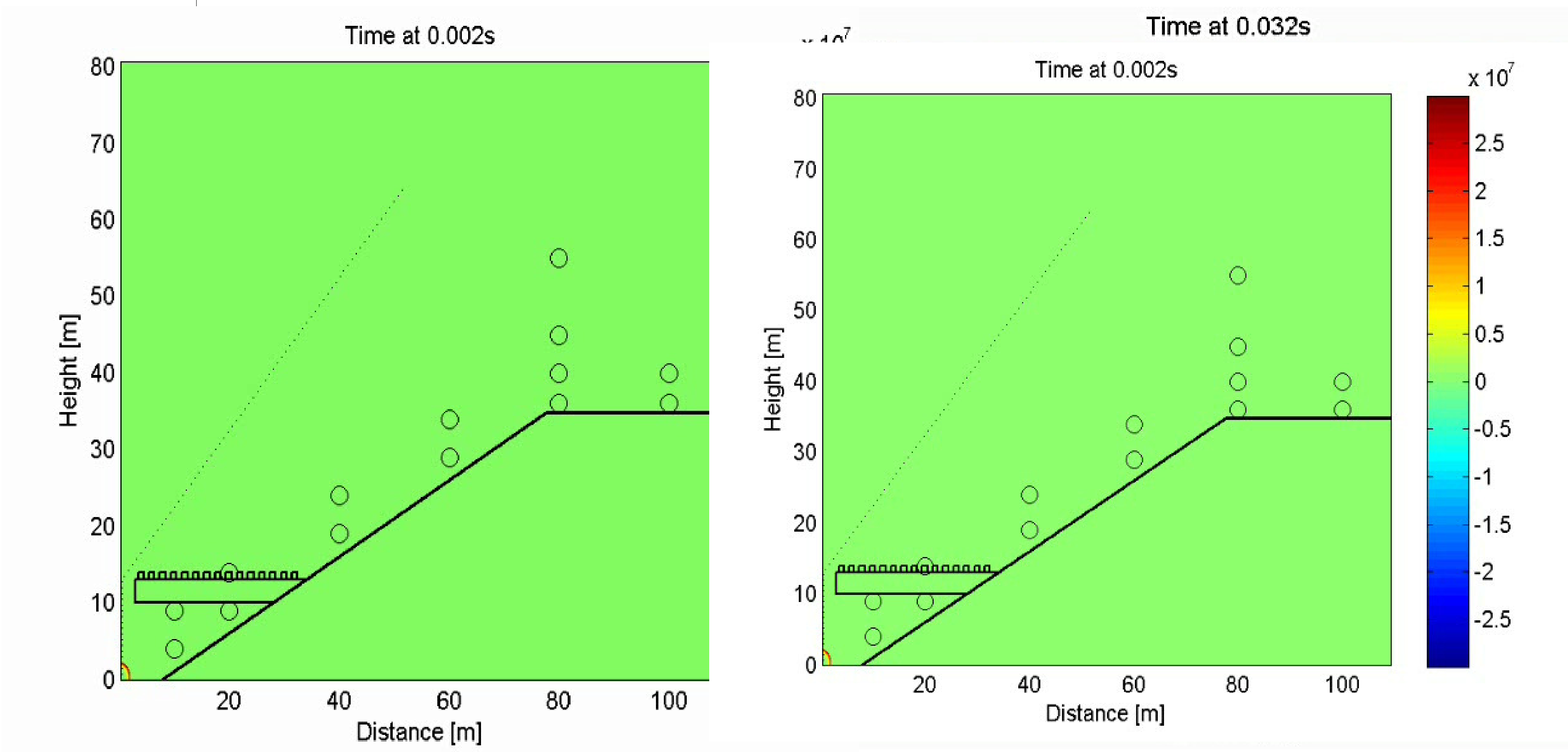
variant0, only low-frequencies propagate into shadow zone

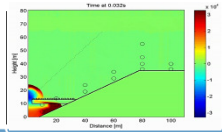




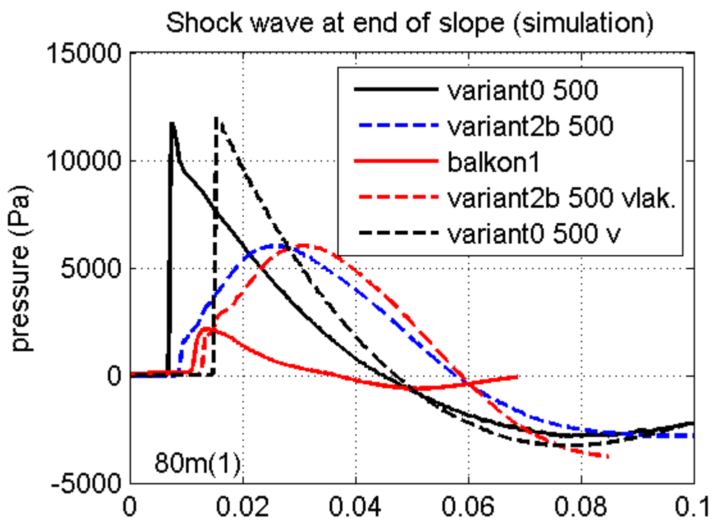


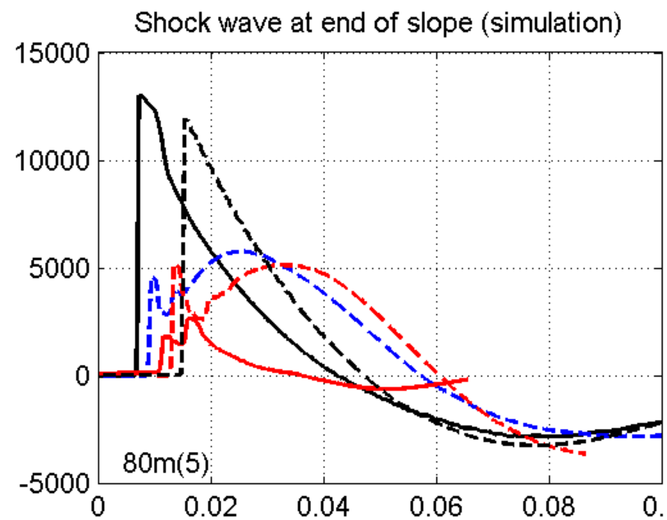
Balcony results: increased screening

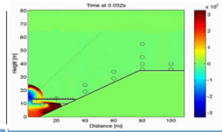




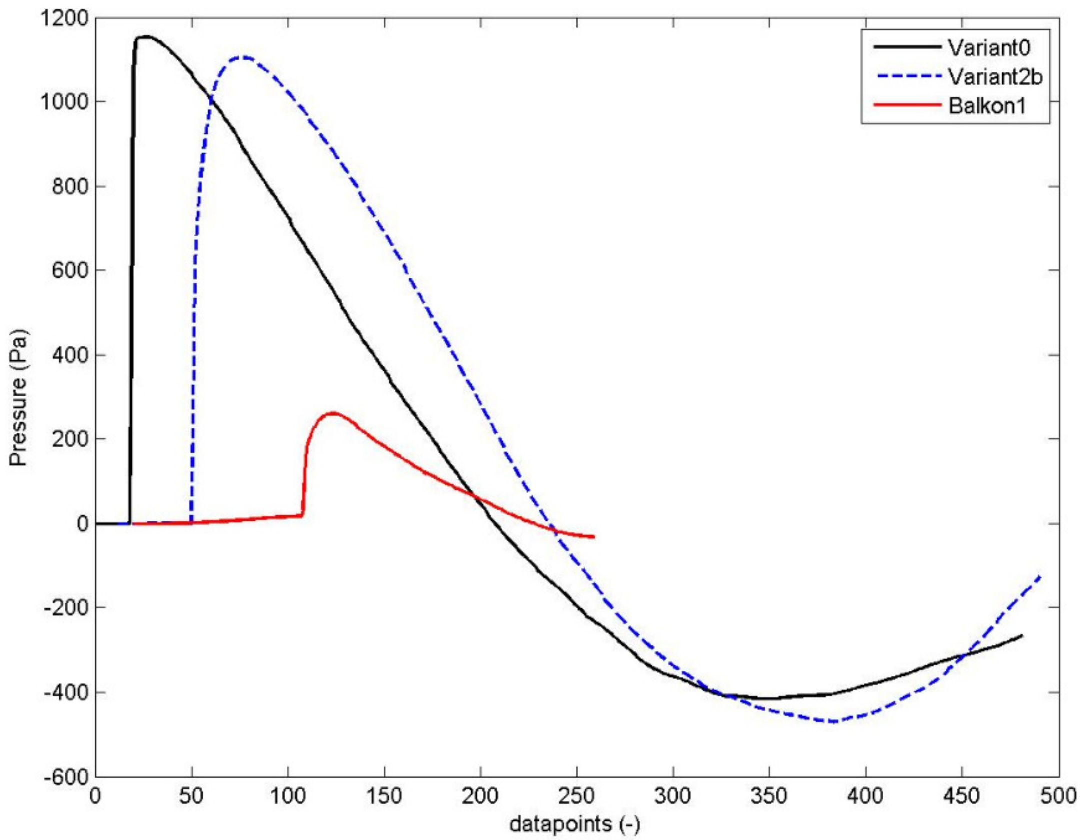
Balcony results: increased screening

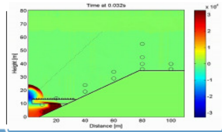






Balcony results at 300 m





Conclusions

- Hybrid FCT-NPE-PE method presented for shock wave propagation
  → non-linear interaction with barrier / absorbing material;
- Standard barrier has limited effect for explosions;
- Adding absorbing material increases shielding effect;
- For strong explosions special constructions (balcony) are needed to increase barrier effect significantly.