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

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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, artillery)
  - Propagation over large distances
  - By means of barriers and sound absorbing material
  - Close to the source (non-linear acoustics)

- gabion or Hesco’s
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 m³):
  - 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
Numerical results (sound exposure level, in dB)
Study to reduce open air explosions from cladding

“Absorbing” material (broken stones)
Simulations: 8 variants (500 kg source)

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

Time at 0.102s

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

Variant0: 12000 Pa  
Variant2b: 6000 Pa  
Result: 6 dB (20log2)

Measurement at 90m: 174 dB  
Simulation at 80m: 176 dB
Levels at 300m (beyond slope)

- No noticeable 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.