MITIGATION OF FLAT 2-DIMENSIONAL SHOCKS TO PREVENT SYMPATHETIC REACTIONS

DR. S.A.L. DE KOSTER & J.H.G. SCHOLTES

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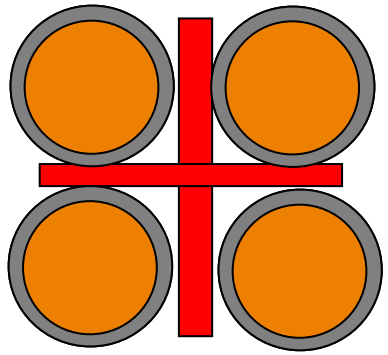
PLATFORM SAFETY

LIFE-CYCLE MUNITIONS - THREATS

- Fragments
- Shaped charge jet
- Bullets
- Cook-off
- **Sympathetic reaction**

MUNITION RESPONSE MITIGATION
BULLET IMPACT AND SYMPATHETIC REACTION

- MOD identified items of interest for testing
- Some tested munition types showed violent response
  - Ranging from type 1 (detonation) to type 3 (explosion)
- Test programme at ‘t Harde to find mitigation solutions
  - Latest series: 3 munition types available
  - Unique solution for every munition type
- This presentation: plastic explosive



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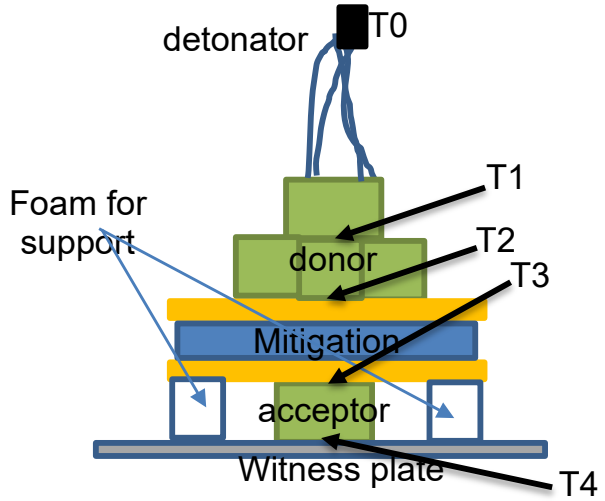
PLASTIC EXPLOSIVE
WOODEN BOXES OF 25 KG

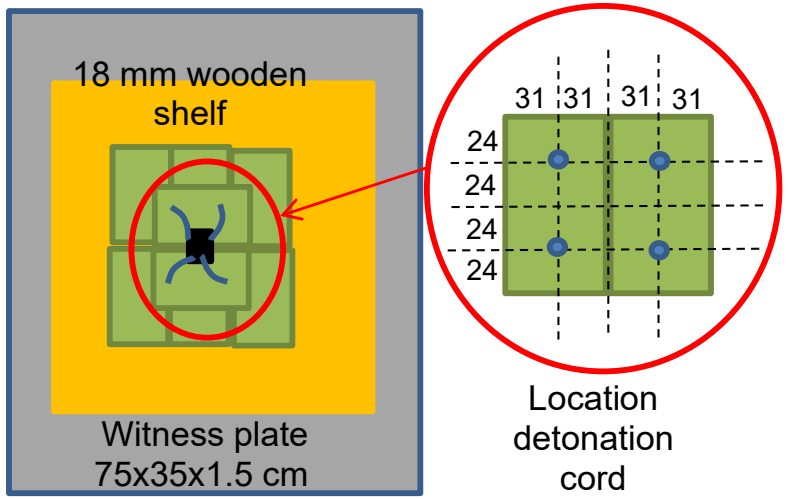
SYMPATHETIC REACTION TESTS
DESIGN

- Donor: product a **large, flat detonation wave**
  - Wood - Mitigating material wood
- Acceptor: just two blocks
- Trigger wires to understand response mechanism
- Steel witness plate to confirm detonation response

Plastic explosive block
Length 95 mm
Width 62 mm
Height 58 mm
v_D 7.35 mm/µs



Side view



Top view

SYMPATHETIC REACTION TESTS
MITIGATING MATERIALS

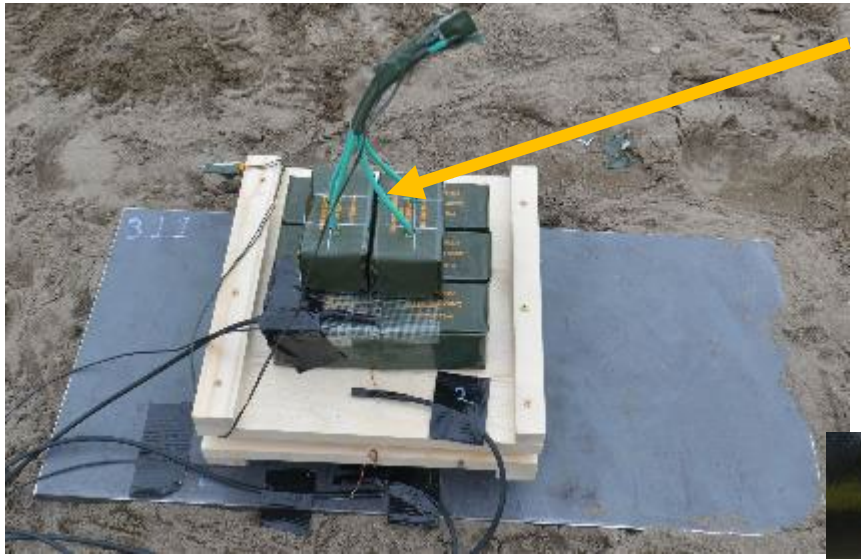
- Several types of mitigating materials:
  - Air (with wooden spacers at edge)
  - PIR foam with density of 0.3 kg/dm^3 (35 and 70 mm)
  - Aerated concrete (35 and 70 mm)
  - Aluminium-rubber layers (5 and 9 layers with 3 mm AL7075 and 4 mm NBR-Rubber)

- 300x300x18 mm pine wood board to simulate box

- However, tests did not go as planned
  - Flat detonation wave more effective than anticipated!

SYMPATHETIC REACTION TESTS

SET-UP (18 MM AIR GAP)

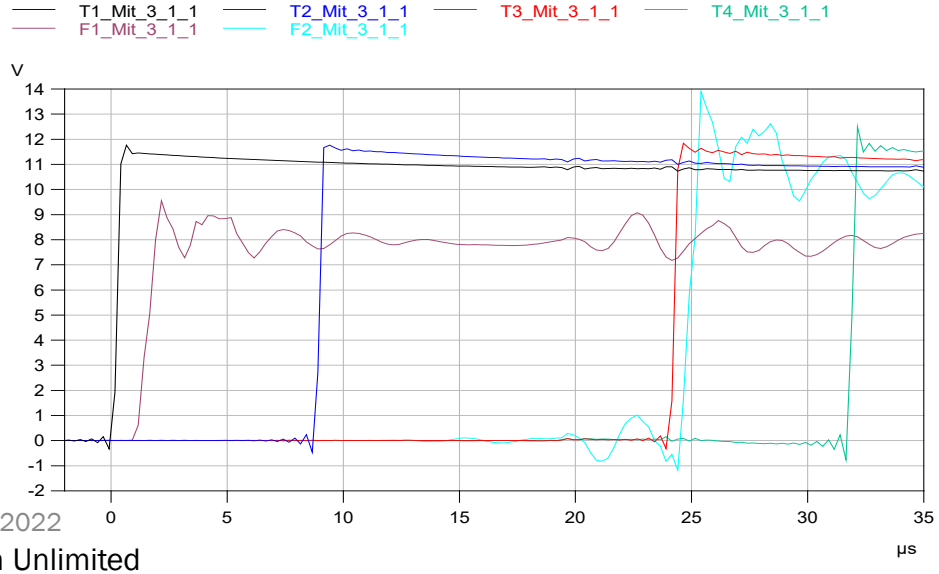


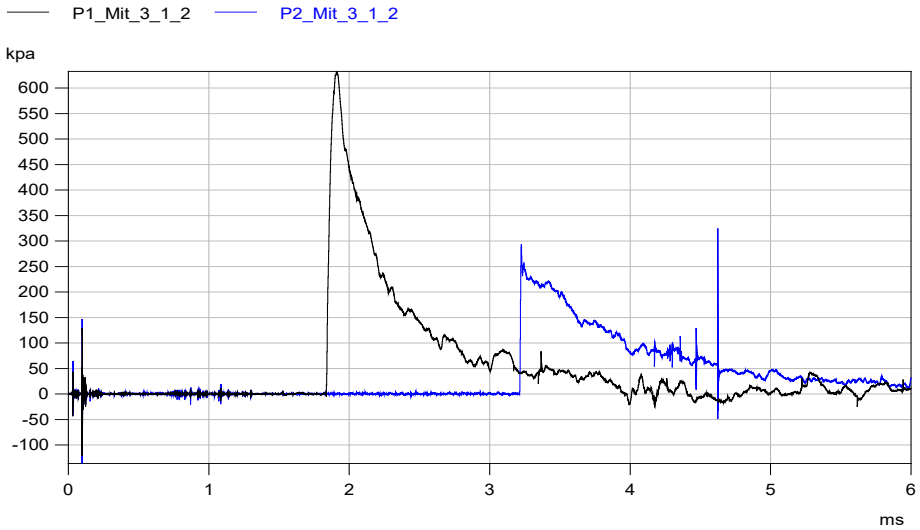
SYMPATHETIC REACTION TESTS

INTERPRETATION OF THE RESULTS (18 MM AIR GAP)

Plastic explosive block
Length 95 mm
Width 62 mm
Height 58 mm
v_D 7.35 mm/µs

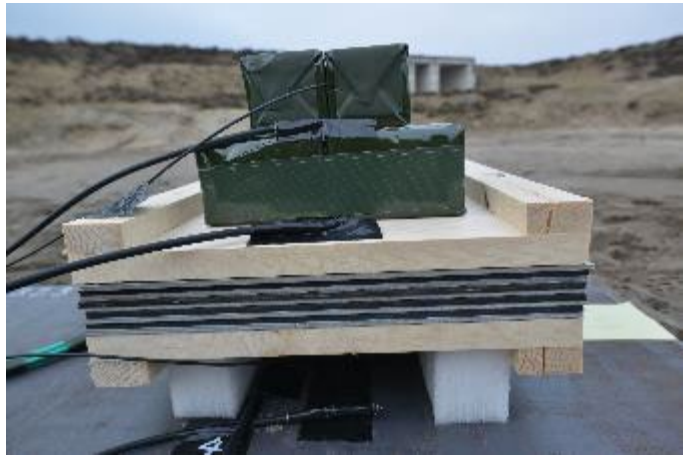
T1-T2 = 8.73 µs
T2-T3 = 15.29 µs
T3-T4 = 7.69 µs
SDT



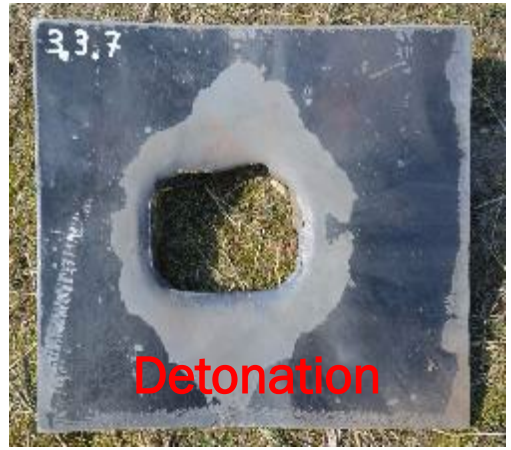


OTHER TESTS WITH AIR GAPS
36 MM AND 210 MM

ALUMINIUM/RUBBER
5, 9 AND 13 LAYERS



AERATED CONCRETE
70 AND 2X140 MM



AERATED CONCRETE

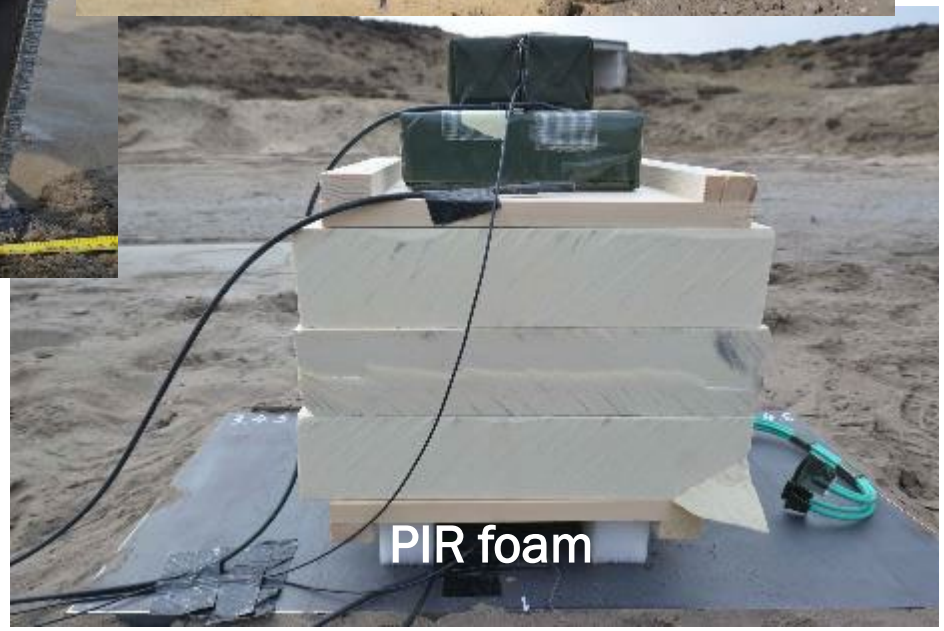
210 MM AND 2X70 MM WITH 16 MM STEEL

No detonation

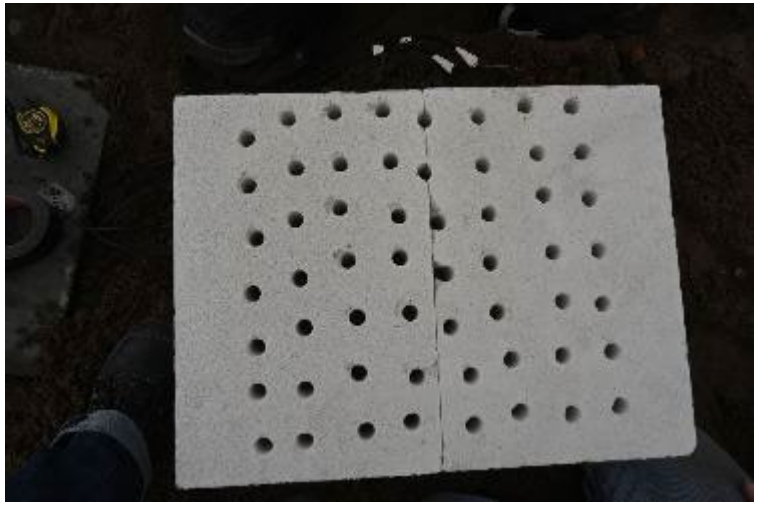
OTHER TESTS

CAN WE MAKE IT LIGHTER?

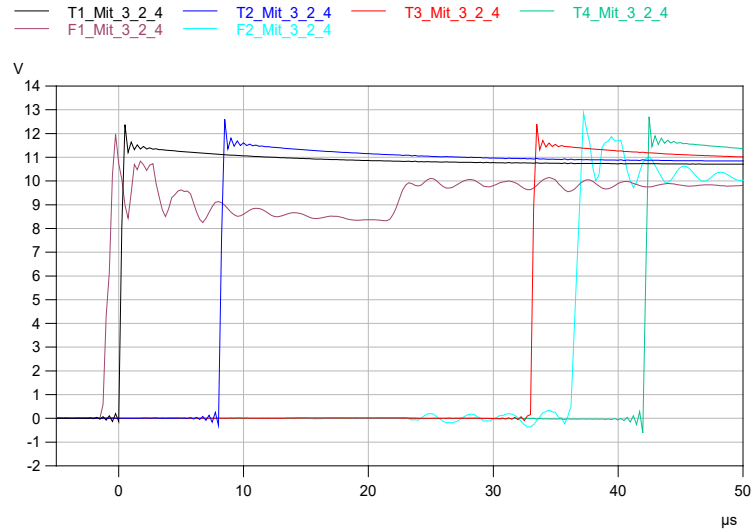
All detonations



OTHER TESTS
LESS IS BETTER?



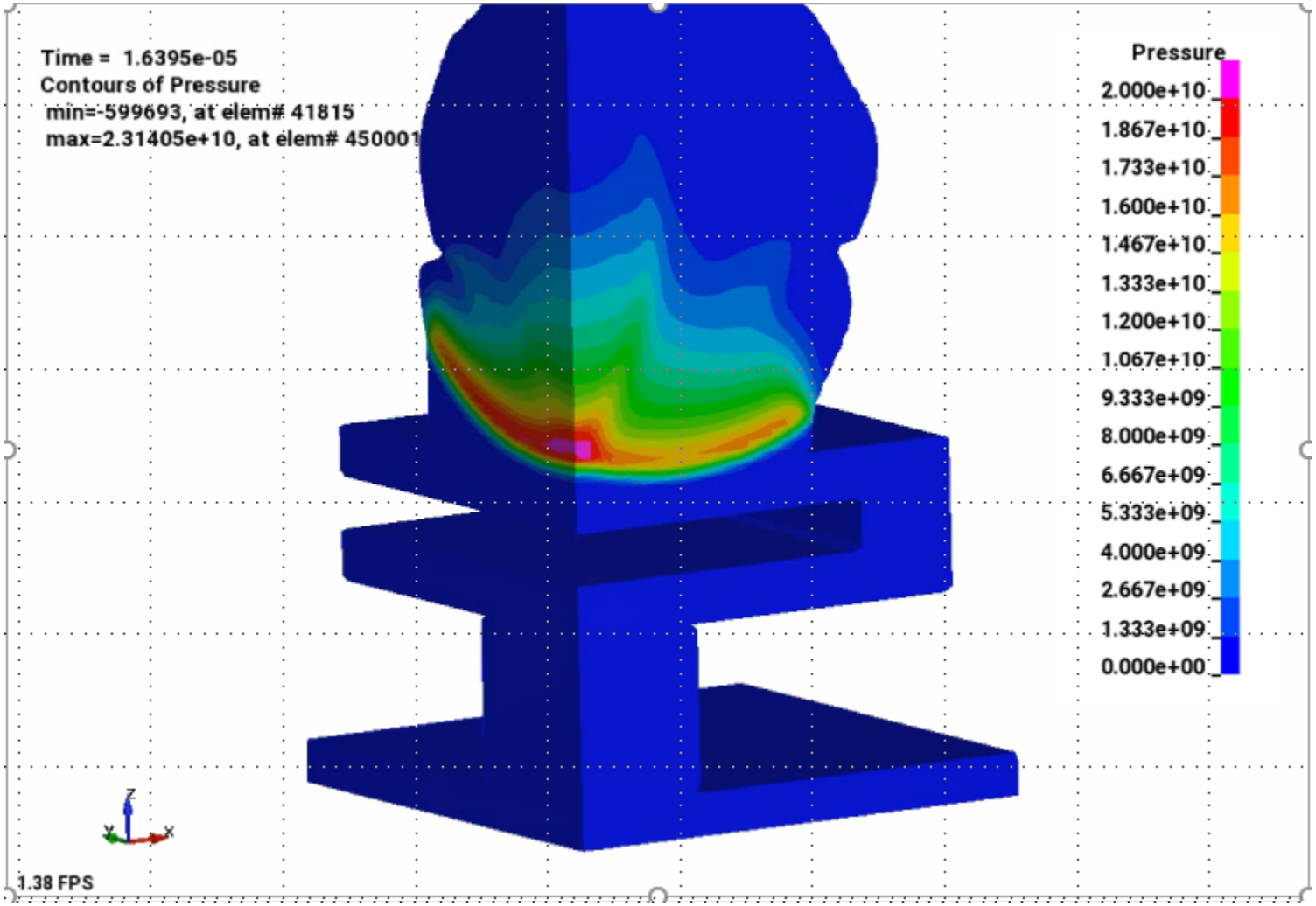
Indentation of the plastic explosive!

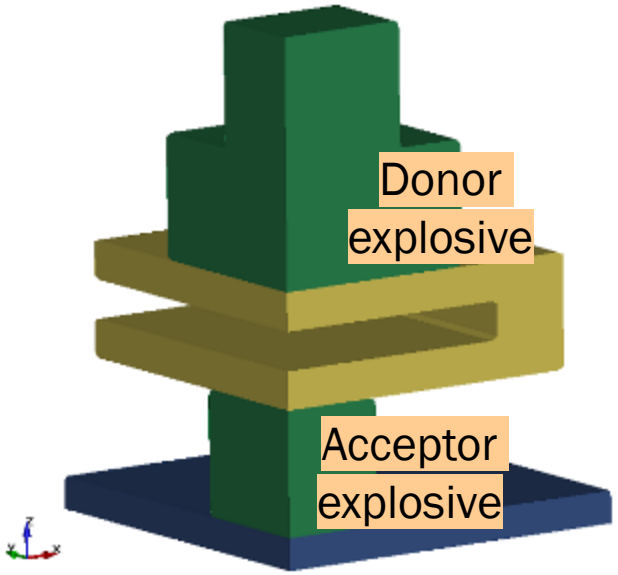


T1-T2 = 10.27 µs
T2-T3 = 37.99 µs
T3-T4 = 122.89 µs
No detonation!

SIMULATIONS TO SUPPORT INVESTIGATIONS

PRELIMINARY RESULTS





NEW TEST SERIES
FOCUS ON BREAKING UP THE SHOCK WAVE

Spoilers:

- Several types of mitigating materials:
  - Aerated concrete to determine minimum thickness ← 190 mm
  - Aerated concrete with 13 mm holes (40 mm spacing)
  - Aerated concrete with 13 mm holes (40 mm spacing), staggered
  - Aerated concrete with 8 mm holes (30 mm spacing)

- Additionally, ceramic blocks

← These did not work

AERATED CONCRETE WITH HOLES

13 MM, 40 MM SPACING

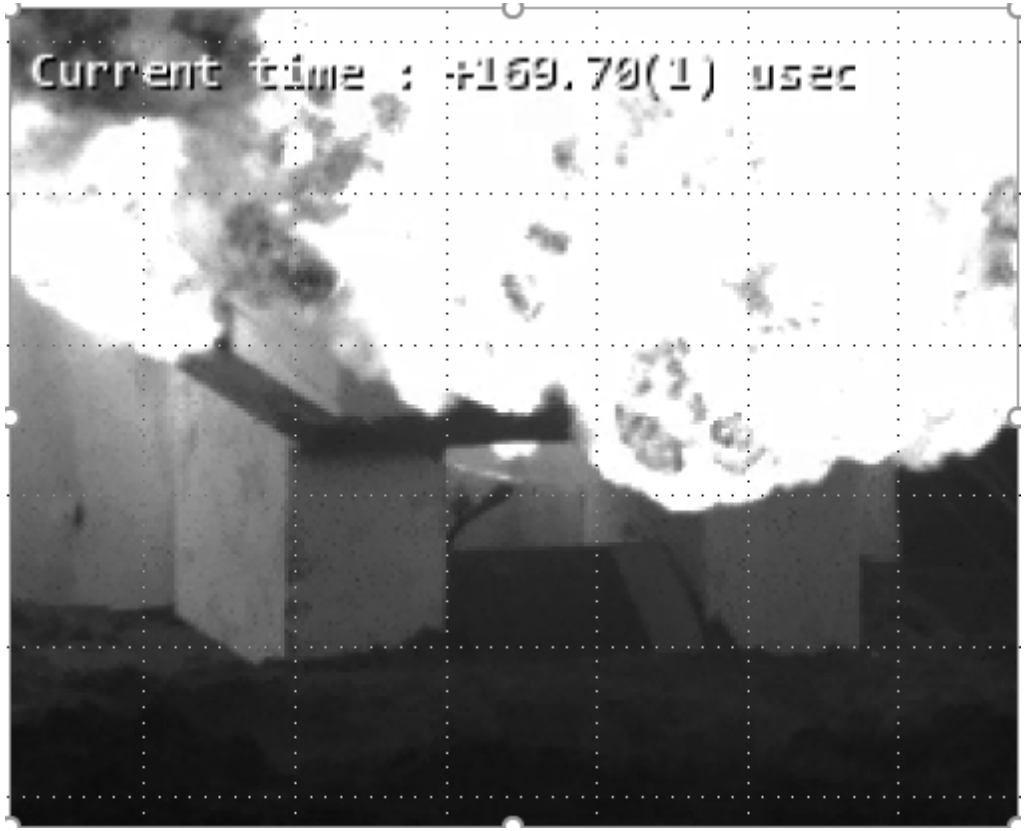
In-line

Staggered

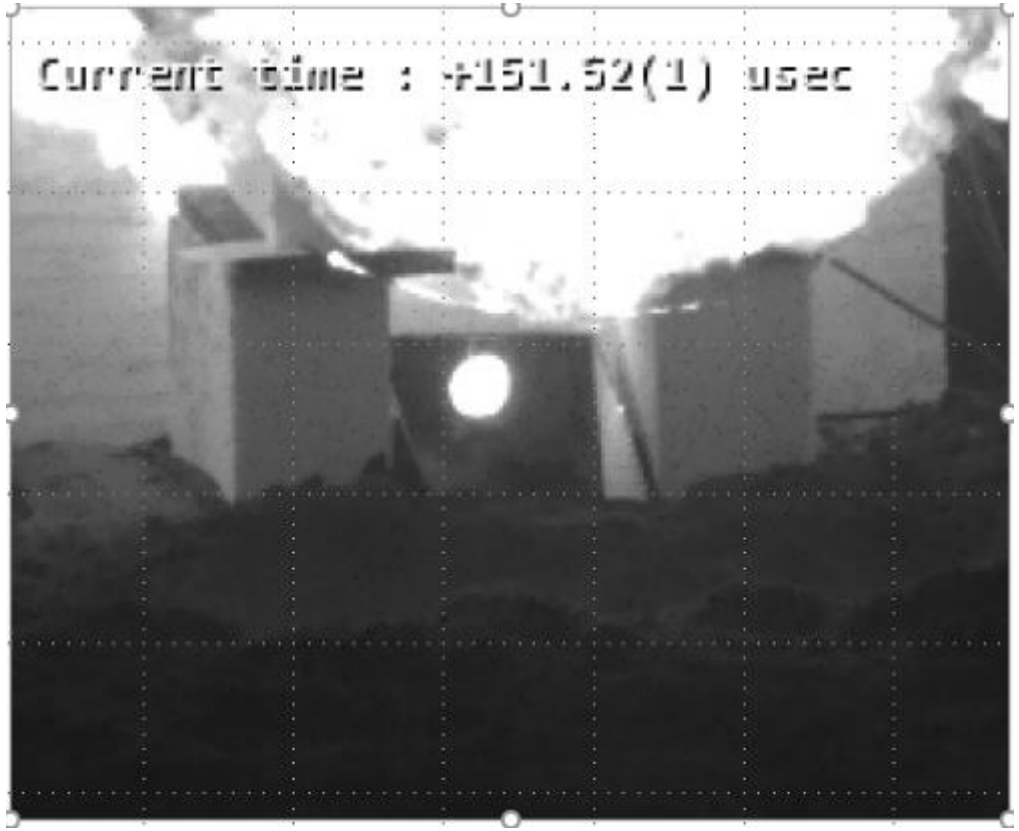
AERATED CONCRETE WITH HOLES

13 MM, 40 MM SPACING, STAGGERED

190 mm



170 mm



AERATED CONCRETE WITH HOLES

8 MM, 30 MM SPACING

120 mm

100 mm

AERATED CONCRETE WITH HOLES

8 MM, 30 MM SPACING

120 mm

100 mm

CONCLUSIONS
MITIGATION OF PLASTIC EXPLOSIVE SYMPATHIC REACTION

- Flat detonation waves are challenging to mitigate!

- Ineffective
  - Air gap (210 mm)
  - Aluminium/rubber (46 mm)
  - PIR foam (210 mm)
  - Wood (210 mm)
  - Ceramic blocks (175 mm)

- Effective
  - Aerated concrete 190 mm
  - Aerated concrete with 13 mm holes 170/190 mm (in-line/staggered)
  - Aerated concrete with 8 mm holes 120 mm

THANK YOU FOR YOUR TIME

innovation for life