

Building Blast Shields: An Overview

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Adrian J Pierorazio, P.Eng.
Principal Engineer
Burlington, Ontario



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Outline

- **What is a building blast shield?**
- **Impetus for this topic**
- **Theory**
- **“Rule of Thumb”**
- **Applications of the “Rule of Thumb”**
- **“Real” answers**



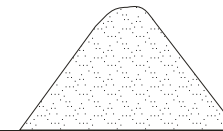
What is a Building Blast Shield?

- For today's purposes, this is an obstacle designed to block a blast wave from a reaching structure

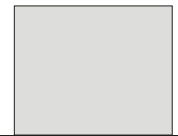
Explosion Source



Berm



Trailer



- Doesn't change frequency or source term, just local consequences at the target

Impetus for this talk

- ~ 1 question /18 months previously
- Since Texas City, this has increased to ~1 question every other month
- API RP 753 has reduced resistance of light wood trailers from 1 psi to 0.6 psi increasing safe distance by ~50%
- Need to find a way to support temporary structures on sites
- Common misunderstandings around shielding



Theory

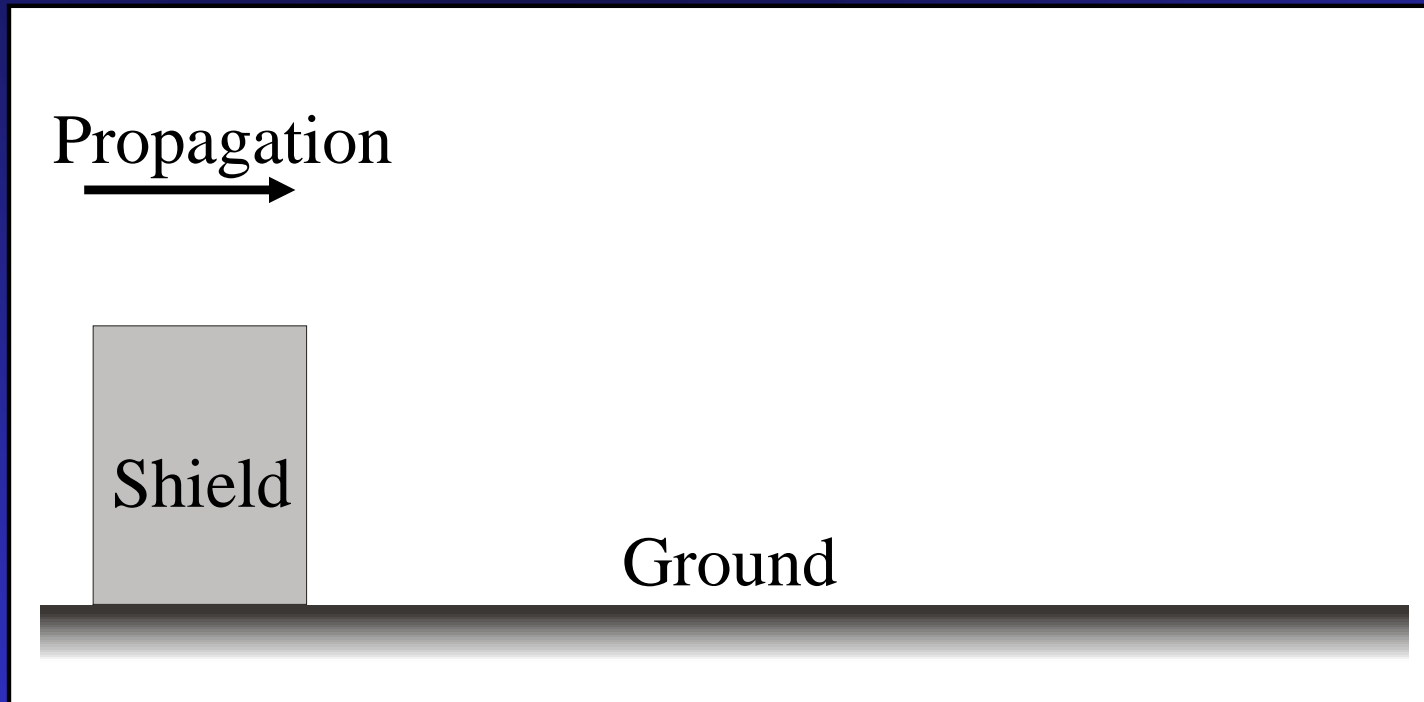
- **Blast and shock waves are waves**
 - *Are not limited to traveling line of sight*

- **Can think about blast waves a high amplitude sound waves**

- **Consider the following case:**
 - *Far field*
 - *Shock wave*

Theory cont.

■ Scenario



Theory cont.

- Wave propagates over obstacle



Theory cont.

- As wave passes the rear of the building



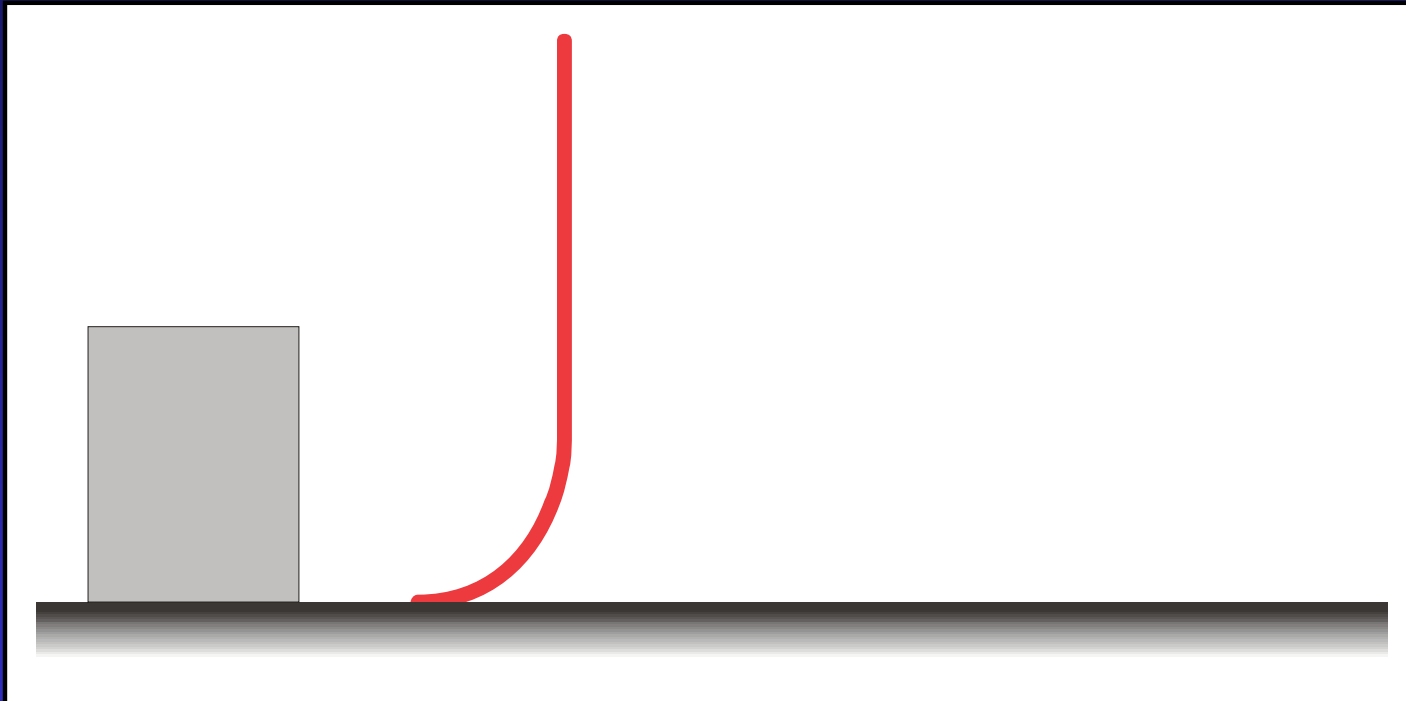
Theory cont.

- Wave curves and expands downwards



Theory cont.

■ Propagation continues



Theory Conclusions

- **Blast wave still loads back face of obstacle**
- **Expansion through rarefaction reduces blast load**
 - *Load immediately behind the shield reduces*
- **Wave re-forms downstream**
 - *Essentially unaffected by shield in far field*
- **Direction of loading behind shield is different**

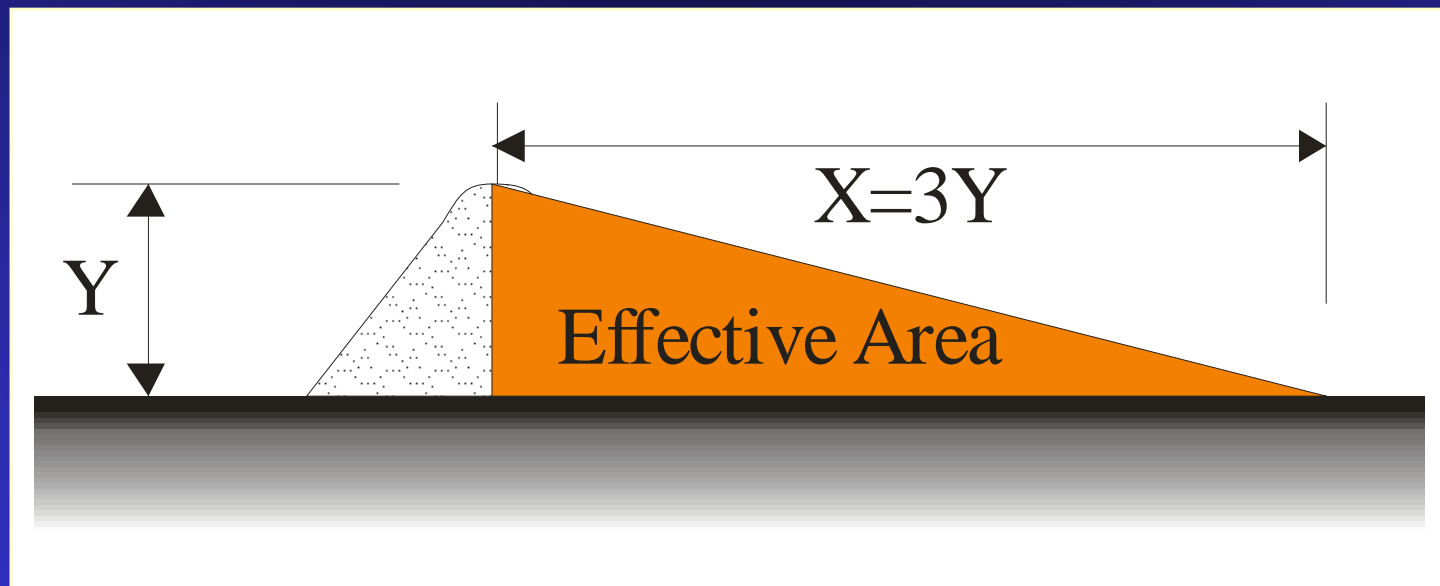
Rule of Thumb Disclaimer

It must be noted that this analysis is for general scoping only and should not be used for final design. If a company wishes to pursue the use of a berm or blast wall for blast protection, a numerical analysis should be performed to accurately analyze the situation and provide results that can be used for design.



Rule of Thumb

The blast load is significantly reduced behind a barrier to a distance of three times the height of the barrier



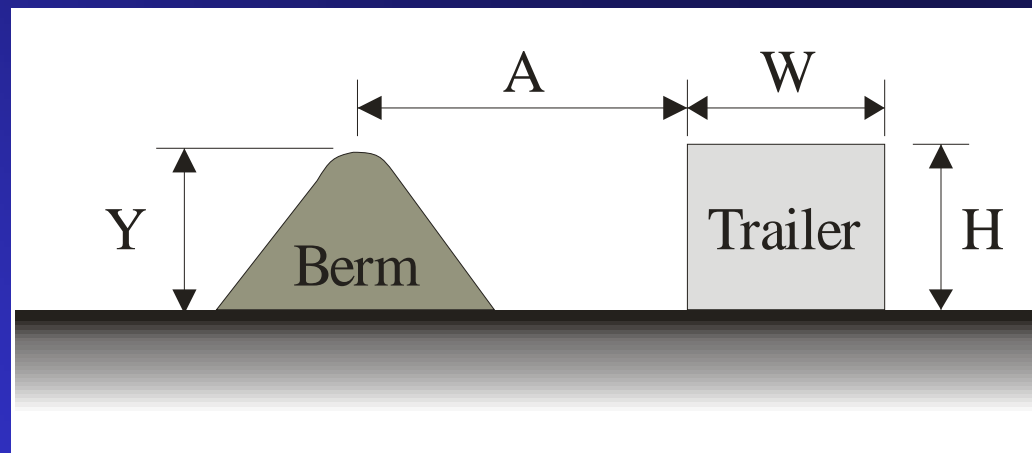
Height Equations

- To shield front wall

$$Y \geq H + \frac{A}{3}$$

- To shield whole building

$$Y \geq H + \frac{A + W}{3}$$



Sample Results

**Assume a blast wall for 32 ft trailer (10 ft tall)
perpendicular to wall**

| | Required Wall Height (ft) | | |
|-------------------------------|----------------------------------|-----------|-----------|
| Space (A) | 0 | 6 | 10 |
| Protect Front Wall | 10 | 12 | 13 |
| Protect Whole Building | 21 | 23 | 24 |

What about width?

- Same issues apply for width
- Width of the shield wall needs to be

$$X \geq L + \frac{2A}{3}$$

to protect front wall and

$$X \geq L + \frac{2(A+W)}{3}$$

to protect side walls as well.

Overall Size of a Blast Wall

- **For a 12 x 32 x 10 ft trailer perpendicular to the wall, the wall would need overall dimensions as follows:**

**No separation: 10 x 12 ft (front wall)
 21 x 33 ft (whole bldg)**

**6 ft separation: 12 x 16 ft (front wall)
 23 x 37 ft (whole bldg)**

**10 ft separation: 13 x 19 ft (front wall)
 24 x 40 ft (whole bldg)**



Overall Size of a Blast Wall Cont

- **For a 12 x 32 x 10 ft trailer parallel to the wall, the wall would need overall dimensions as follows:**

**No separation: 10 x 32 ft (front wall)
 14 x 40 ft (whole bldg)**

**6 ft separation: 12 x 36 ft (front wall)
 16 x 44 ft (whole bldg)**

**10 ft separation: 13 x 39 ft (front wall)
 17 x 47 ft (whole bldg)**



Berms

- Berms are attractive since they are
 - *Cheap*
 - *Easy to set up*
 - *Easy to tear down*
 - *Readily available*

- Must account for critical angle of repose for slope stability

Berm Angle of Repose

- The angle of repose (α) will control the minimum width of the berm itself according to the following equation:

$$A \geq \frac{Y}{\tan(\alpha)}$$

- Sample calculation results are shown for clay (angle of repose = 45 degrees) as a berm material.
- Other berm materials have smaller angles of repose and the corresponding berm heights and widths would be increased from what is shown here.

Sample Berm Results

Clay Berm Material ($\alpha = 45^\circ$)

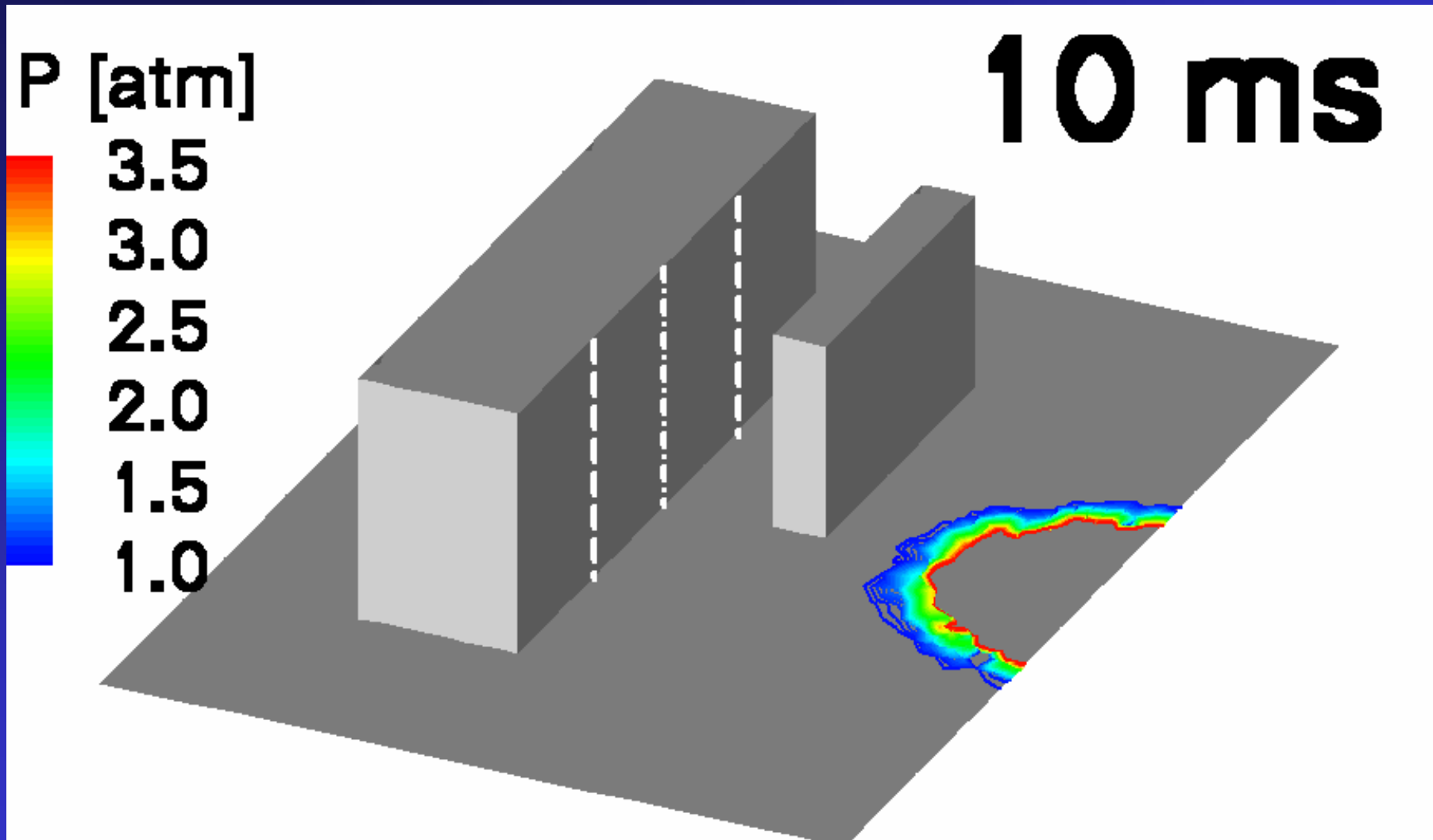
Trailer 12 x 32 ft, 10 ft high

| Trailer Location | Trailer Orientation | Minimum Berm Height to Shield (ft) | |
|-------------------------|----------------------------|---|-----------------------|
| | | Whole Trailer | Blastward Wall |
| Touching Berm | Parallel to Berm | 19 | 15 |
| | Perpendicular to Berm | 31 | |
| 6 ft. from Berm | Parallel to Berm | 22 | 18 |
| | Perpendicular to Berm | 34 | |

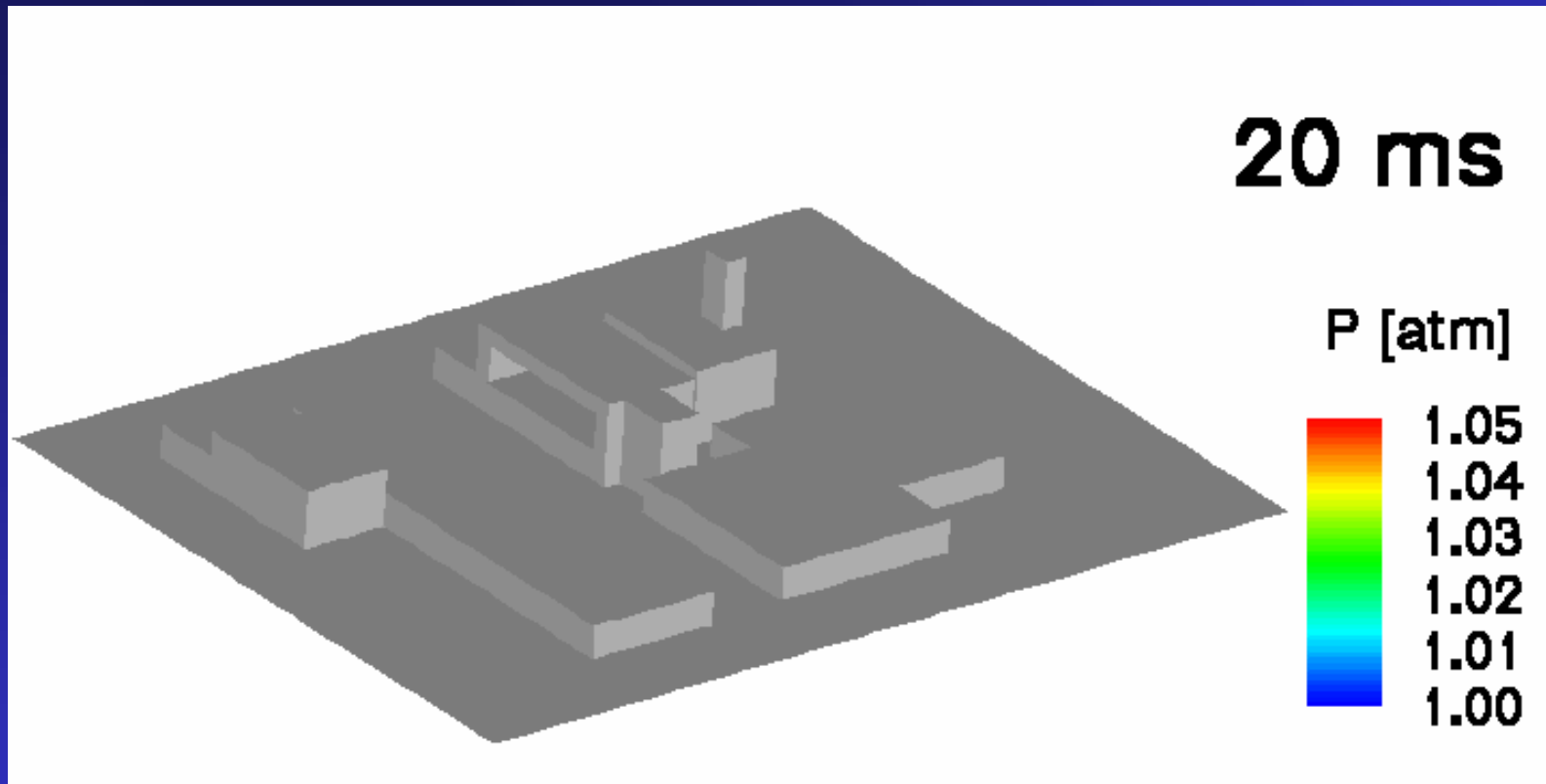
“Real Answers”

- **The Rule of Thumb indicates the area where blast load reduction is “significant”**
- **To quantify reduction, need to run numerical model**
- **Note that blast loading direction may not be the same as when the shield is not there**

Animation of Shielding



More Complex Shielding



Another Way to Get the Answer



Conclusions

- **Rule of thumb presented for approximate blast wall sizing**
 - *Indicates feasibility*
 - *Wall needs to resist blast load*
 - *May need significant reaction structure*

- **Numerical analysis needed to determine**
 - *Actual reduction*
 - *Load distribution*
 - *Load direction*

Questions?



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