



**EXPLOSION LIAISON
GROUP**

45th UKELG One-Day Discussion Meeting on “Blast Effects on Buildings and Structures”

Blast Response of Cladding

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31 March 2010



Cover two topics today:

- Insulated Cladding Panels
- Planar Glass Systems

Cladding Panels (Kingspan Insulated Panels)

- Preliminary test
- Analytical comparisons
- Observations

Insulated Cladding Panels – Preliminary Test



Insulated Cladding Panels – Preliminary Test

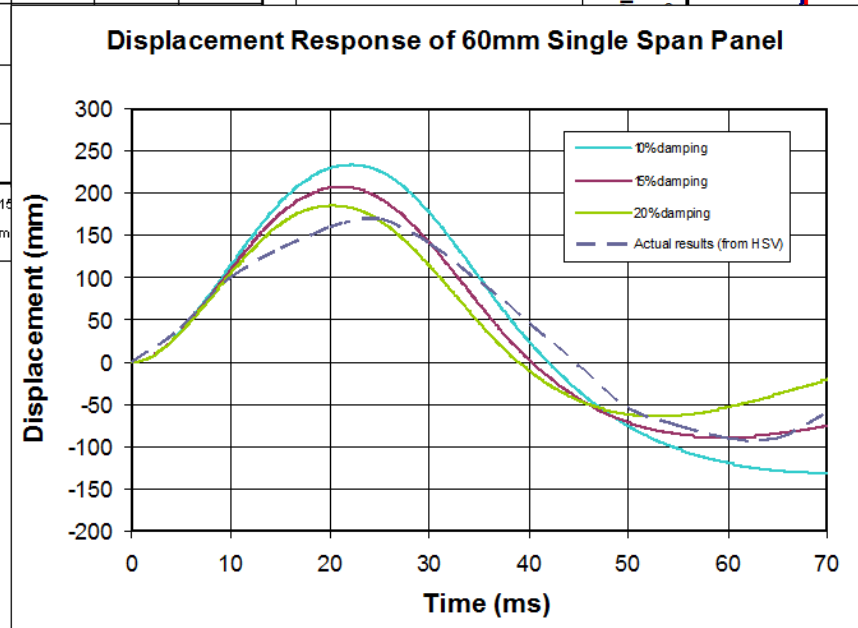
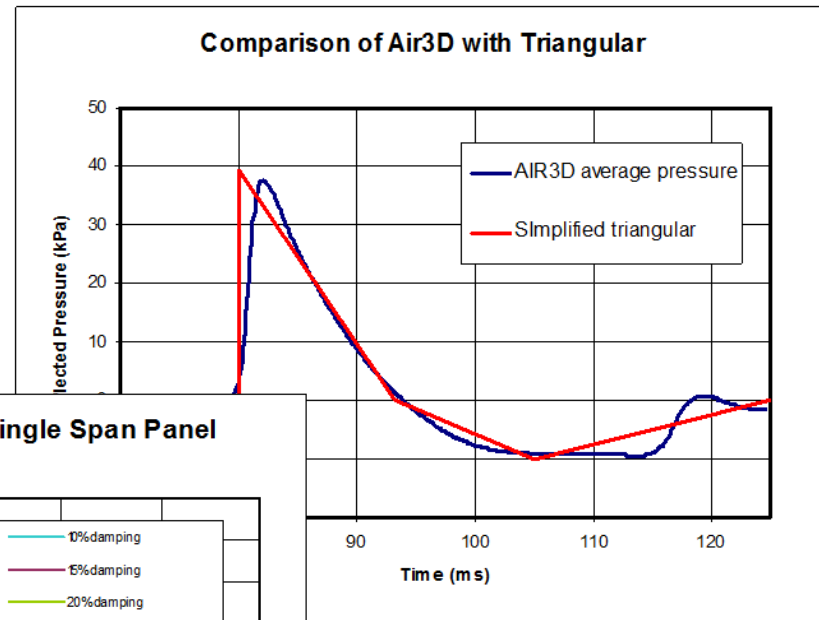
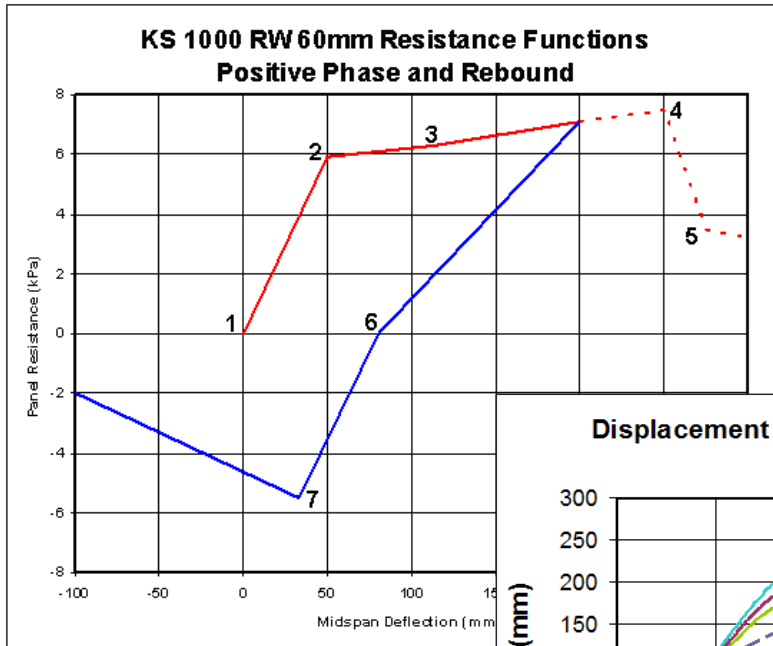


Insulated Cladding Panels – Preliminary Test

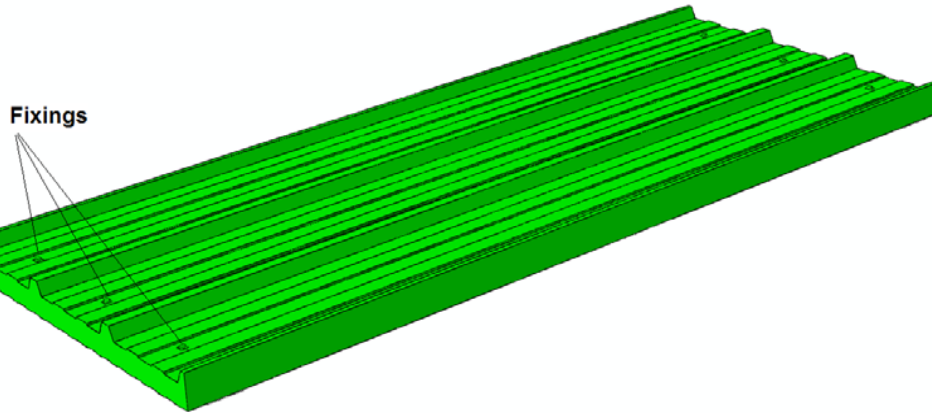




Insulated Cladding Panels – SDOF

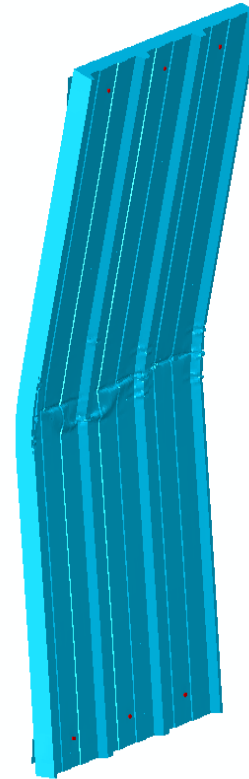
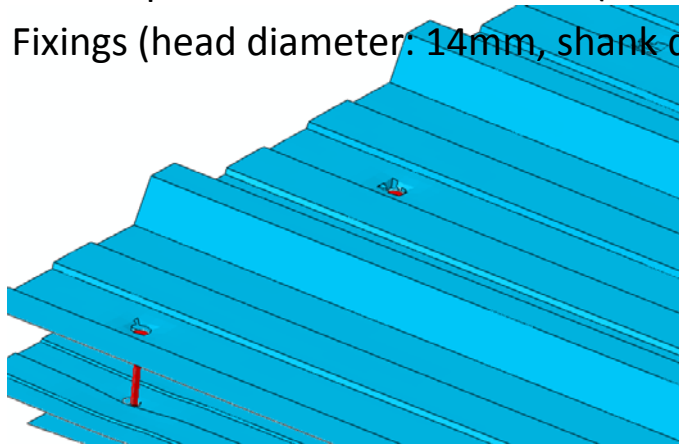


Insulated Cladding Panels – FEA



KS1000RW composite insulated panel :

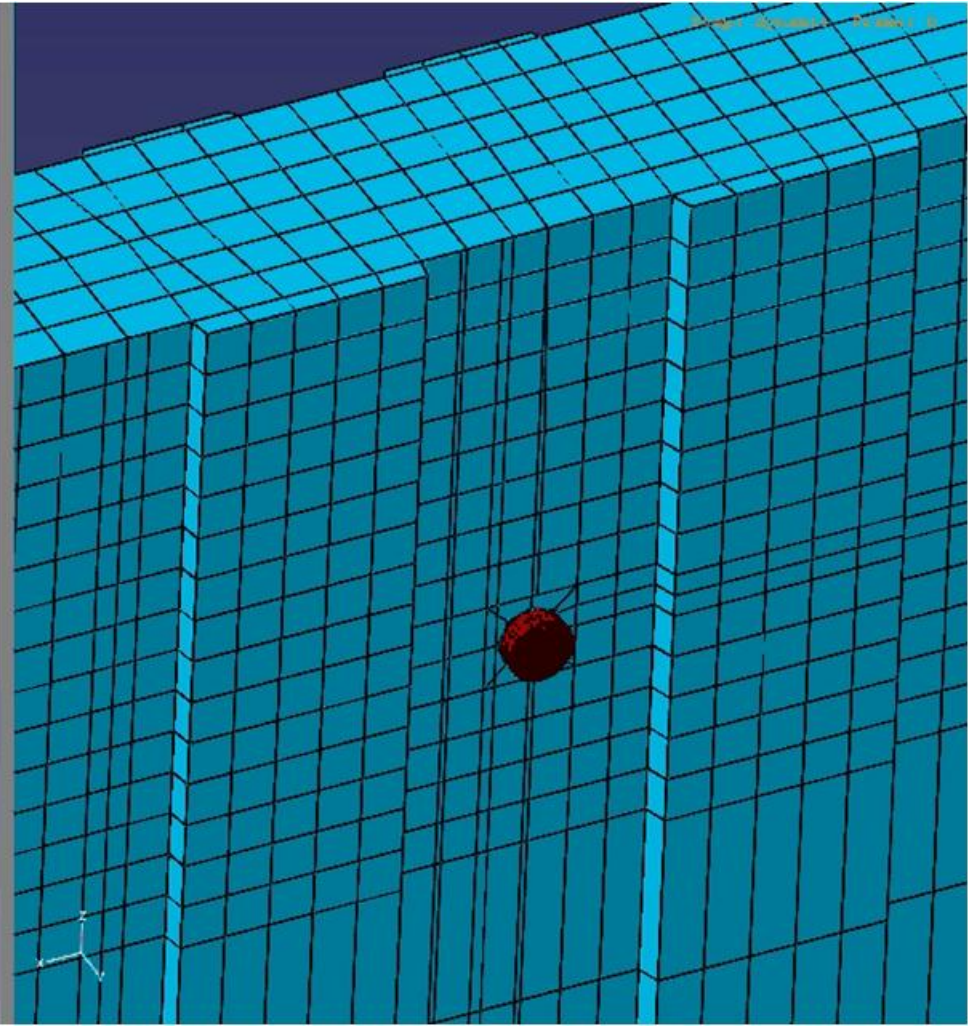
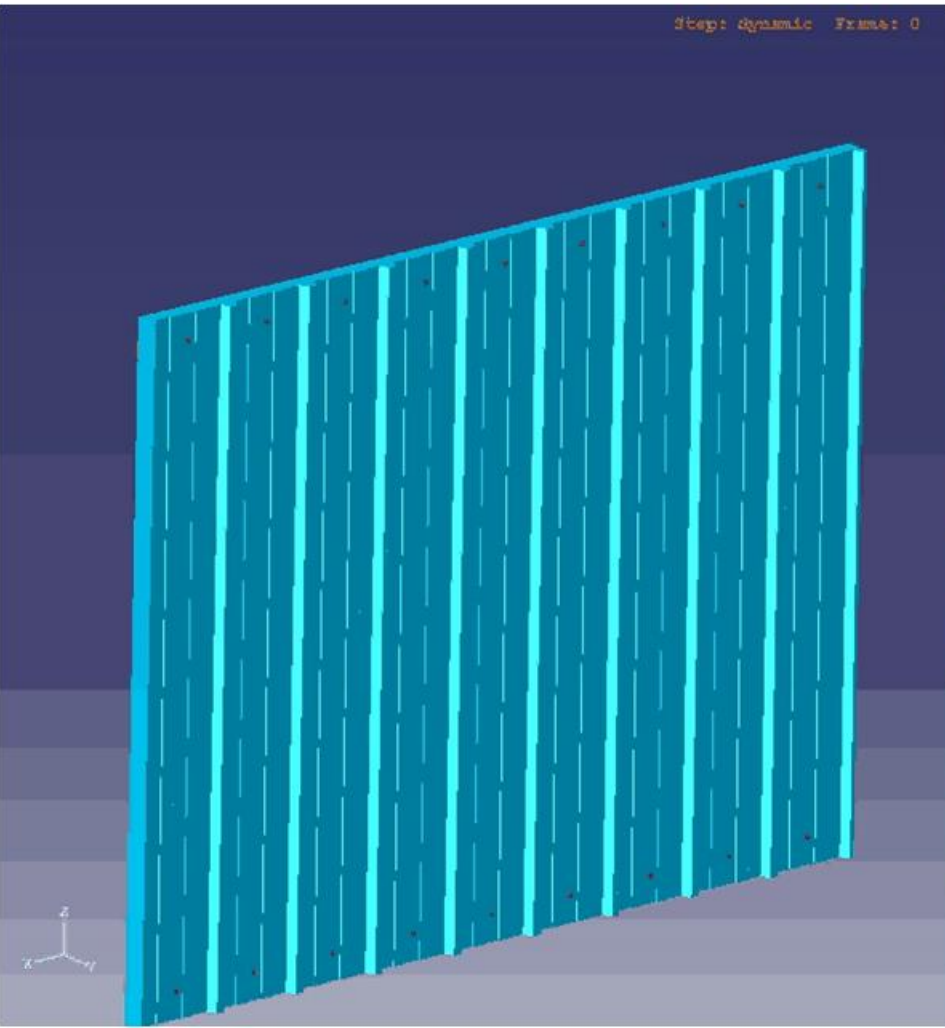
- Lightly profiled inner steel sheet (0.4mm)
- Core of polyisocyanurate (PIR) rigid foam (60mm)
- Thicker profiled outer steel sheet (0.5mm)
- Fixings (head diameter: 14mm, shank diameter: 5.5mm)



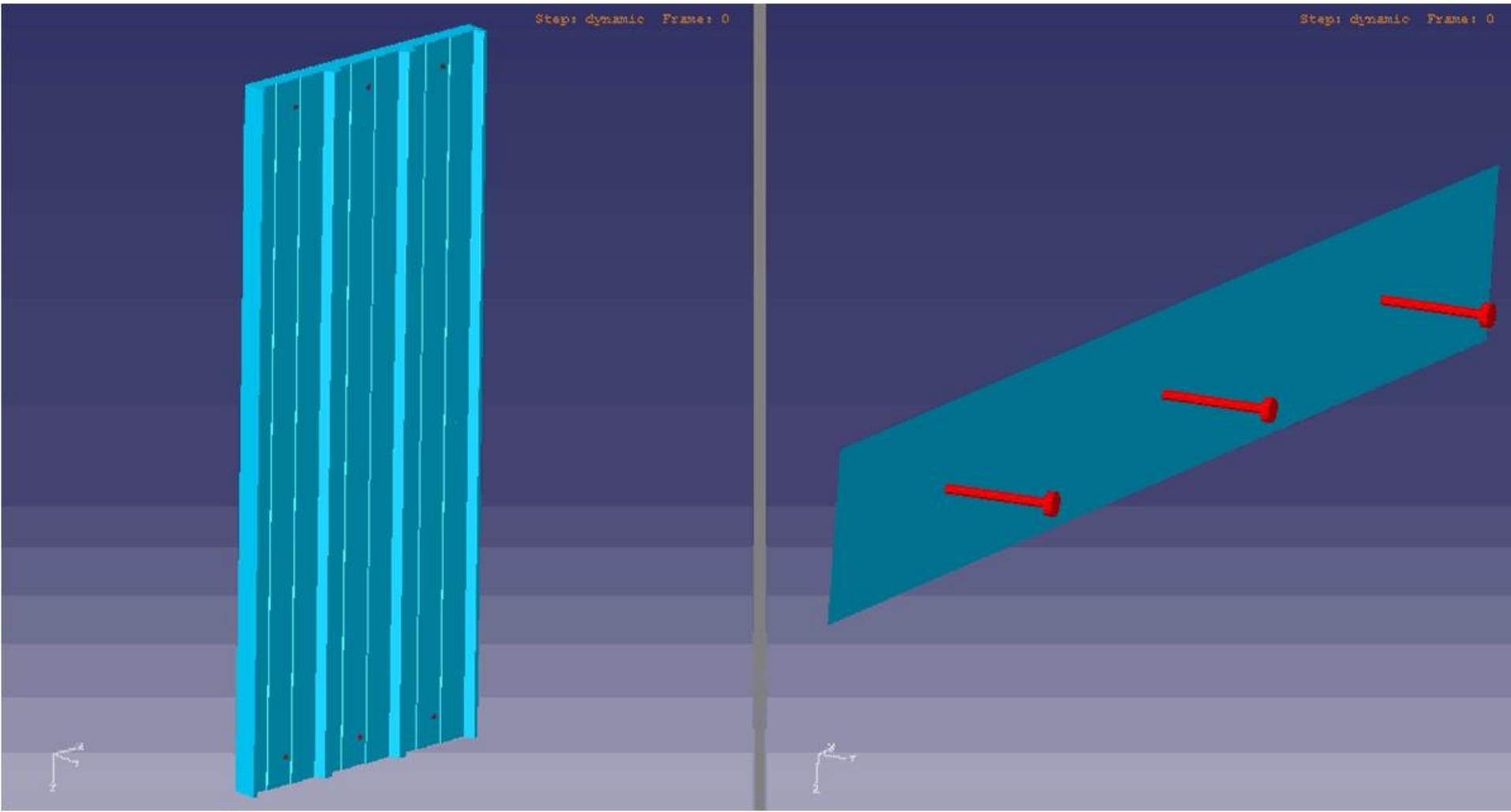


Blast Response of Cladding

Insulated Cladding Panels – FEA



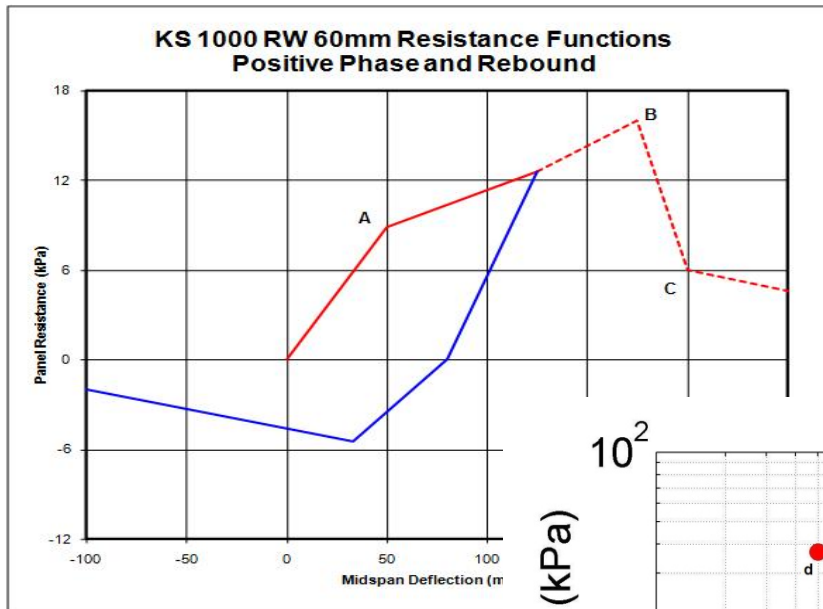
Insulated Cladding Panels – FEA



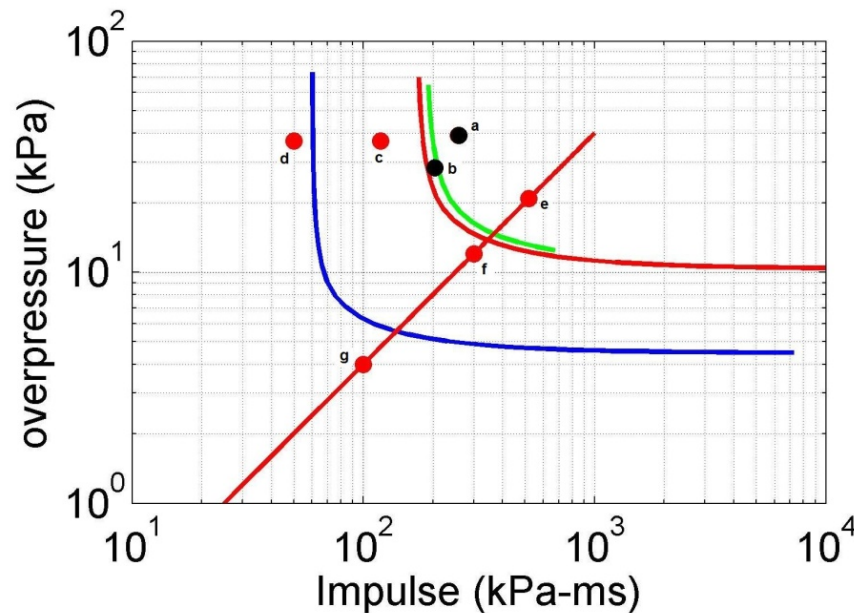
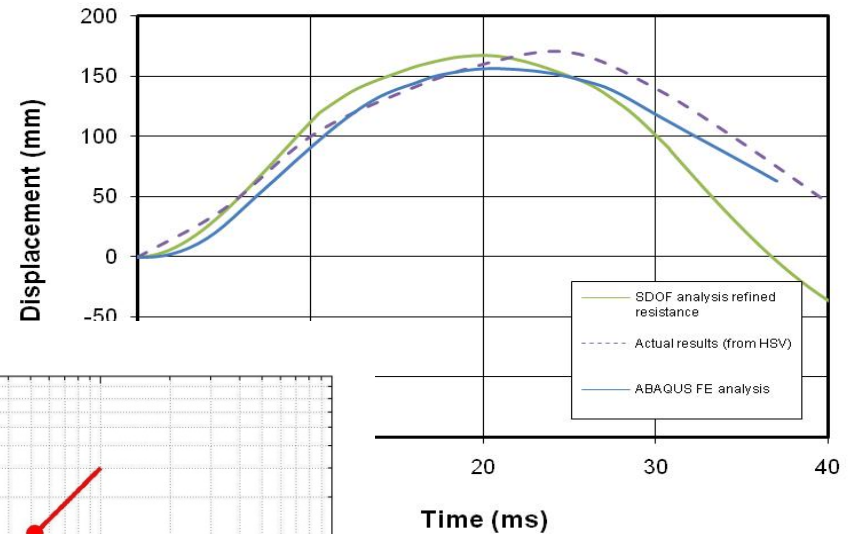


Blast Response of Cladding

Insulated Cladding Panels – Refined SDOF/FEA



Displacement Response of 60mm Single Span Panel



Insulated Cladding Panels – Observations:

- Relatively weak/lightweight
- Internal hazard – low debris 😊 internal pressure 😞
- Rigid supports – conservative, not representative
- Membrane action - significant
- Fixings – key design aspect, limit response
- Developing design guidance – P-I curves

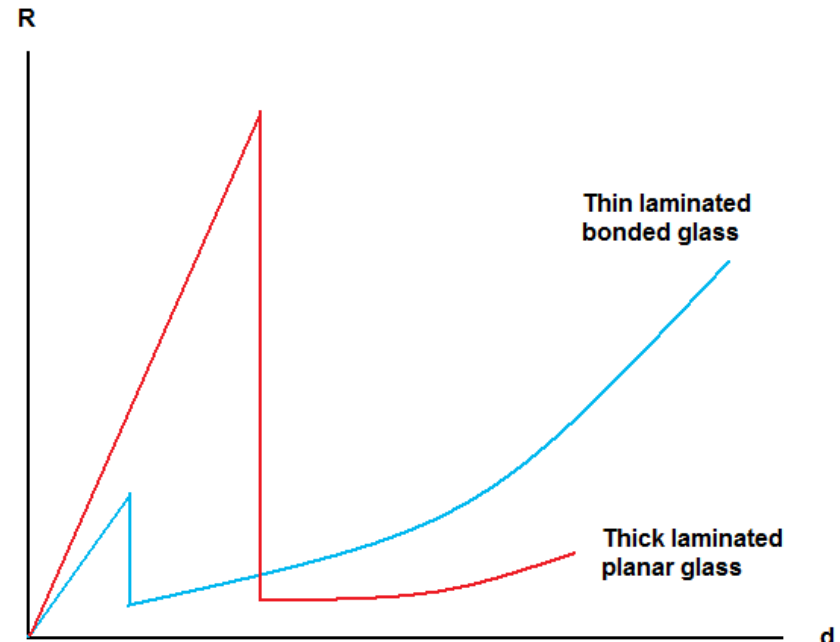
Planar Glass Systems (Pilkington)

- Design challenge
- Review of test results
- Analysis models
- Design and detailing



Planar Glass Systems

- Design challenge
 - Architecturally attractive
 - Sudden fixing failure
 - Generally avoided for blast
 - Tests in 2002 and 2004



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Blast Response of Cladding

Elastic Response



Before



After

Blast Response of Cladding

Elastic positive, tear rebound



Blast Response of Cladding

Membrane positive, held in rebound



Blast Response of Cladding

Tear positive



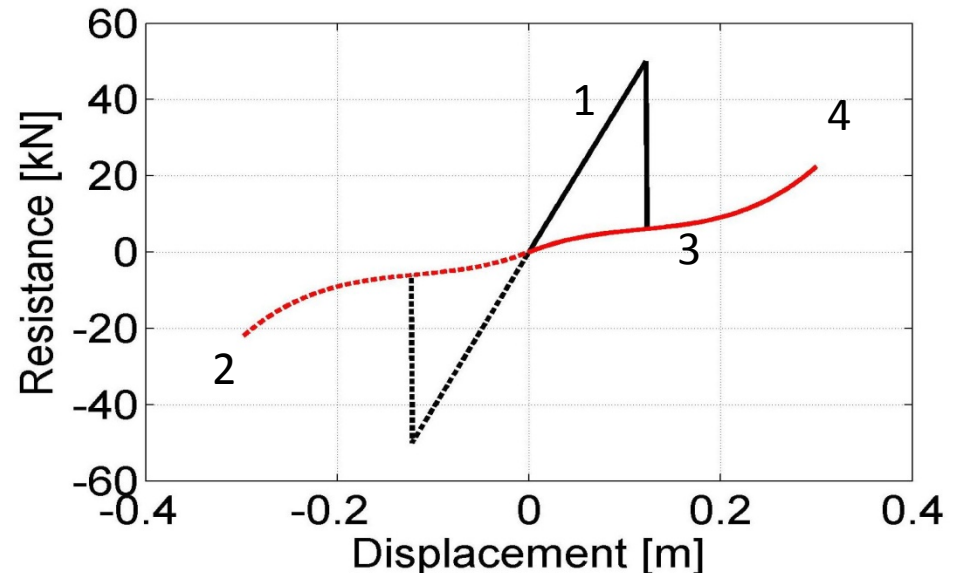
Before



After

Planar Glass Systems

1. Distant blast – elastic response 😊
2. Closer blast – elastic positive, tear rebound 😐?
3. Closer blast – membrane positive, held in rebound 😐
4. Too close – tear positive 😞

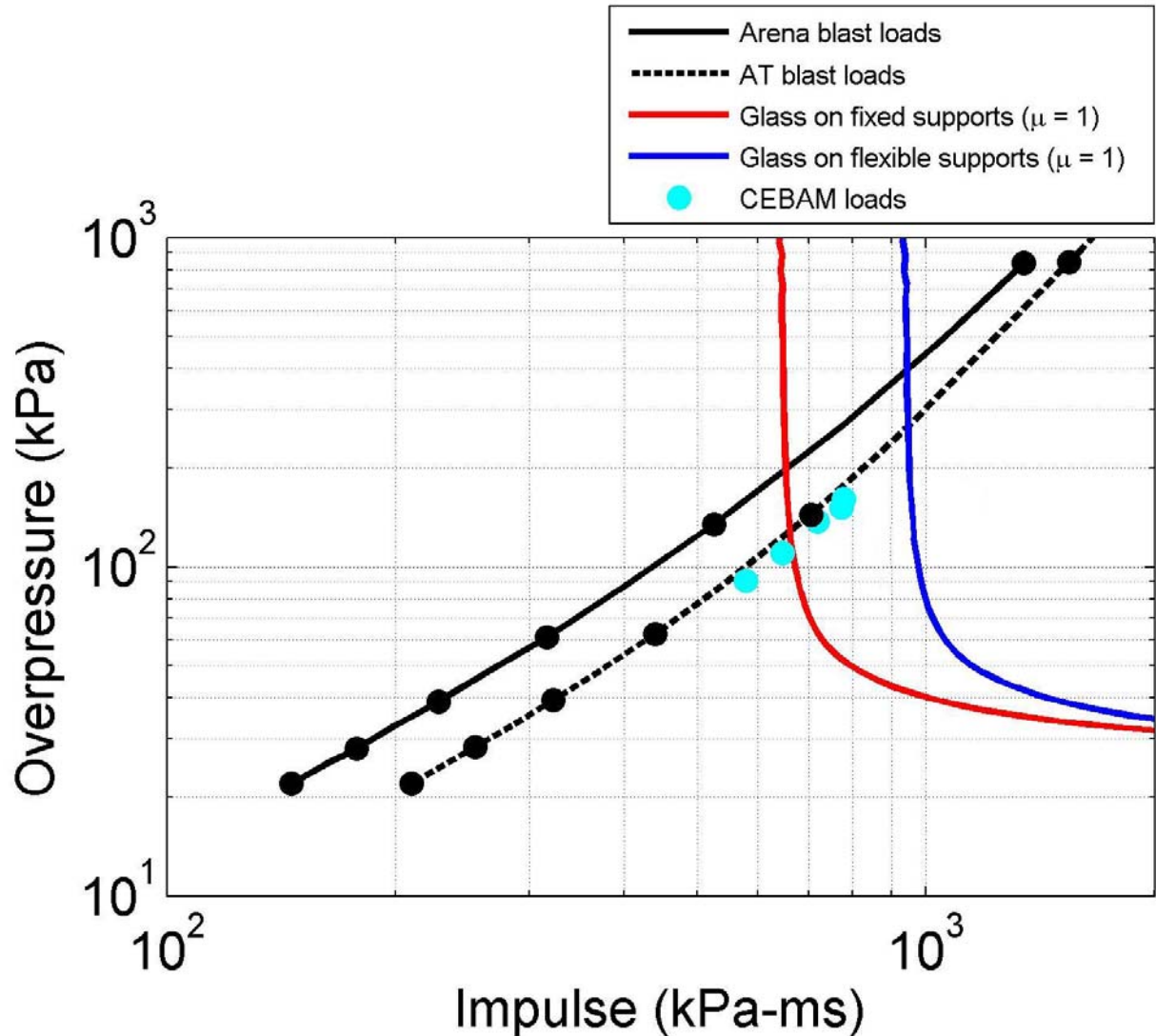


Blast Response of Cladding

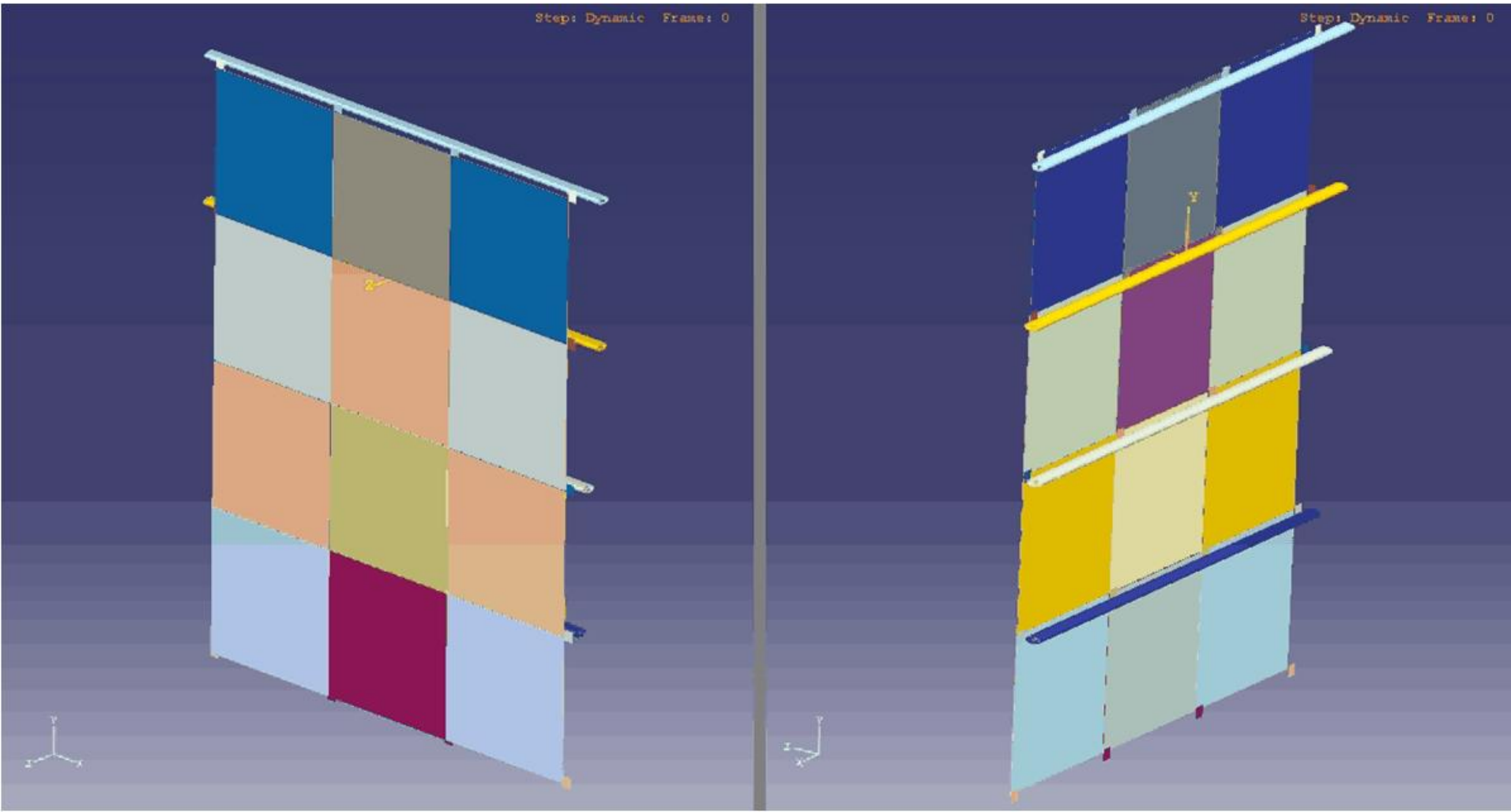
Planar Glass
Systems

P-I Curves

Benefit of
flexible
supports



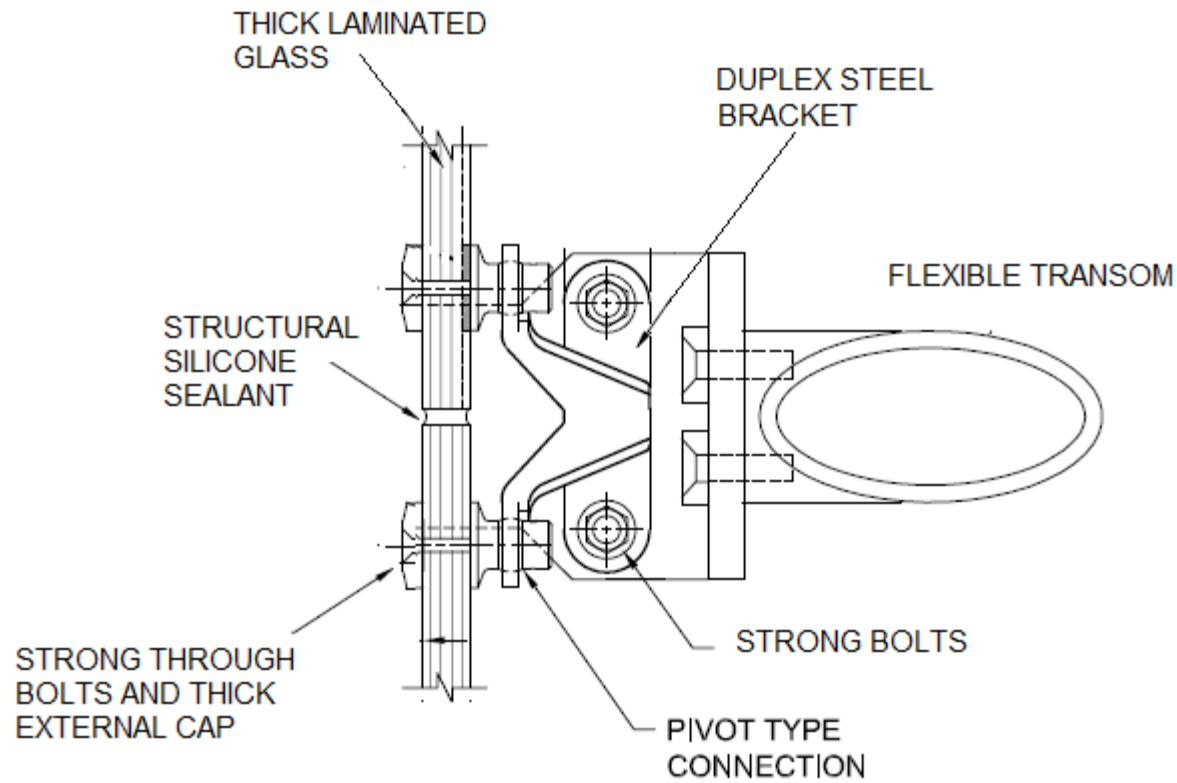
Planar Glass System Analysis



Planar Glazing – Design Recommendations

- Thick laminated glass - broadly elastic
- Membrane/bonding as safeguards
- Flexibility in supports (not too much!)
- Enhanced fixings:
 - Pivot type
 - Higher grade steel brackets, strong fixings
 - Larger diameter through bolts
 - Thick external caps

Planar Glazing – Design Recommendations



Conclusions

- Apparently weak/lightweight architectural components possess useful blast resistance
- SDOF analyses can be helpful, but may be conservative
- FEA may permit complex systems to be more efficiently designed
- Testing is an important component - validation
- Fixings are a vital component in the as-built solution and should receive considerable attention