A Practical Perspective on the Use of Advanced Composites for Blast Mitigation

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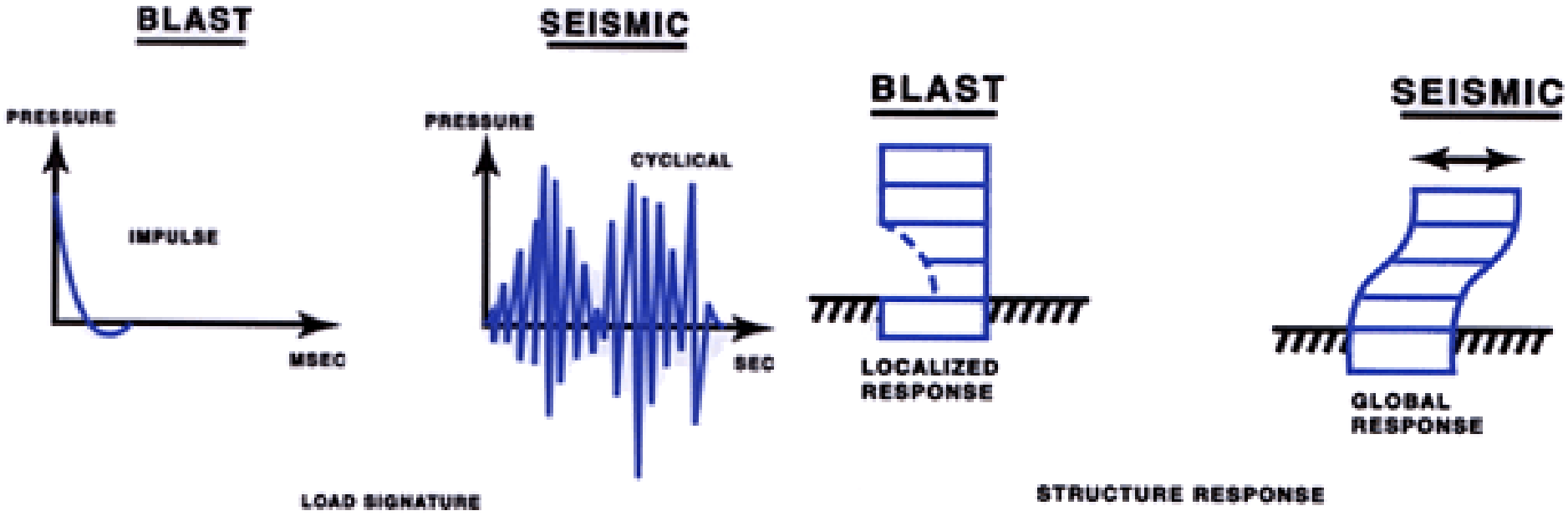
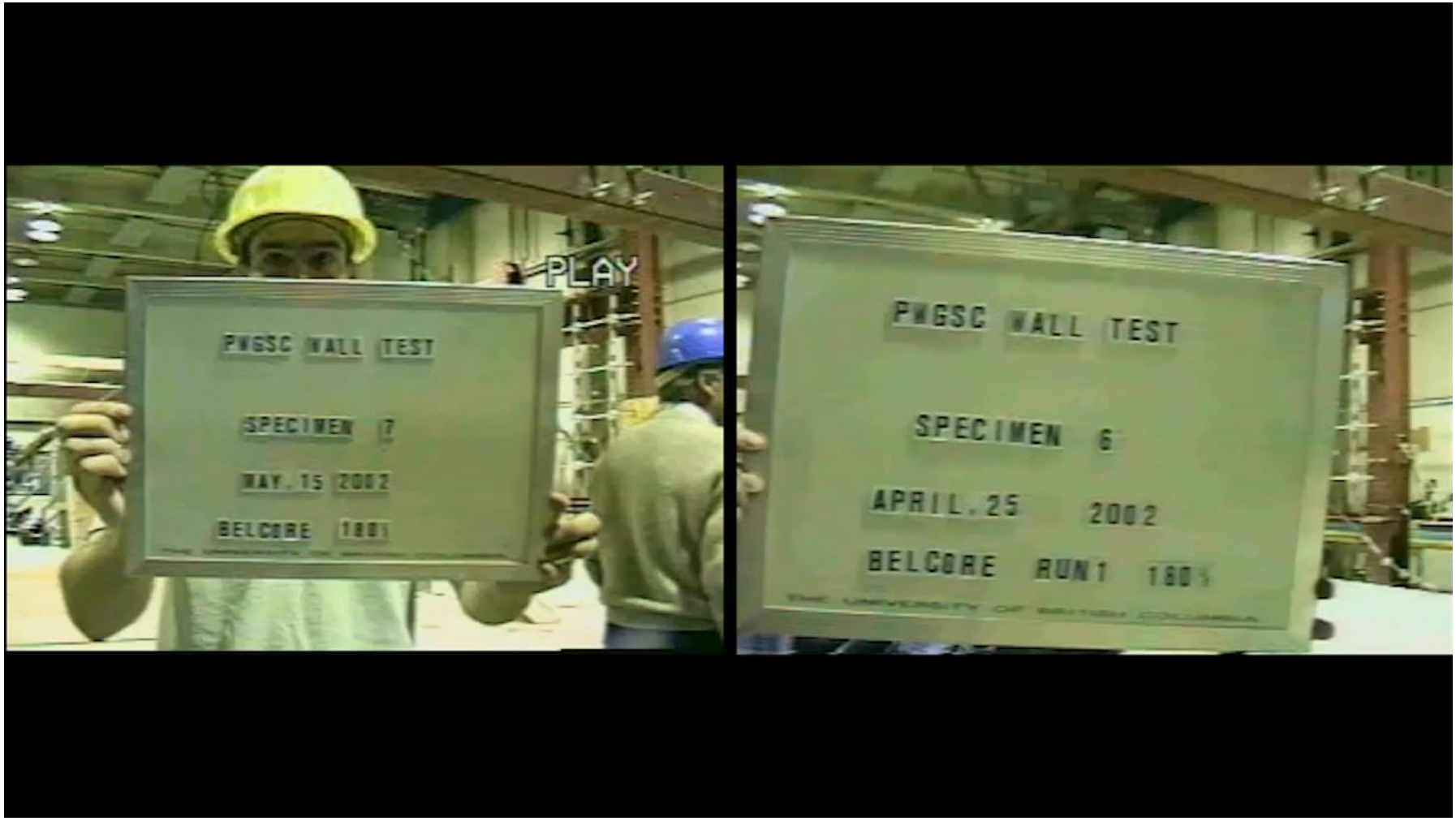
Force Protection vs. Seismic Retrofit



Potential Applications of FRP for Blast Mitigation

- **Strengthening of Masonry Infill Walls**
- **Adding Tie Forces**
- **Strengthening for Uplift**
- **Progressive Collapse**
- **Alternate Load Paths**
- **Adding additional shear capacity**
- **Column confinement & protection**
- **Spall protection**
- **Prefabricated blast curtain walls**

Shake Table Testing – URM Walls



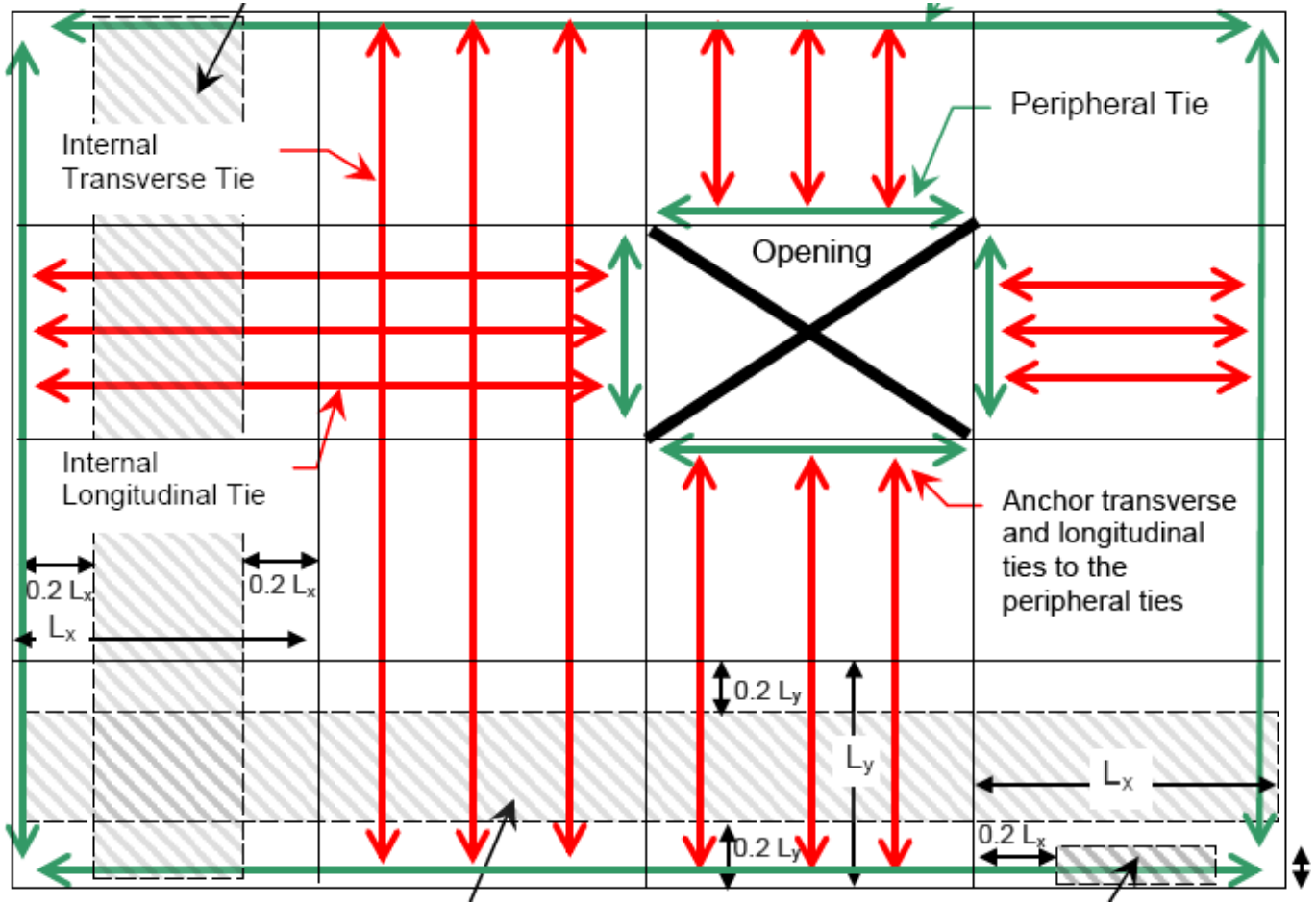
Blast Hardening of Walls


8
A

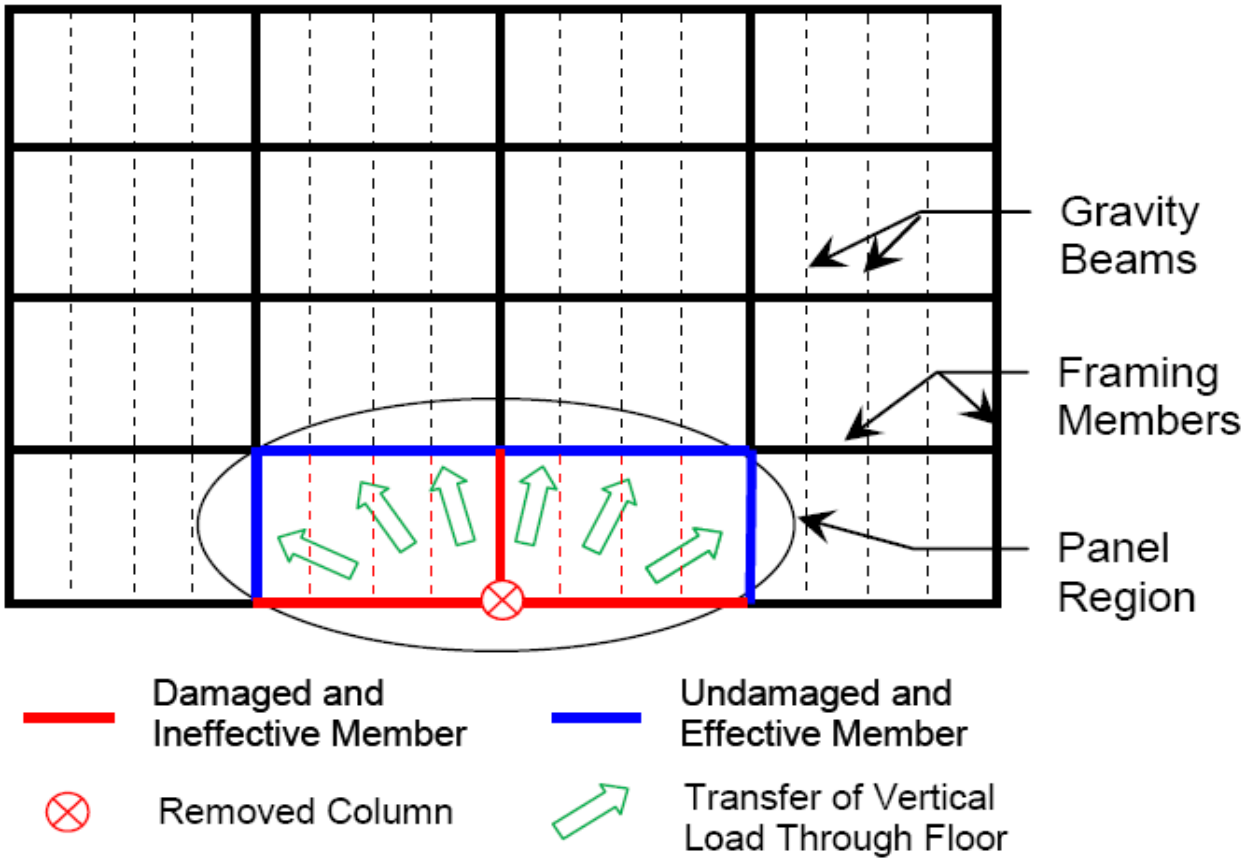
Spray Applied Polyurea

- 3 wythe masonry brick wall
- ½” Tyfo spray applied urea-urethane
- High pressure, short duration
- P =10.7 psi
- I = 279 psi-msec
- Disp +2.5/-4.5
- Strain = 15%

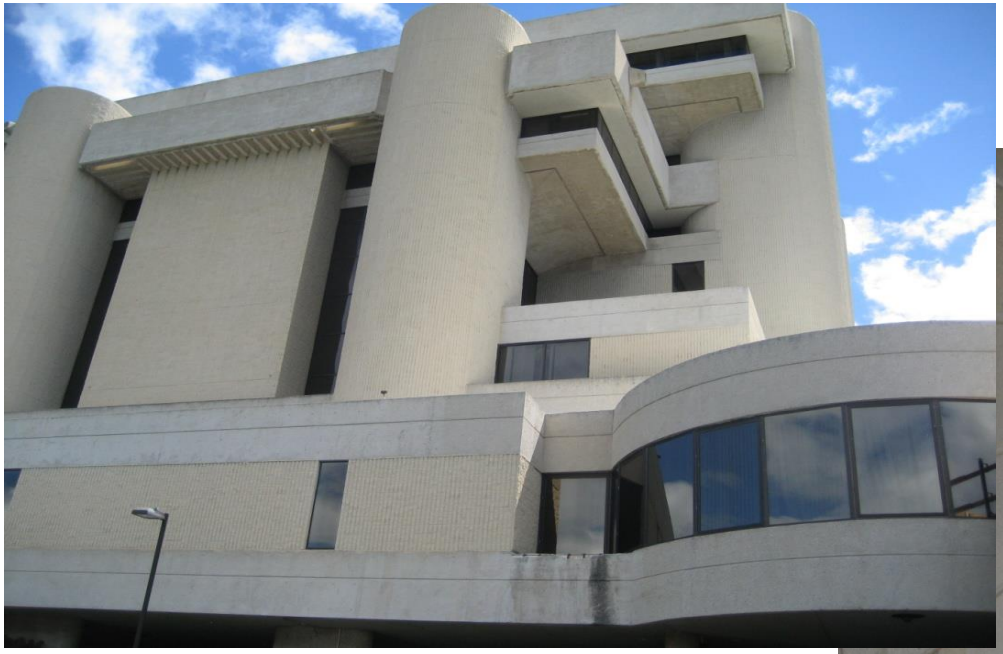
Tie Force Method



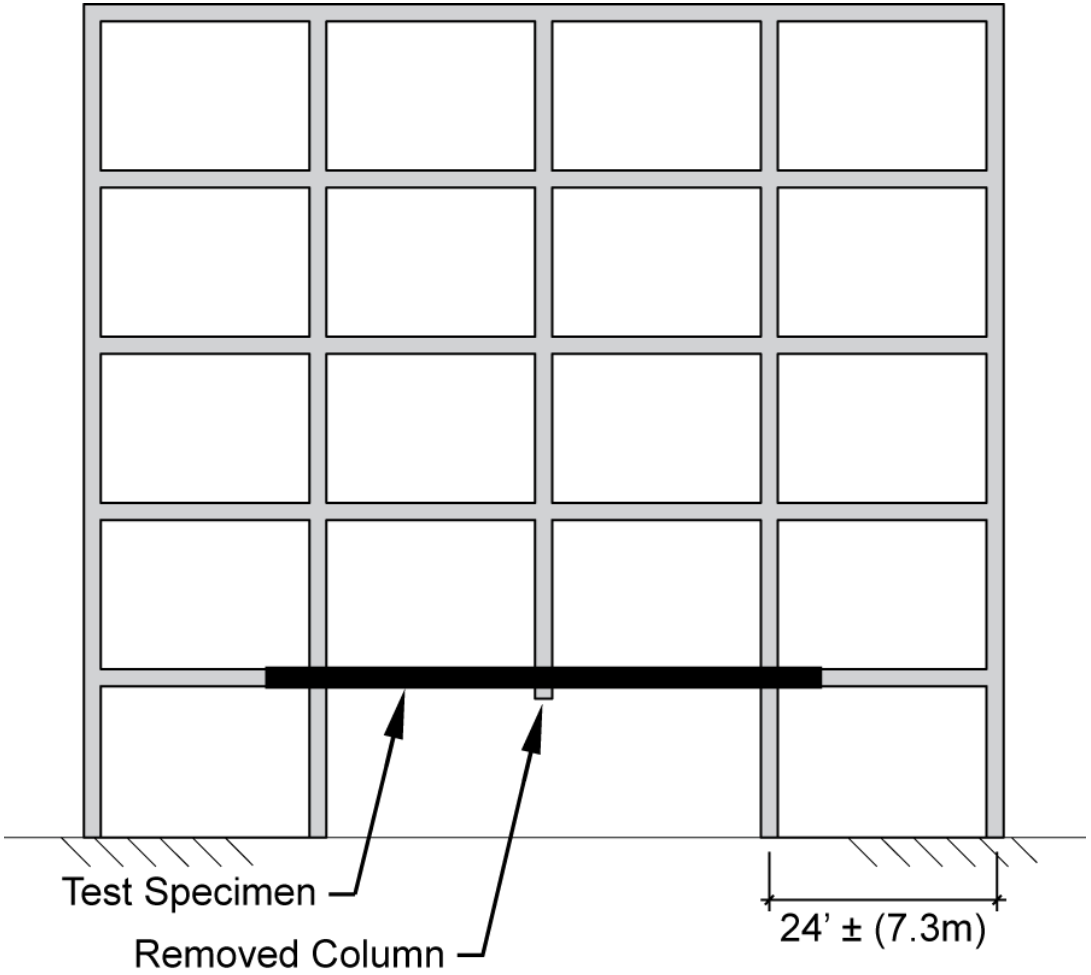
Strengthening for Up Lift Forces



Strengthening for Up Lift Forces



Progressive Collapse / Alternate Load Paths



Progressive Collapse / Alternate Load Paths

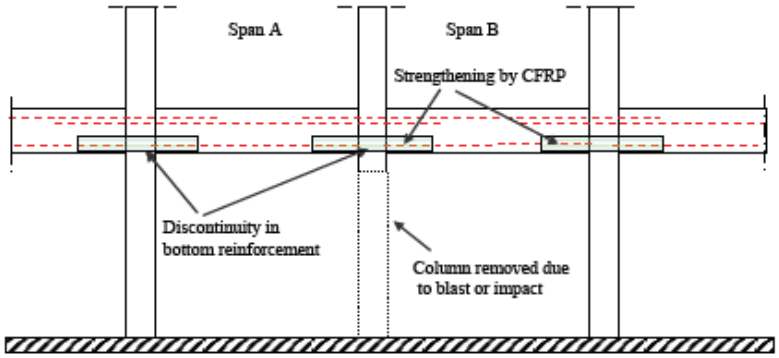


Figure 1.1 Rehabilitation Technique

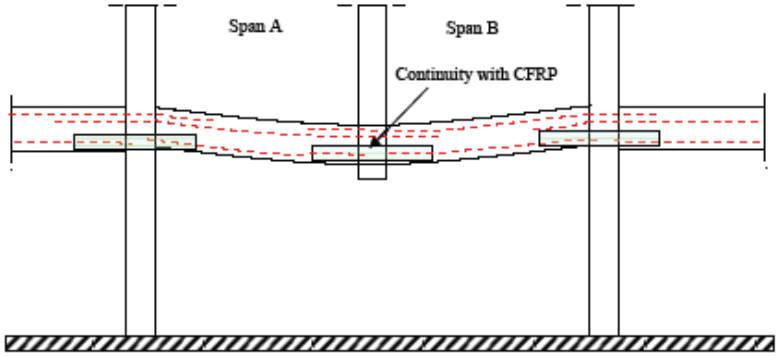
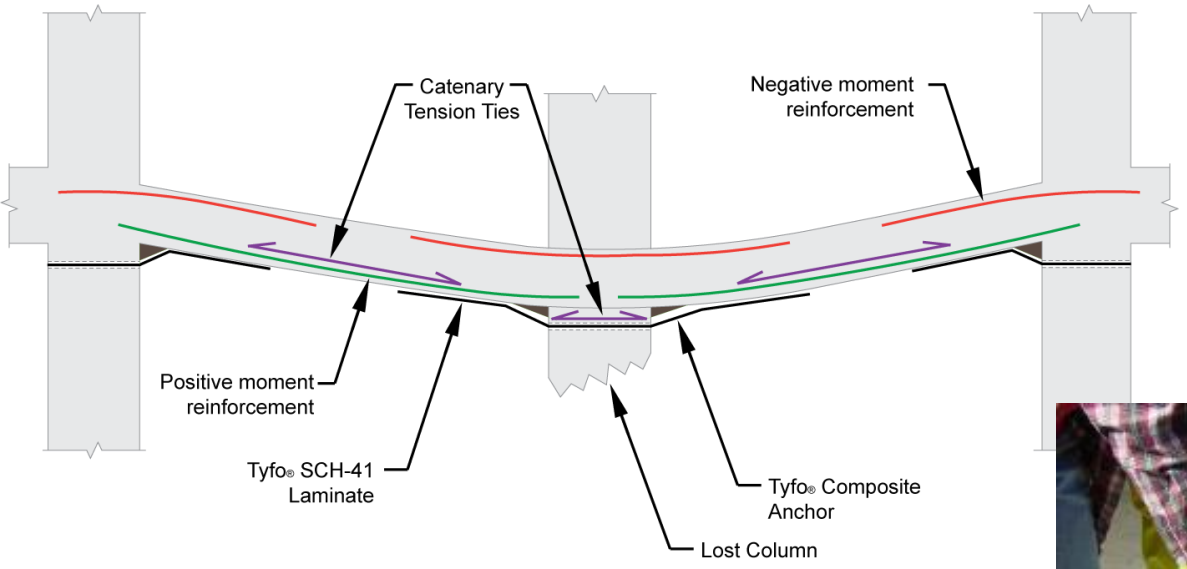
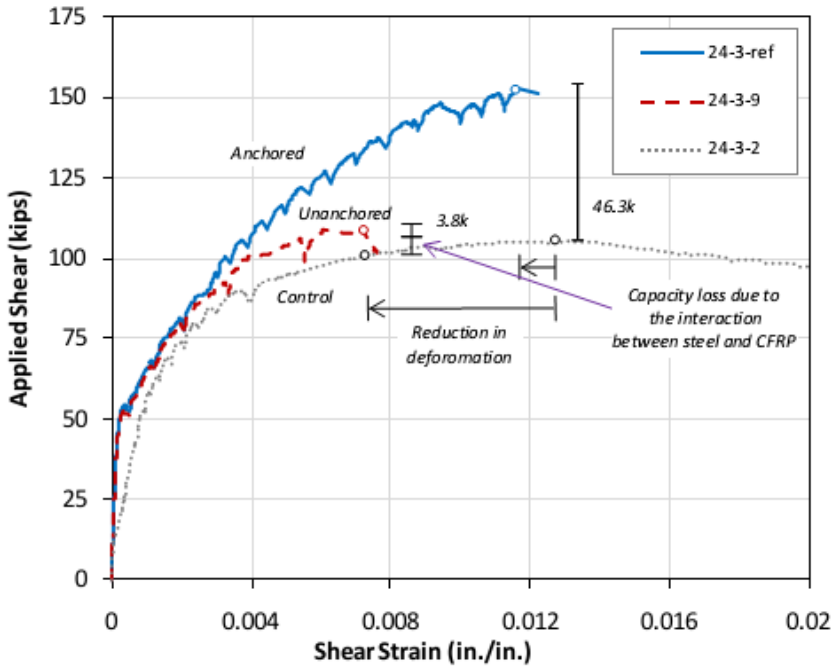


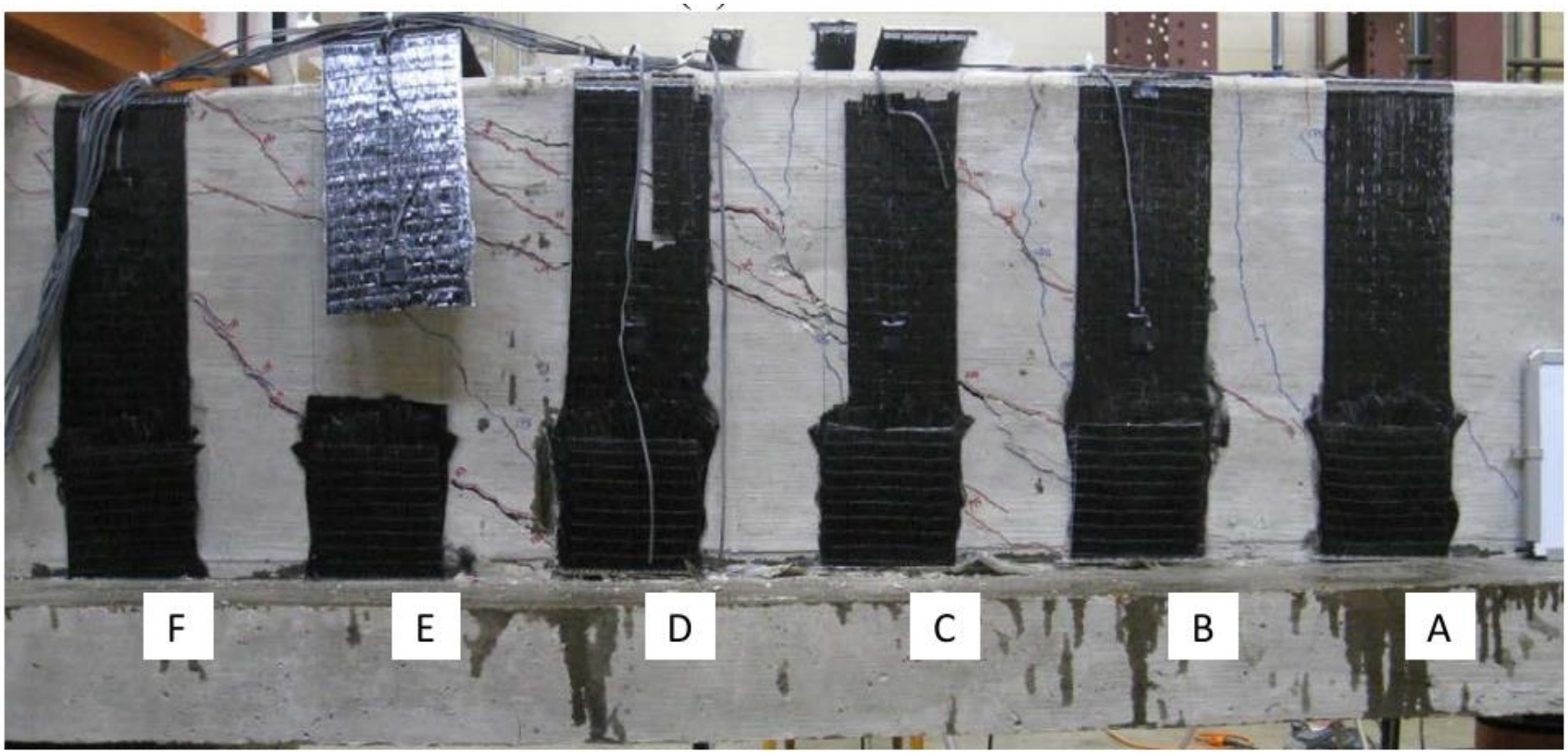
Figure 1.2 Behavior of Rehabilitated Structure after Removal of the Column

Progressive Collapse / Alternate Load Paths

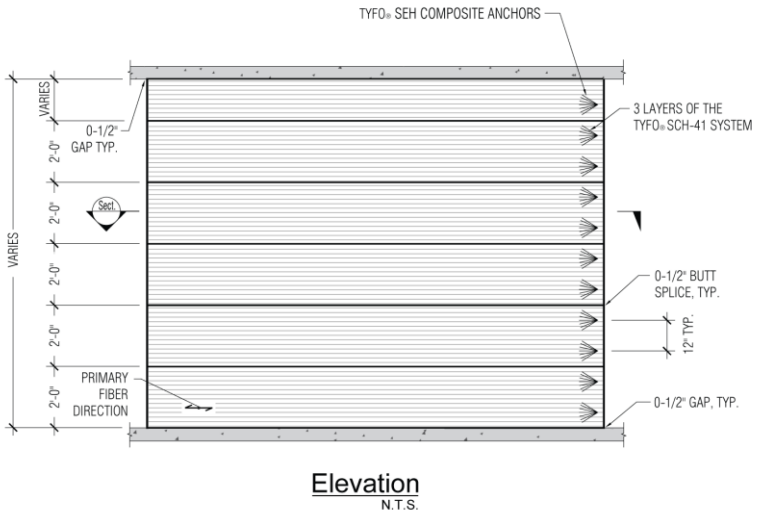


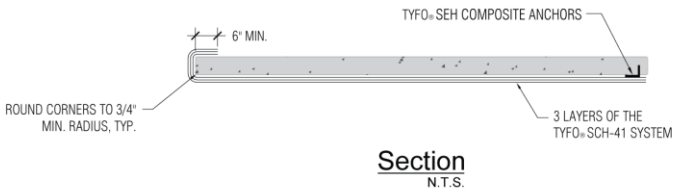

175
150
125
100
75
50
25
0
Applied Shear (kips)
0
0.004
0.008
0.012
0.016
0.02
Shear Strain (in./in.)
24-3-ref
24-3-9
24-3-2
Anchored
Unanchored
Control
3.8k
46.3k
Reduction in deformation
Capacity loss due to the interaction between steel and CFRP

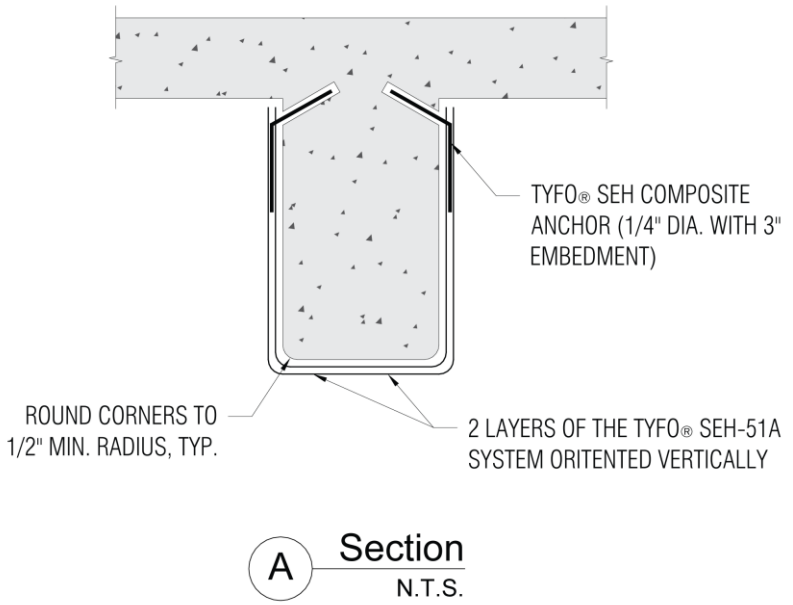
Fiber Reinforced Polymer Anchors Turn Bond Dependent Systems into Bond Independent Systems

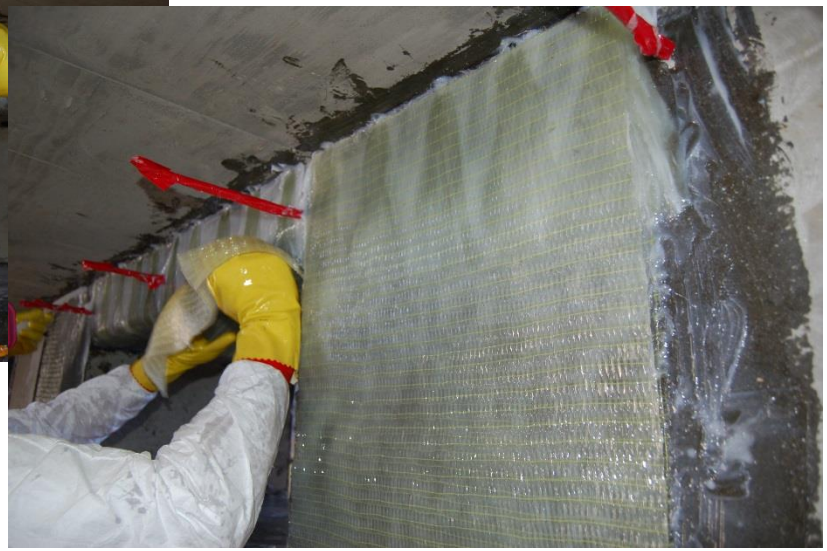


- **Development at Termination Points**
  - Typically detailed with the “standard” SEH Composite Anchors (1/4” diameter with 2” minimum embedment)

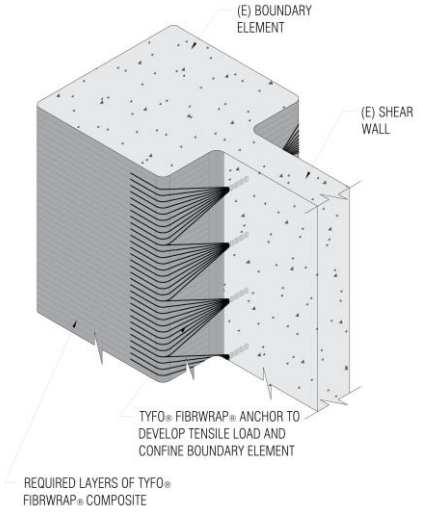


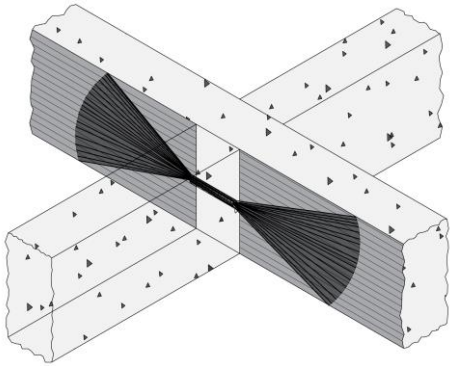


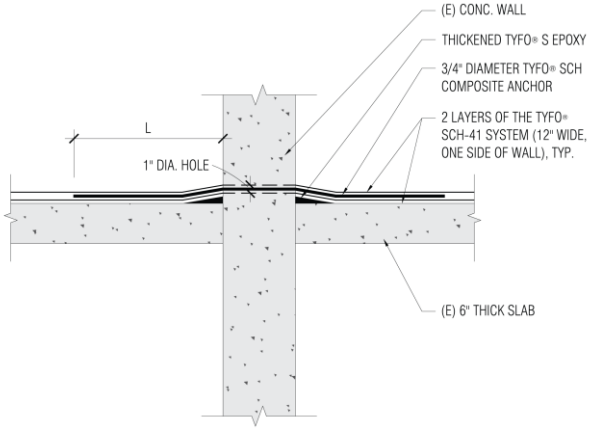




- **Tension Force Development**
  - Fiber Anchor area per unit width shall be equal or greater than the installed Fibrwrap® laminates.
  - Fiber Anchor splay shall be no greater than 60-degrees. Typical details use 45-degree splay.
  - Bonded area shall be sufficient to transfer tensile forces.

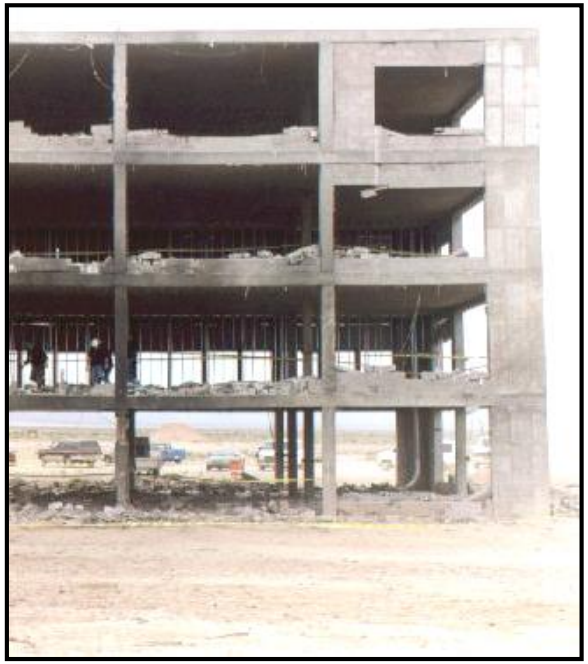






Unreinforced column

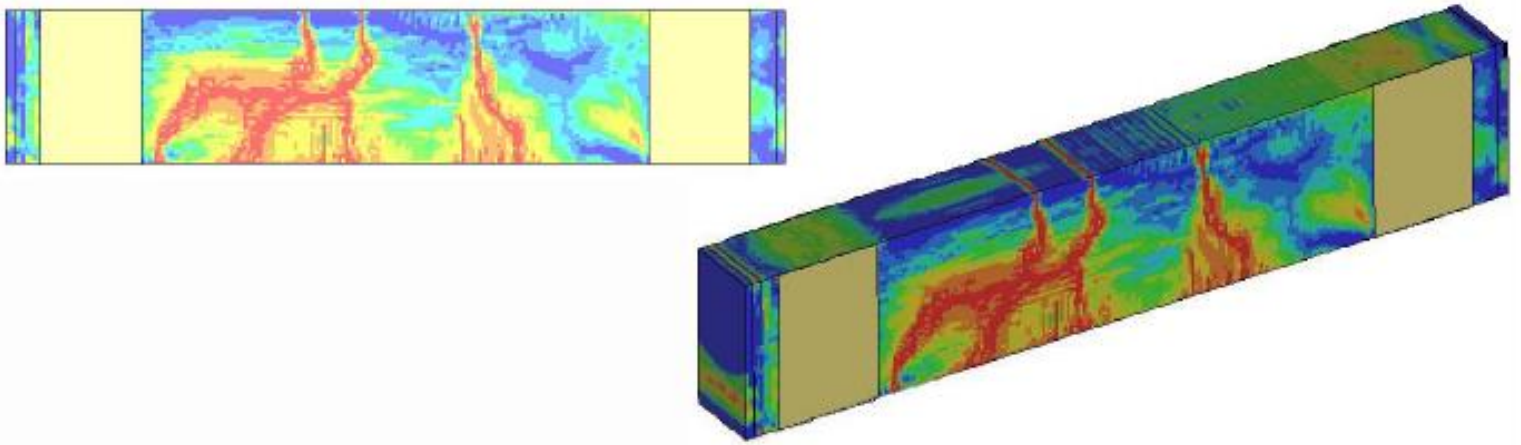
after test blast



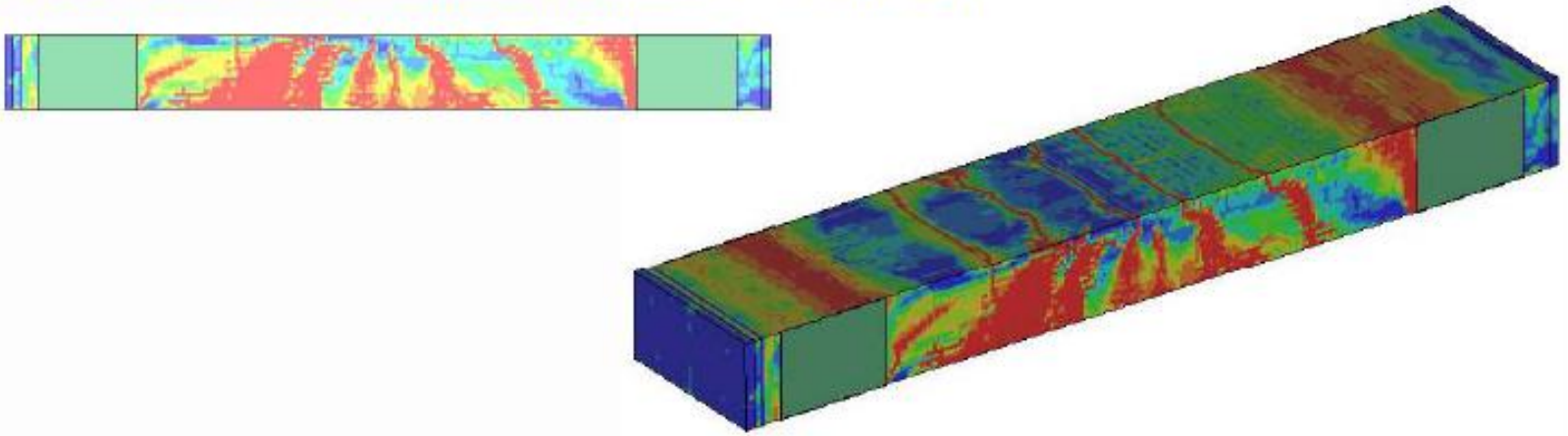
Blast Test Site

Retrofitted column
after test blast

Test 1: Strong-axis orientation, Standoff = 4 ft (A8-2)



Test 2: Weak-axis orientation, Standoff = 4 ft (A7-2)

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Close-In Blast Applications

Tyfo Blast Panel Specimen #2

Specimen #1 & #2 Summary

(a) Specimen 1 (b) Specimen 2

Figure 12. Post-Test Permanent Displacement

Table 3. Test Result Summary

Test Number	Applied Blast Load			Maximum Wall Deflection (inches)	Permanent Wall Deflection (inches)	Maximum Support Rotation (degrees)
	Peak Pressure (psi)	Applied Impulse (psi-ms)	Duration (ms)			
1	12.8	175	57.7	9.1	6.5	7.1
2	12.0	142	52.9	3.5	0.75	2.7

Prefabricated Blast Walls

Thank you!

Questions?

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