

Blast Hardening Retrofit Concepts for Existing Buildings

Marlon Bazan, PhD, PE, SE

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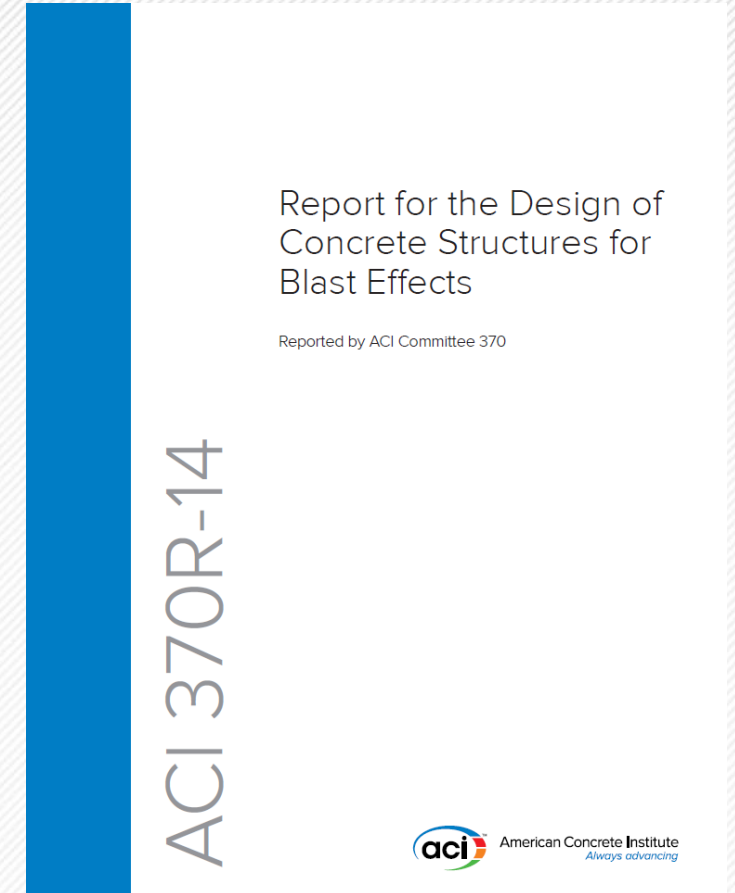
ACI Committee 370, Blast and Impact Load Effects

Overview

- Introduction
- General recommendations
- Examples
- Final Remarks

Introduction

- Chapter 10 – Blast Hardening Retrofit Concepts for Existing Buildings
- Strengthening Existing Components
 - Columns, Floors and Slabs, Beams and Girders, Frames and Shear Walls
 - Other: Precast Panels, CMU Walls
 - Nonstructural
- Employing Additional Components
 - Shield walls and roof, additional structural elements



General Recommendations

- Why do you need to retrofit?
- Understand deficiencies and desired performance
- Consider retrofit options:
 - Performance (does it meet the required performance)
 - Feasibility (constructability)
 - Cost efficiency
- **Evaluate effect of retrofit on other response modes (e.g., shear, connections)**
- **Evaluate effect of retrofit on other elements and system**

Columns

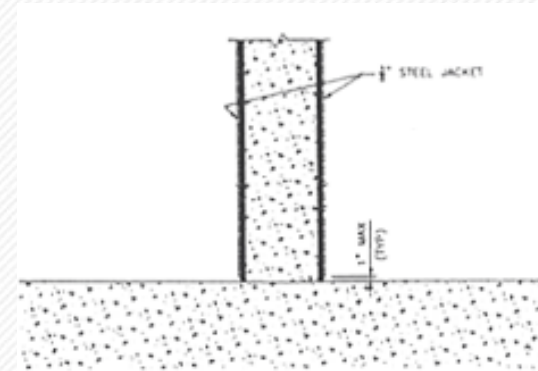
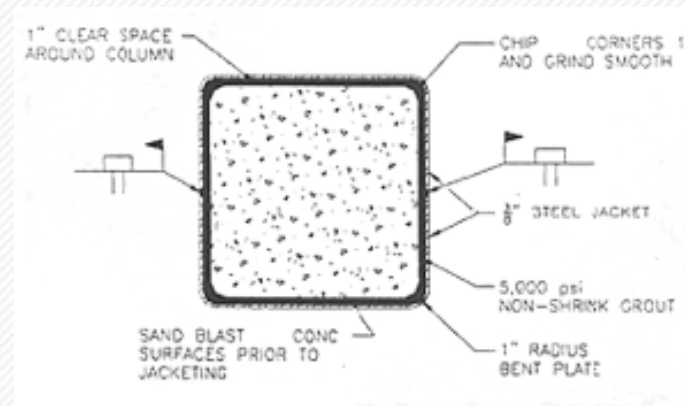
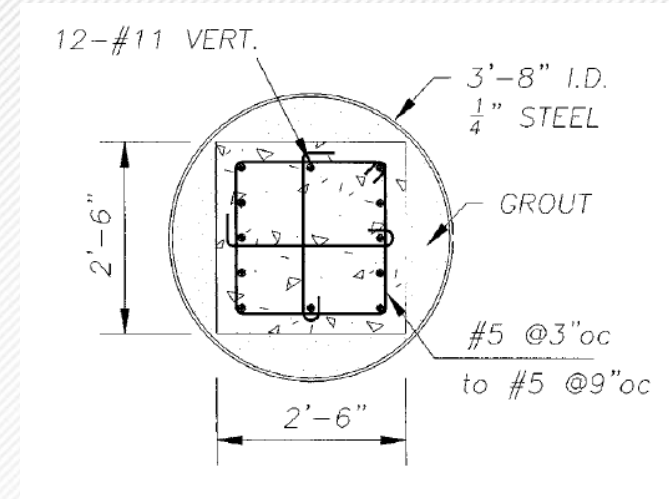
- Typically required for closed-in detonations
- Shear failure, local effects (spalling, scabbing, brisance)
- Possible retrofits:
 - FRP wrapping
 - Rounding of corner for rectangular columns
 - Steel jackets
 - Particularly for near-contact charges



Columns

IMPORTANT CONSIDERATIONS:

- Direct shear failure at supports and steel jacket termination
- Detailing of steel jacket welds
- Effect of modified column stiffness and strength on building system (load redistribution)

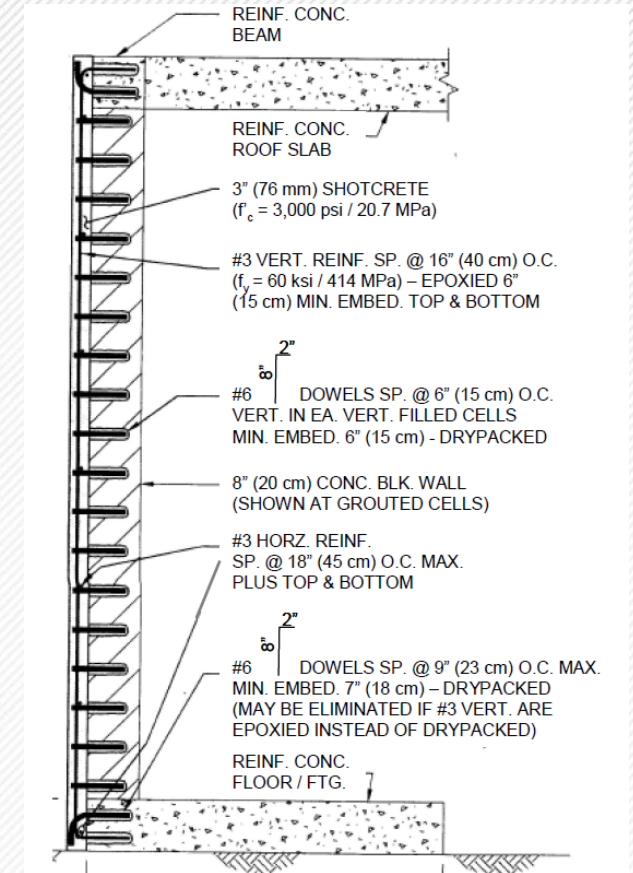
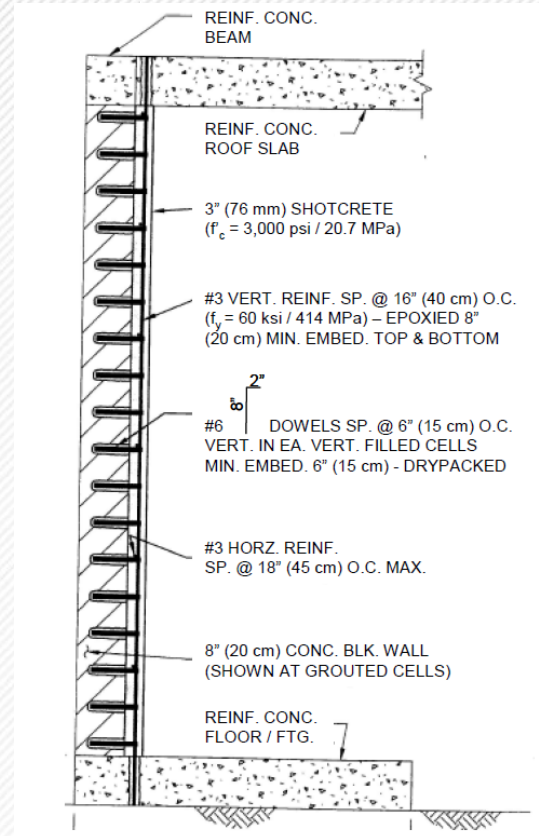
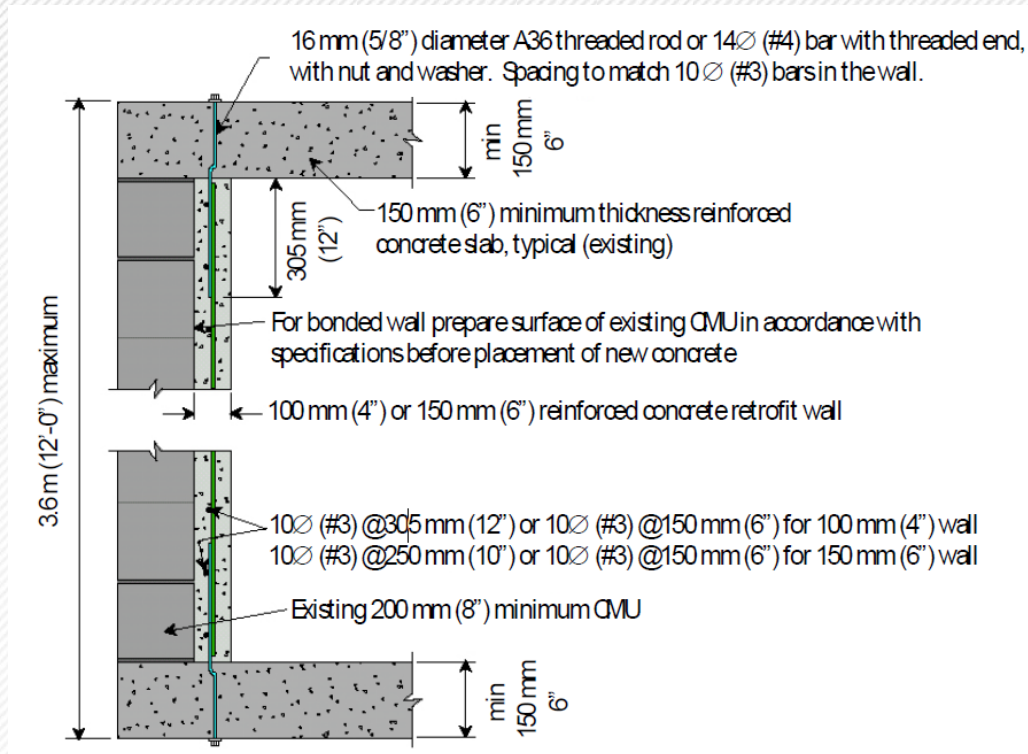


Beams and Slabs

- Possible retrofits:
 - FRP wrapping
 - Steel plates
 - Add concrete and reinforcement
- Typical issues:
 - Increase shear demands
 - FRP or steel plates can be used to increase shear capacity for beams
 - However, difficult to increase shear capacity of existing slab



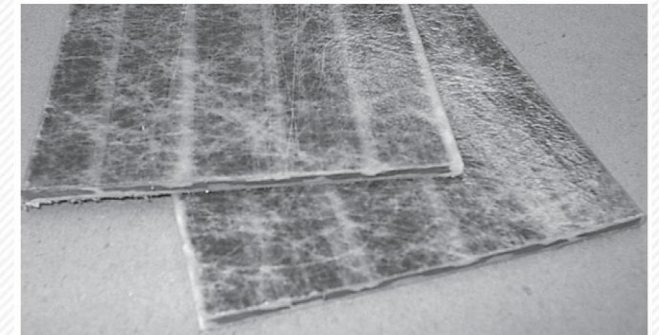
Composite Backing Wall System



Sample details (UFC 4-023-02)

Fiber Reinforced Polymer (FRP)

- Increased flexural strength
 - Can increase shear strength for columns and beams
- However:
 - **Brittle (not ductile)**
 - **May be controlled by shear capacity of element**
- Several published papers
- ACI 370 working on report on blast design of FRP retrofits



Bonded Polymer (for CMU)

- Spray or trowel application
- Lower strength than FRP, but ductile
- It may reduce hazards associated with shear failure
- For non-load bearing URM walls
- **Most analysis and design methods are proprietary**
- **Limited response criteria**
- **Localized strain concentrations**



Bonded Polymer (for CMU)



Multiple-crack formation



Single-crack formation



Shear failure

Steel Straps / Corrugated Metal

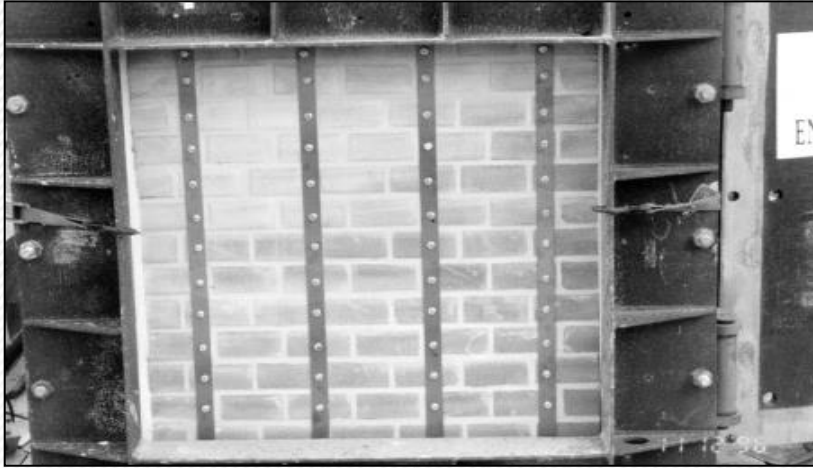


Fig. 10.1.6b—Steel straps with thru-bolts retrofit to CMU panel.

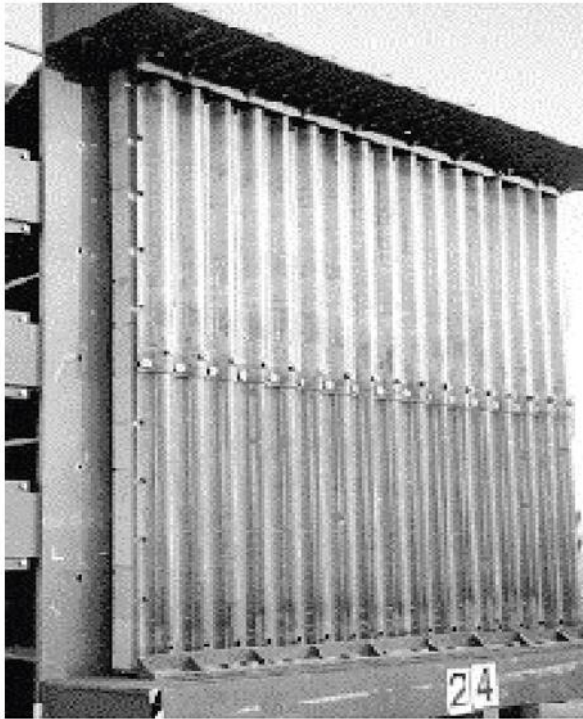
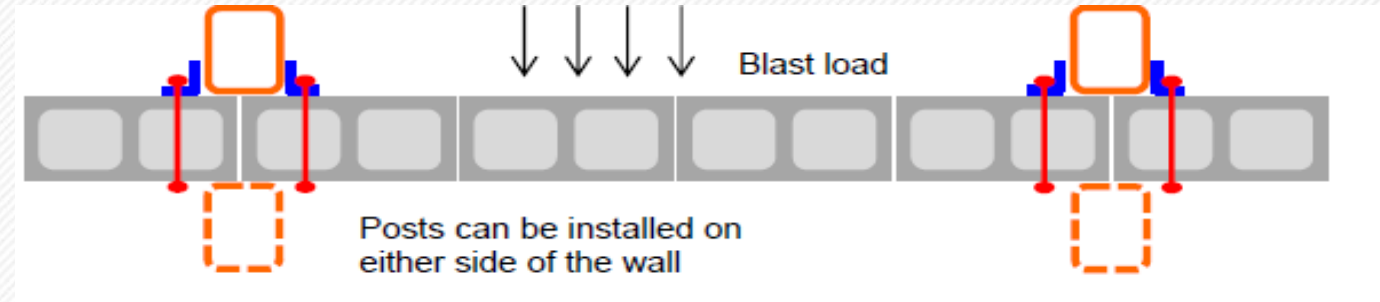


Fig. 10.1.6c—Heavy corrugated steel panel retrofit to CMU panels.



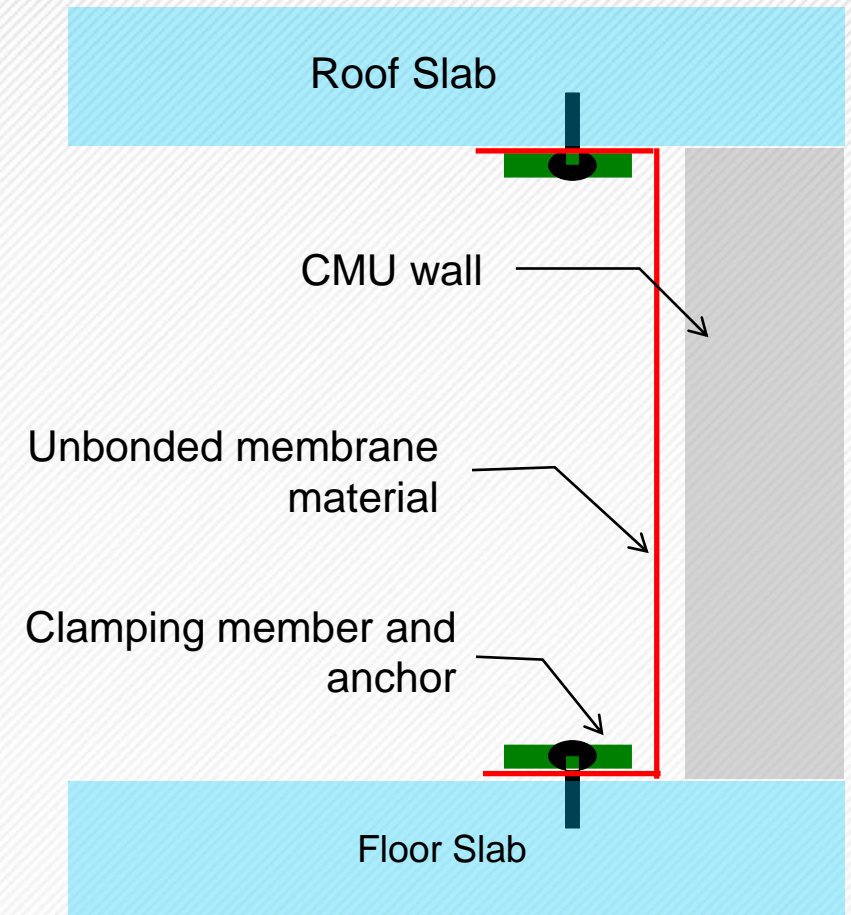
Steel Post (for CMU)



(from ASCE Blast-Resistant Design of Petrochemical Facilities)

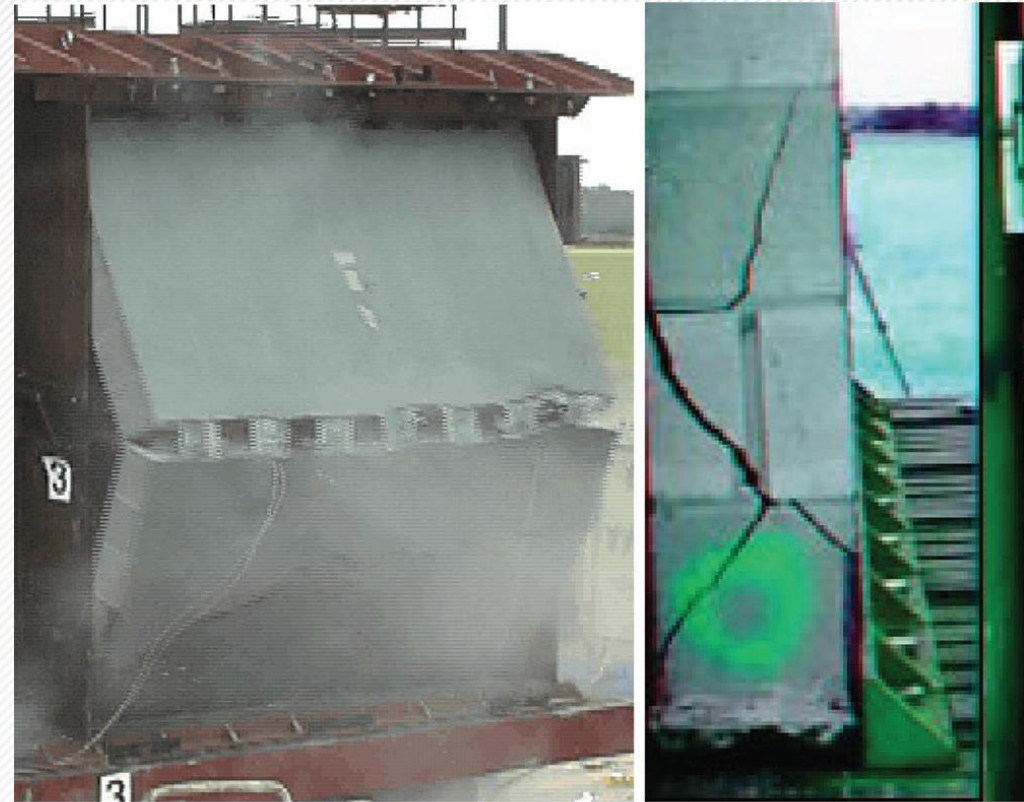
Unbonded Membrane Catch System (UMCS)

- Does not increase strength of wall.
Protects interior space from debris
 - For non-load bearing URM walls (wall allowed to fail)
- Connection must develop tensile strength of material
 - Detailing of connections to avoid tear around clamping plates
- Different materials available
 - Geotextile, steel sheets, polymer



Final Remarks

- Retrofits that increase flexural capacity require evaluation of shear capacity and connections
- Retrofits may result in other unintended failure modes:
 - Load redistribution
 - Effects of additional weight (shotcrete, backing wall, grouting of CMU walls)
- Retrofits must be designed by an experienced structural blast specialist



Questions?

Thank you for your attention

Contact information:

Marlon Bazan

512-380-1988

mbazan@protection-consultants.com