Repair and Retrofit of Earthquake damaged middle school with FRCM: A Case Study

Today’s Presenter

ALEX DADDOW
Senior Composite Strengthening Systems Field Engineer
Simpson Strong-Tie

Gruening Middle School

Summary:

- School in Anchorage suffered major damage during 2018 Alaska Earthquake.
- SEOR – Reid Middleton, Anchorage.
- GC – Cornerstone.
- FRCM Installer – Generation Plastering.
- 36,000 SF of Ribbed Masonry Walls were strengthened with FRCM.

What is FRCM?

Fabric-Reinforced Cementitious Matrix (FRCM) System = Carbon-Fiber Grid + Cementitious Matrix

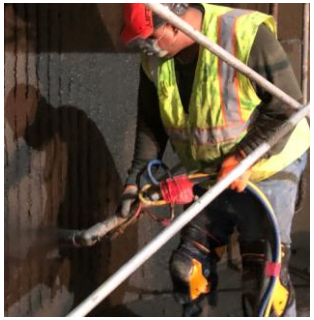
FRCM Benefits and Process

- High tensile strength
- Low impact
- Conform to existing shapes
- Fast installation
- Cost-effective solution

- Substrate compatible
- Heat resistance of matrix
- Provides a protective barrier
- Repairs as it adds strength (minimal surface prep needed)

Prep + SSD

Mix + Pump

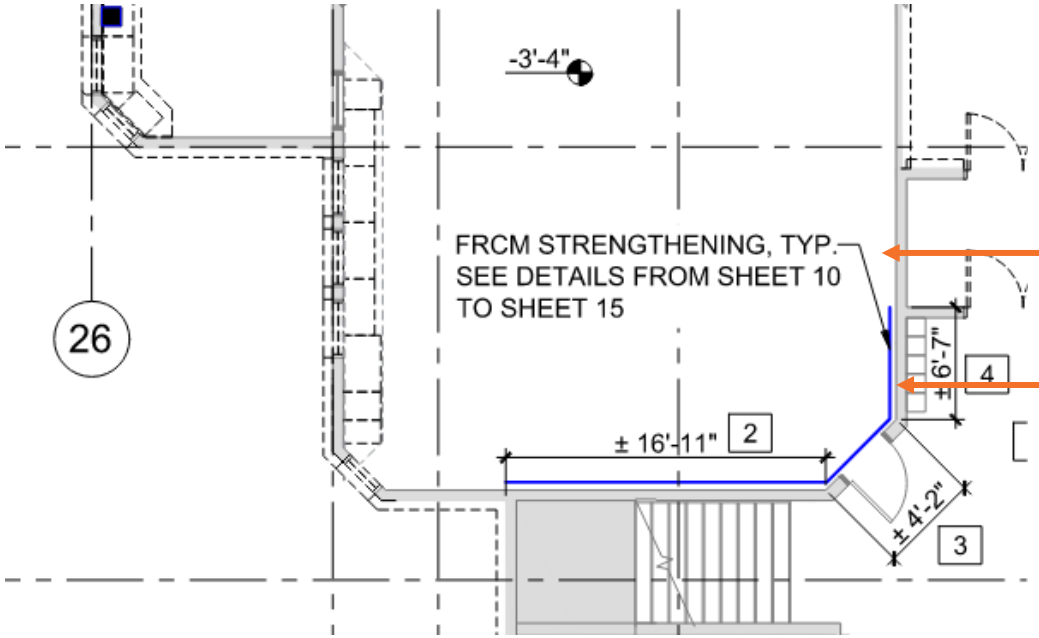


Spray + Grid

Cure, Finish, Anchor

After EQ and After Prep

Most walls needed supplemental reinforcement



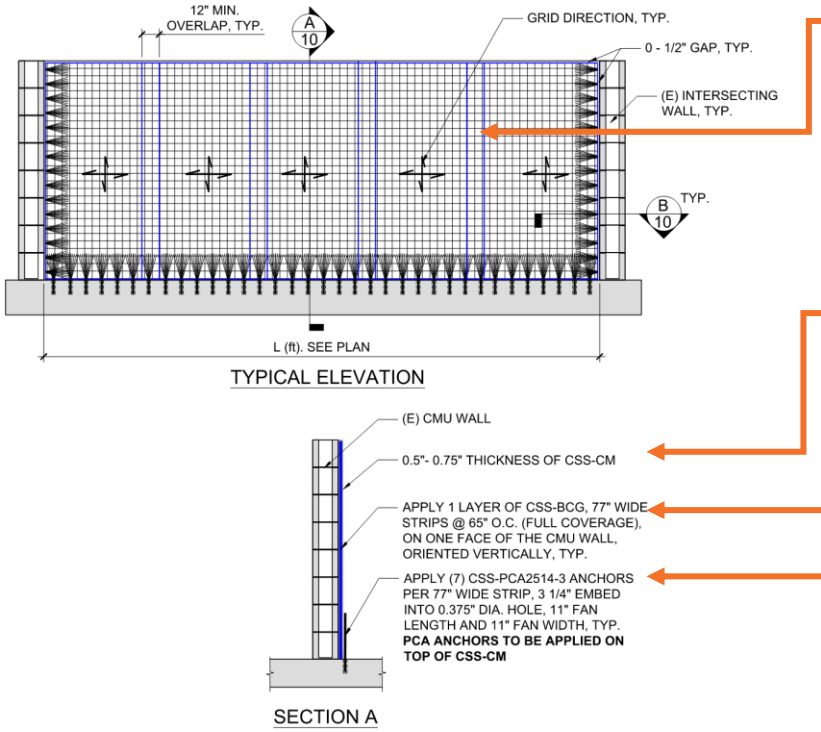
FRCM was Applied to a single face of the wall to approximate the tighter reinforcement spacing required by today's standards.

0.5"-0.75" FRCM application with a single layer of CSS-BCG (Bi-directional carbon grid) + FRP anchors around the perimeter and FRCM anchors between floors for positive connection.

Supplemental reinforcement detailing

CMU SHEAR WALL STRENGTHENING (1/2)

1 FACE OF CMU SHEAR WALL



Coupled with FRP anchors the FRCM gives an additional ~10 k/ft of tensile capacity in both orthogonal directions (vert. + horiz.)

Thickness

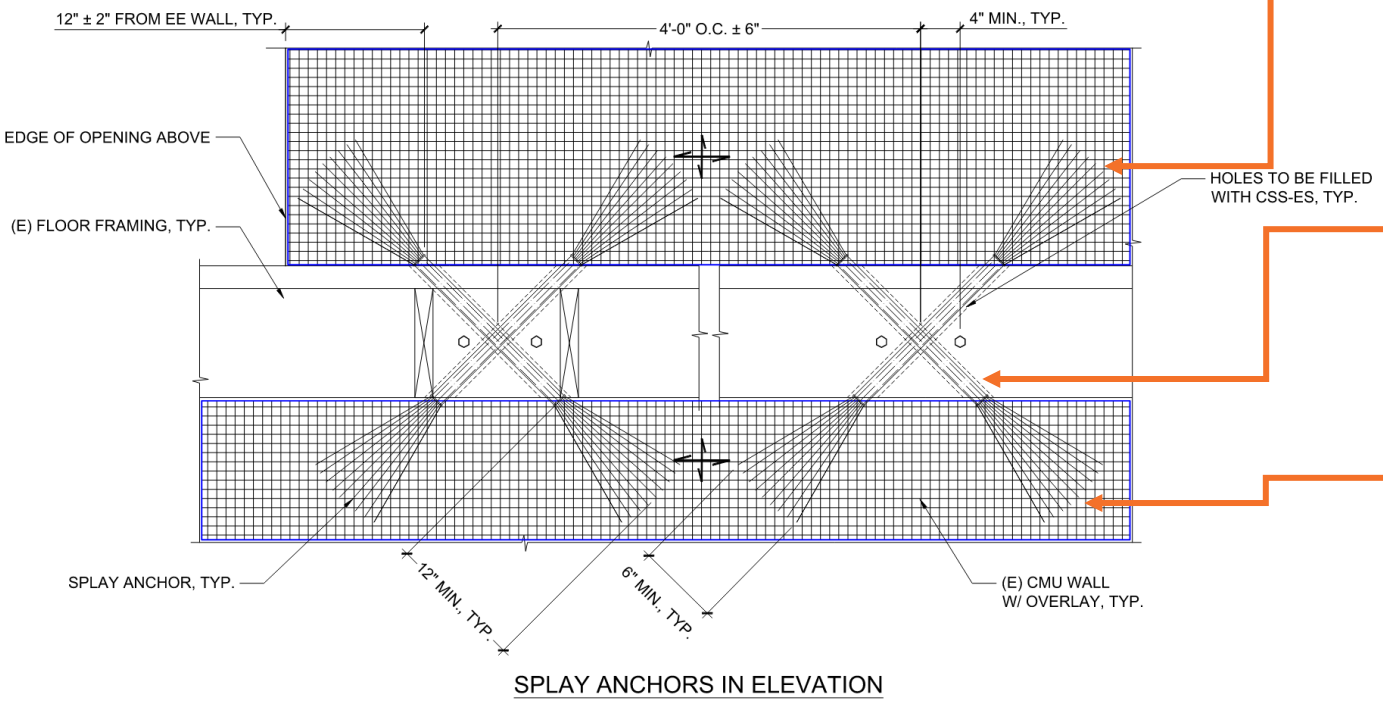
Grid Type

Anchoring Requirements

Supplemental reinforcement detailing – Anchors between floors

OVERLAY AT 2ND FLOOR WALLS

DETAIL FOR WOOD FLOOR FRAMING



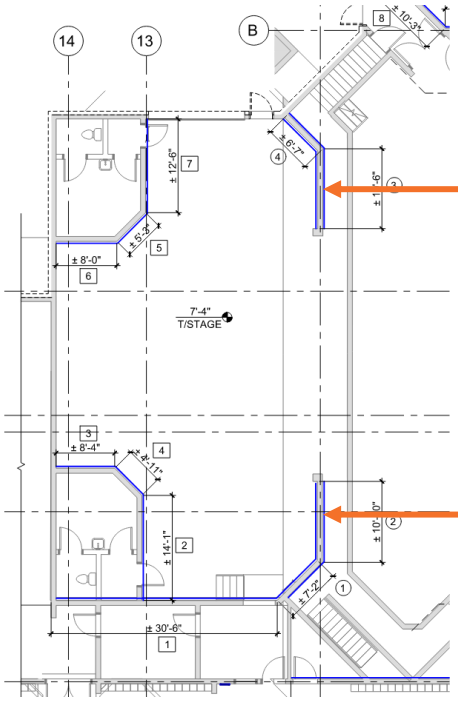
SPLAY ANCHORS IN ELEVATION

Diagonal placement to provide force components in both directions.

Embedded to secure anchors in place and keep fibers straight.

Fibers cut to lap into FRCM abv. and below.

Tall walls needed supplemental reinforcement + strengthening for OOP



The taller walls received FRCM to both faces of wall for OOP strengthening. Note, FRCM provides strength in its primary fiber directions through tension only.

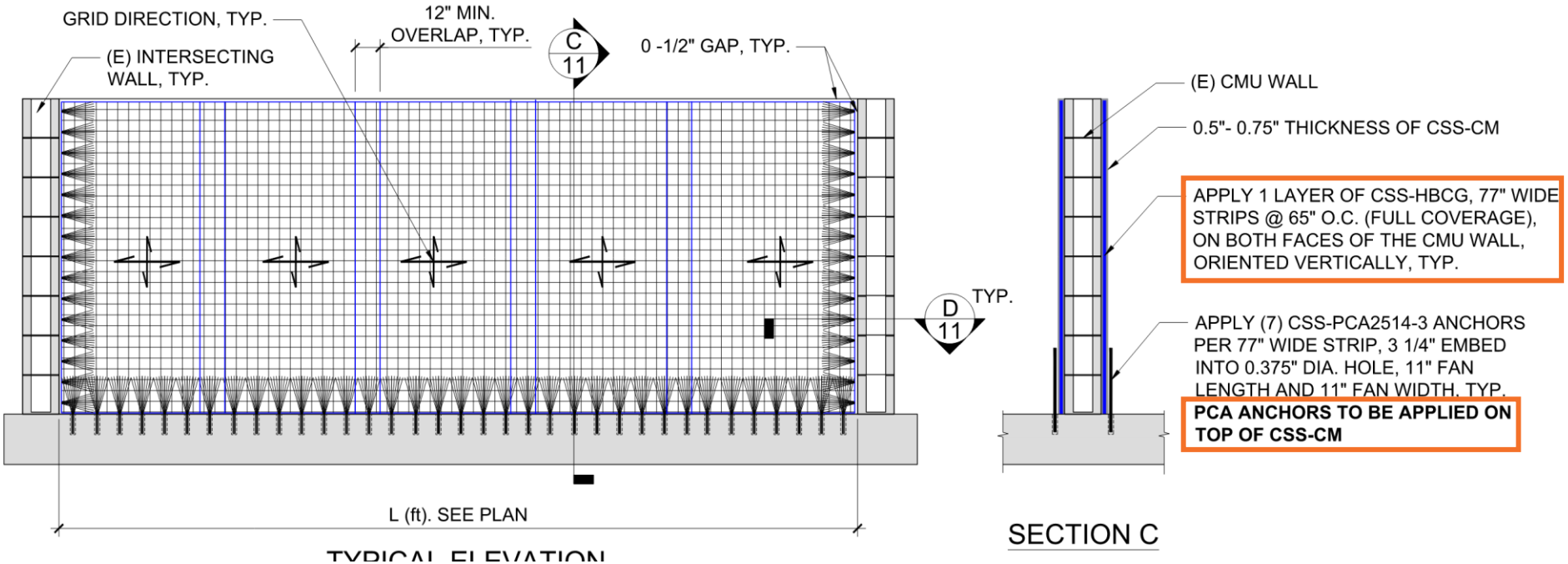
0.5”-0.75” FRCM application with a single layer of CSS-HBCG (Heavy bi-directional carbon grid) + FRP anchors around the perimeter and into the support below.

The existing wall had #5 @ 32” o.c. Verticals and the FRCM brought it up to resist ~2 k-ft/ft of OOP moment at both faces.

OOP strengthening detailing

CMU SHEAR WALL STRENGTHENING (2/2)

BOTH FACES OF CMU SHEAR WALL



Anchoring Installed

Quality Assurance

Field Testing – Adhesion Tests to ensure the system is correctly bonded with failure of the test inside the masonry substrate.

Lab Testing:
+ Compression tests to verify the compressive strength of the CSS-CM component.

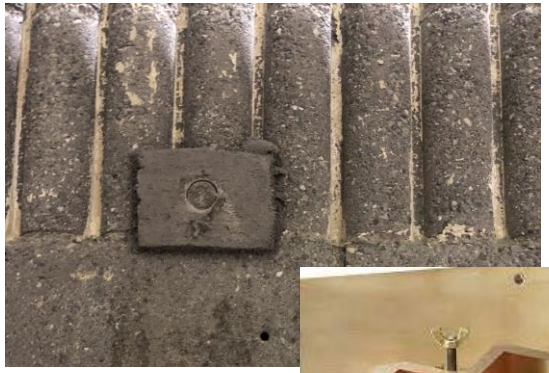
+ Tensile coupon testing to verify the system's modulus and strength meet the specifications.

B. Field Testing
1. Adhesion Tests
   a. Pull-off tests shall be conducted in accordance with ASTM C1583 and performed on flat surfaces. 3 tests shall be executed on each type of substrate or surface preparation method used, with a minimum of 3 tests per 1,000 square feet of surface area covered. A single 2" maximum diameter pull-off test may occur per each 77" wide strip. Before pull-off tests are performed, the composite system shall be allowed to reach full cure.
   b. The mode of failure shall be in the masonry substrate.
   c. Special Inspector shall use cored pull off specimens to determine if cured thickness is equal to or greater than the thickness specified on the approved shop drawings.
   d. Pull-off testing locations shall be repaired with CSS-CM

C. Lab Testing
1. Compression Tests
   a. General
   i. Test matrix in accordance with ASTM C109 as modified by making samples using matrix.
   ii. Obtain samples of mixed wet matrix from nozzle or mixer during construction for testing at 7 and 28 days.
   iii. Provide a minimum of three cube samples per day or 2,000 square feet of repair, whichever is greater.
   iv. Record location where matrix is being applied at time samples are obtained.
   v. Compressive strength results at 28 days shall be in excess of 7,500 psi.
2. Tension Tests
   a. General
   i. Lab tension tests are only required when structural performance criteria is specified (two-sided applications only).
   ii. Tension tests shall be performed to verify the tensile strength and modulus of the composite strengthening system.
   iii. The composite tensile properties used in the design calculations must be lower than the average of the test results unless calculations are performed with the reported average tensile properties show that the strengthening requirements are satisfied.
   b. FRCM System
   i. 18" x 18" panels shall be made not less than twice daily and shall be representative of the FRCM system being installed that day.
   ii. One panel from a minimum of 15% of all sample sets shall be selected for tension testing performed in accordance with AC434 Annex A by an IAS accredited testing lab.
   iii. 5 coupons (16" long x 2" wide) shall be cut from each panel to be tested.

Quality Assurance

Field Testing – Adhesion Tests to ensure the system is correctly bonded with failure of the test inside the masonry substrate.



Lab Testing:
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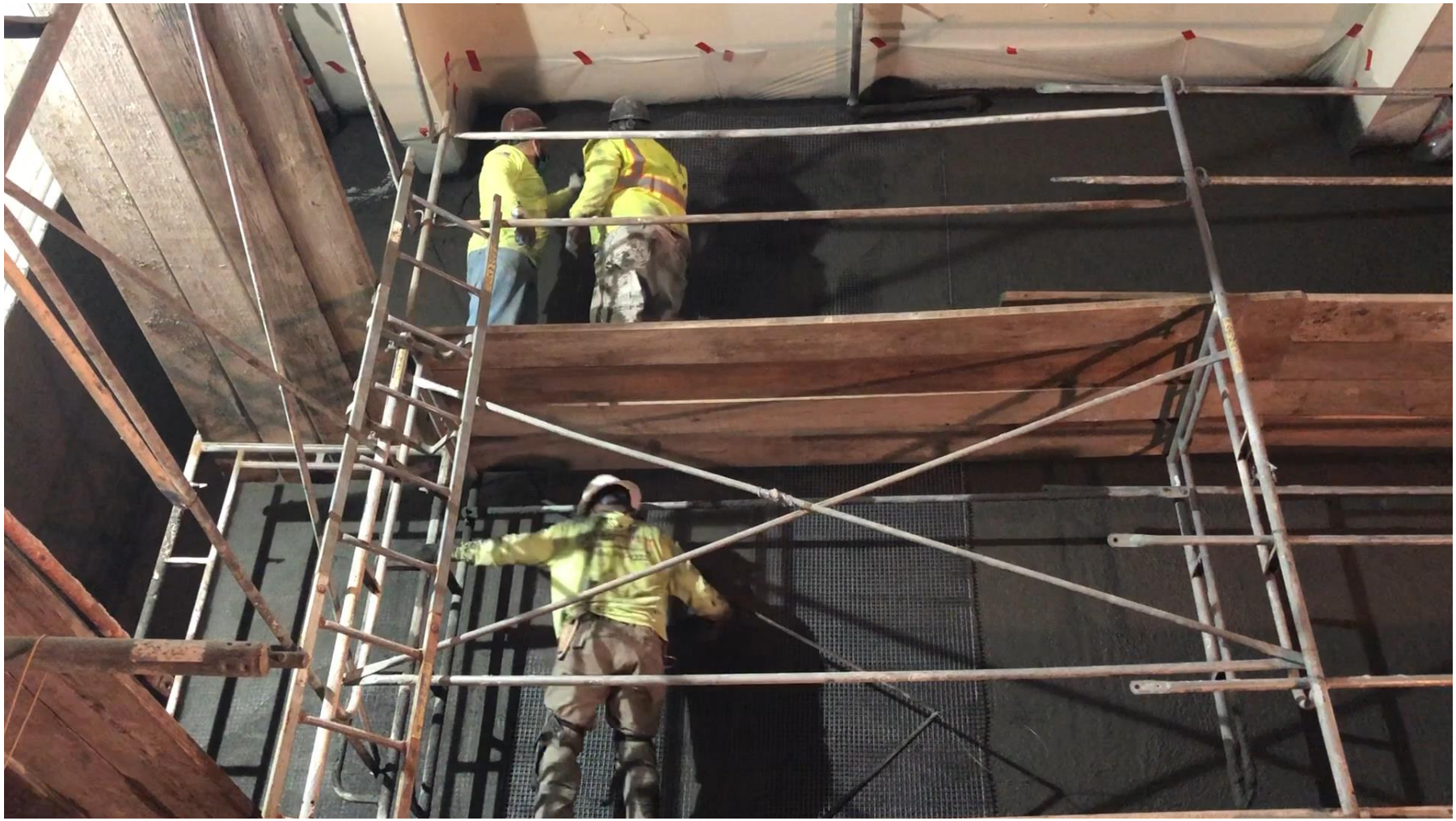
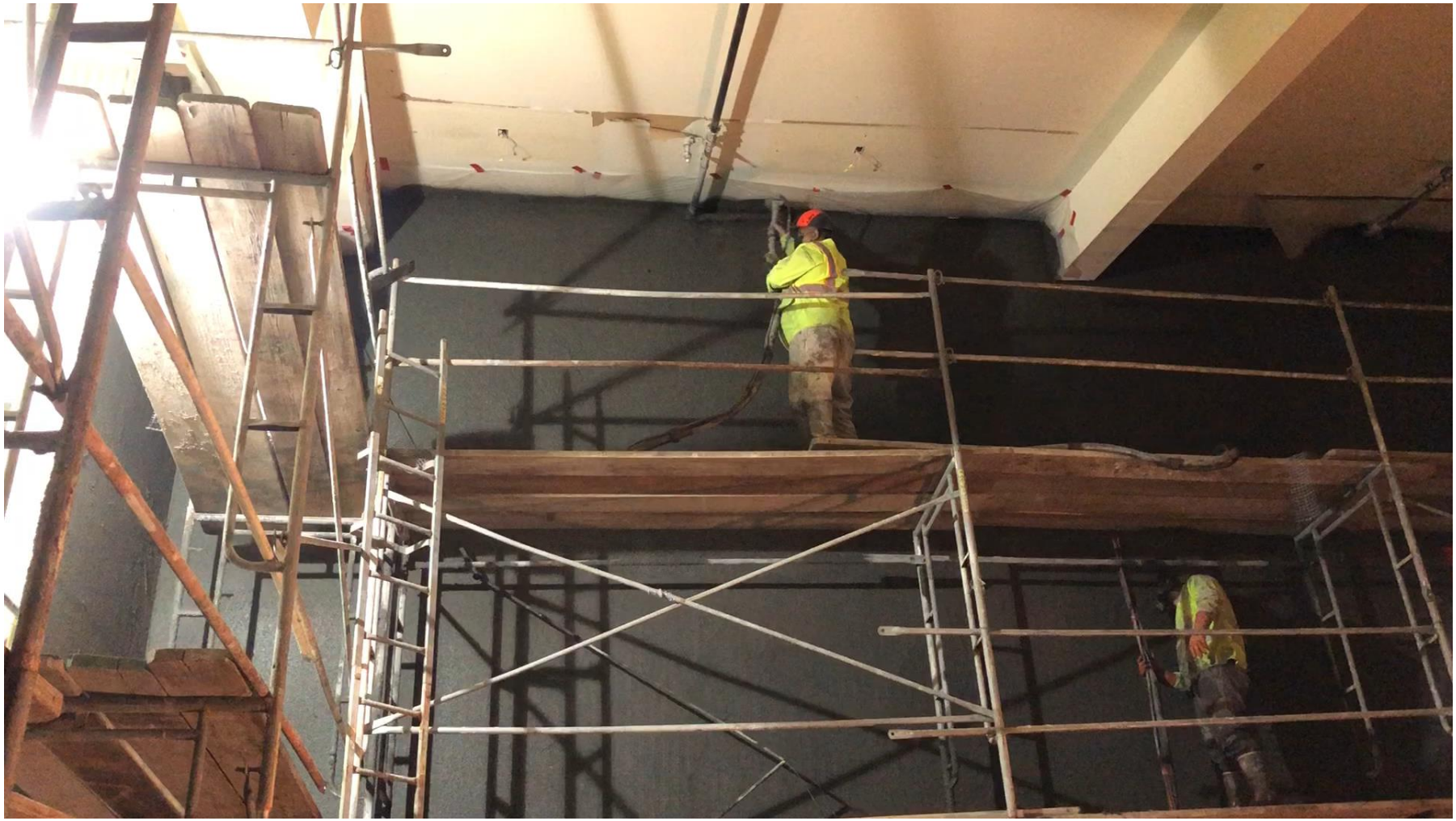
+ Tensile coupon testing to verify the system's modulus and strength meet the specifications.

Installation Video – First Coat

Installation Video – Setting Grid



Installation Video – Final Coat



Complete FRCM Installation

Gruening Middle School - 2021

- Kids returned to Gruening MS in August 2021
- Ribbon cutting ceremony, October 2021

Thank you and Questions!

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MCG EXPLORE DESIGN

CORNERSTONE GENERAL CONTRACTORS

Generation PLASTERING

SIMPSON Strong-Tie®

Alex Daddow, P.E., C.D.T.
Senior Composite Strengthening Systems Field Engineer
adaddow@strongtie.com
714.448.9143