Fiber-reinforced polymer (FRP) solution helps keep college students in class during building retrofit

Exterior view of the tenting required to install the FRP at proper temperatures in winter conditions.

BACKGROUND Forty-five-year-old community college building required a seismic retrofit to its concrete roof diaphragm

Linn-Benton Community College was founded in 1966 to serve the post-secondary educational needs of Linn County and Benton County residents in central Oregon. In 2019, Industrial Arts Building A required diaphragm strengthening as part of a seismic retrofit.

The original 1974 construction of the facility's roof consisted of concrete framing supporting a concrete cast-in-place diaphragm. The retrofit design initially proposed would have entailed demolishing the cast-in-place roof topping slab and pouring a new lightweight reinforced concrete topping slab in its place to help transfer structural loads.

THE CHALLENGE Design a concrete roof retrofit less disruptive to classes in progress than roof slab demolition and a new concrete pour

Complicating the retrofit was the fact that the building housed classrooms in active use at the time. If topping slab demolition were to take place as proposed, the entire affected portion of the facility would need to close during the work, causing classes to close or relocate. Finding an alternative solution that didn't involve concrete demolition might allow classes to continue in place uninterrupted despite the retrofit work above.

Workers installing FRP strips as in-plane shear reinforcement to the concrete roof diaphragm.

PROJECT INFORMATION

Project
Linn-Benton Community College in Albany, Oregon

Project Category
Seismic Retrofit

Project Owner
ZCS (Oregon City, OR)

Application
FRP diaphragm reinforcement; new slab openings with FRP reinforcement; FRP shear transfer at diaphragm joints

Simpson Strong-Tie Products
CSS-UES underwater epoxy saturant; CSS-CUCF11, CUCF22, and CUCF44 code-listed unidirectional carbon fabrics; CSS-ES epoxy primer and saturant; CSS-EP epoxy paste and filler; FX 263 rapid-hardening repair mortar

CHALLENGE

Design an alternative diaphragm retrofit that wouldn't shut down classes.

SOLUTION

Use code-listed Simpson Strong-Tie carbon fabrics for diaphragm reinforcement and shear transfer.

RESULTS

FRP installation completed in less than five weeks with minimal impact to the facility's ongoing operations.

THE SOLUTION Consult Simpson Strong-Tie about an FRP solution for strengthening the existing diaphragm without demolishing and replacing the topping slab

Workers applying a second, perpendicular, layer of in-plane diaphragm reinforcement over the initial layer.

Fortunately, one of the superintendents on the project had some familiarity with fiber-reinforced polymers (FRP) as a repair and strengthening solution for concrete. In October 2019, he decided to give Simpson Strong-Tie a call to see whether an FRP solution could allow the team to forgo the planned demolition and rebuild.

One challenge that an FRP design presented was that the FRP would need to be installed on lightweight (LW) concrete slabs, and FRP applications to LW concrete are not very common. Furthermore, since LW concrete is not directly covered by ACI, substantial slab testing was necessary to ensure the concrete was adequate to an FRP strengthening solution. Simpson Strong-Tie consequently went to the jobsite and performed several bond tests to ensure the soundness of the existing concrete slabs before proceeding with design work.

Favorable bond test results and continual communication between Simpson Strong-Tie and the construction crew resulted in an FRP design, with no slab demolition. The project engineer, ZCS, of Oregon City, approved the new solution.

Another potential challenge the new FRP solution posed was that the contractors responsible for the concrete repair, TGC Structural, had never performed an FRP installation in the past. Therefore, Simpson Strong-Tie field specialists had to train the TGC project team as Simpson FRP installers.

To retrofit the diaphragm, the installers needed to remove the roofing and waterproof membrane, roughen the concrete to be strengthened, apply the FRP, and then reinstall the roofing. In order to keep the FRP above the required minimum temperature for installation — a challenge in Oregon in mid-winter — tenting and heating were required. Plus, the area to be reinforced was so large that the tenting needed to be moved sequentially among five separate segments or "zones" of the building — presenting an additional logistical challenge for the first-time FRP installers.

The strengthening solution consisted of applying FRP strips at 45° angles to each other across the joints between the diaphragm slab and the perimeter beams; applying FRP reinforcement strips along edges of slab penetrations to transfer loads around the openings; and applying FRP strips orthogonally along the length and width of diaphragm surfaces for in-plane shear reinforcement in both directions.

FRP installed around a slab penetration to transfer loads around the opening.

Alternating FRP strips at 45° angles for shear transfer between slab and perimeter beam or wall.

THE RESULTS Retrofit accomplished a month ahead of schedule without closing classes

The FRP installation took place predominantly in January 2020 and was completed by the end of the month. TGC estimates that roughly 16,700 square feet of concrete were covered with multiple layers of FRP in approximately four weeks.

Ryan Dellit of Gerding Builders, the general contractor on the project, estimates the FRP solution shaved a month from the job schedule and was much less intrusive to school business than the concrete demolition-and-replacement solution that had been planned initially.

The project engineer, Kristofer Tonning of ZCS, agreed that, although the FRP solution was largely driven by the general contractor, its use "was critical to the successful completion of the project" within the "major" time and funding constraints the project faced. According to his written statement, "Initially it [FRP reinforcement] was thought to be more expensive, but a significant advantage when it came to schedule. In the end, I believe the costs ended up being an overall savings over conventional construction methods."

It's noteworthy that Simpson Strong-Tie worked with the Engineer of Record to submit signed and sealed (not deferred) design drawings for the FRP. Because a minimally invasive retrofit was required to strengthen an occupied building, involving Simpson early in the process to help test, design, and install an FRP solution resulted in schedule and cost savings. The case illustrates very well the value to a successful project of a cohesive partnership between the building ownership, Engineer of Record, general contractor, and specialty manufacturers such as Simpson.

MORE INFO

For complete information regarding specific products suitable to your unique situation or condition, please visit **strongtie.com/css** or call your local Simpson Strong-Tie RPS Specialist at **(800) 999-5099**.