Repairing and Strengthening

Masonry Walls with FRPs

Fiber reinforced polymers have twice the strength of steel.

Many older masonry buildings require repairs or strengthening to address deterioration that naturally comes with aging or to meet new code requirements such as seismic upgrades or protections against blast loading. While masonry is a strong material in compression, its tensile strength is very low and requires reinforcement with steel. In existing structures, however, adding new reinforcing steel is usually very costly and requires drilling through the masonry, anchoring the reinforcement, and filling the voids with grout.

Fiber reinforced polymer (FRP) products are very strong in tension and can be bonded to the exterior surface of masonry. These materials have been used in other industries such as aerospace and ship-building, for decades, but their application in civil engineering began in the mid-1990s.

In the field, rolls of fabric constructed with carbon or glass fibers are saturated with a special epoxy resin and then bonded to exterior surface of the wall (much like wallpaper). The material cures quickly and reaches strengths twice that of steel in 24 hours. The design of the fabric can be customized, such as including fibers running in both directions that would simulate horizontal and vertical steel reinforcement in conventional wall construction.

Numerous test conducted at the University of Arizona through research funded by the National Science Foundation have demonstrated the effectiveness of this system for the retrofit of existing structures. Once applied, FRP can be painted or coated with stucco.

The resins are non-toxic and odorless, making the system ideal for work in occupied buildings. FRP also serves as a waterproofing membrane, and a variation of this system is being used in the mining industry for lining of tanks that contain acids.

The fabrics are flexible and conform to the geometry of the substrate wall during installation. This feature facilities the construction significantly because it eliminates the need to manufacture any sections offsite.

FRP at Work

There have been numerous applications of this technology worldwide. One recent project involved the retrofit of the historic Fox Tucson Theatre, Tucson, Arizona.

Originally built in 1930 in the heart of downtown at a cost of $300,000, the theatre provided city residents with live entertainment and movies for over 40 years before closing in 1974. The building began to fall into disrepair while sitting idle all those years.

By the time the Fox Tucson Theatre Foundation purchased the building in 1999, it would require an ambitious $12 million restoration and rehabilitation effort. A major portion of this project was for strengthening old structural elements.

Cost and time constraints of conventional methods for reinforcing cast-in-place concrete and unreinforced masonry were too high. By incorporation creative designs using FRP, many structural elements, such as unreinforced brick parapets, decaying columns and beams, and fly loft walls, were strengthened. In addition to efficiency of construction, the thin FRP elements (typically less than 1/8-in thick) could be easily hidden, allowing preservation of the historic character of the building.

The speed and low construction cost led the contractor to replace a few of the other conventional retrofit schemes with those utilizing FRP. For example, the entrance lobby slab was waterproofed and strengthened with a single application of FRP from the top. This step replaced two separate procedures, one for waterproofing the slab and another for supporting the slab from below.

The project was a great success, as evident from the project manager's comment about the FRP, which was supplied by QuakeWrap, Tucson. "The structural engineering team made every effort to ensure that design solutions met the objectives of preserving an historic structure for the use and enjoyment for generations to come, as well as achieving all structural work as cost and time efficiently as possible," he said.

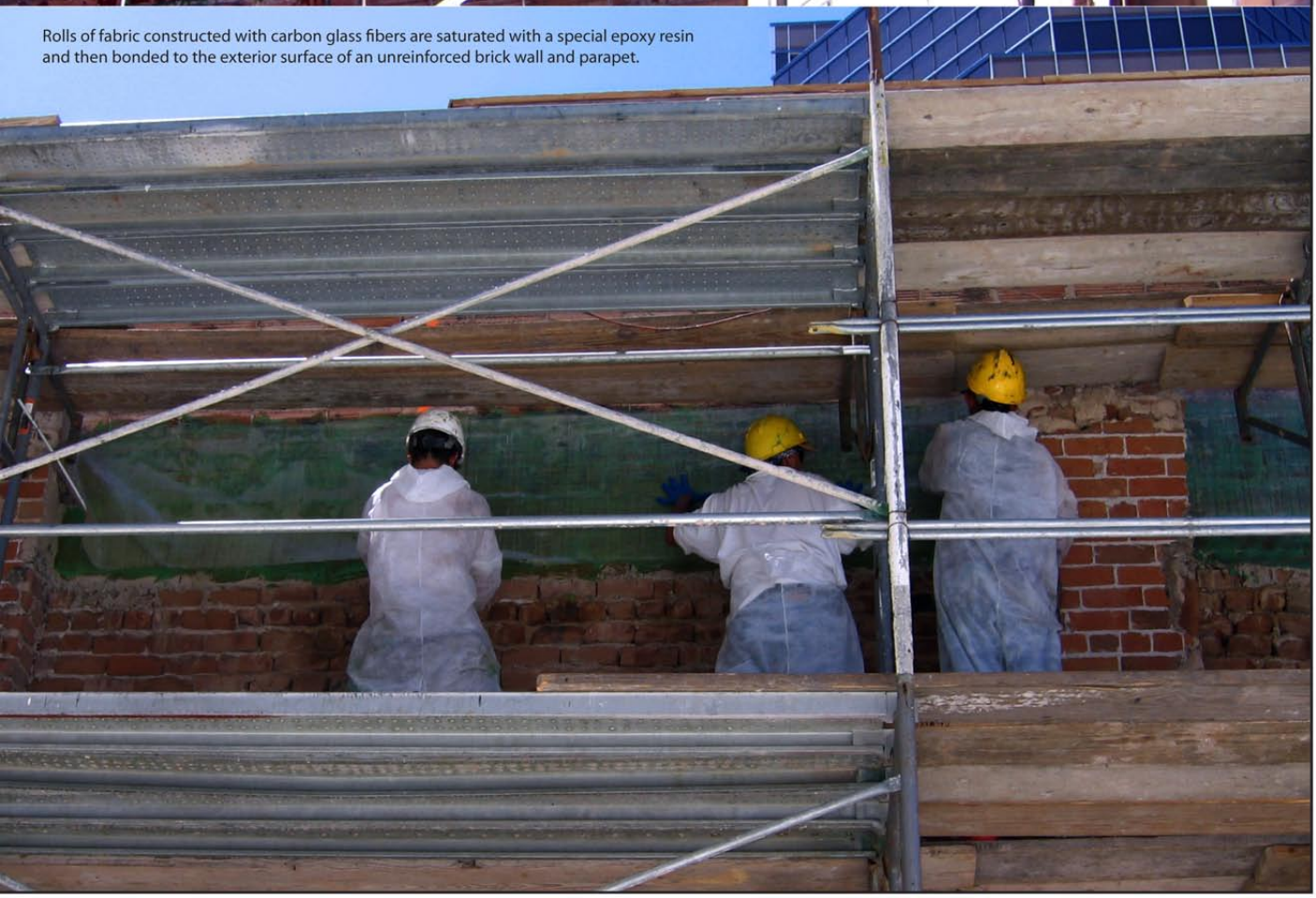
QuakeWrap's innovative FRP strengthening approaches were the opening piece on an episode of Back to the Blueprint show dealing wit the retrofit of the Fox Theatre, which aired on the History Channel. The video clip showing how FRPs are applied to a masonry wall can be viewed and downloaded at www.QuakeWrap.com.

The project received the 2006 Award of Excellence from the Structural Engineers Association of Arizona.

Mo Ehsani, president, QuakeWrap Inc., and professor of civil engineering, University of Arizona, has focused his research efforts on the seismic behavior of structures and innovative approaches to the repair and retrofit of civil structures with fiber composite materials. Dr. Ehsani has been featured on major media such as CNN, National Public Radio, and the History Channel for this expertise on the strengthening of structures, particularly related to earthquakes, terrorist attacks, and other potential structural disasters.

BY MO EHSANI, PH.D., P.E.

Workers are applying FRP to strengthen a hollow-clay wall.



Rolls of fabric constructed with carbon glass fibers are saturated with a special epoxy resin and then bonded to the exterior surface of an unreinforced brick wall and parapet.