RESEARCH

Research Notes

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A Better Way to Strengthen Bridges

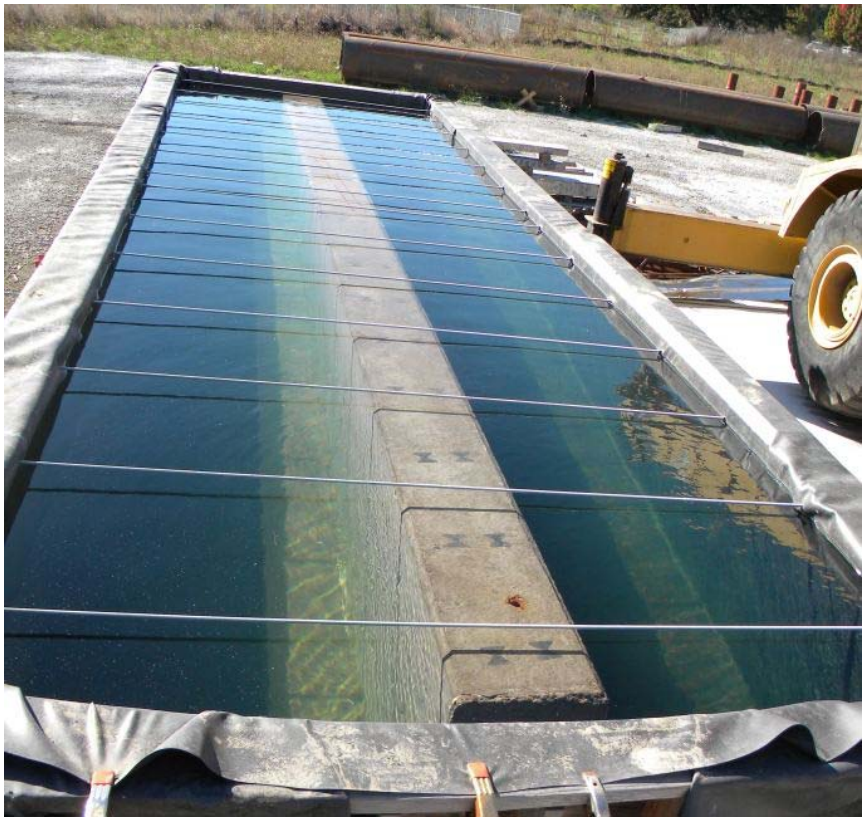
The Oregon Department of Transportation will strengthen bridges that have deficient load capacity if it makes economic sense to do so. A number of methods have been deployed for strengthening including internal and external supplemental steel reinforcement, surface-bonded carbon fiber reinforced polymers (CFRP), and post-tensioning. Surface-bonded CFRP, in which strips of flexible carbon fiber composite material are adhered to the concrete surface, has been the method of choice for most strengthening situations.

A new strengthening system called near-surface-mount carbon fiber reinforced polymers (NSM-CFRP) has emerged that has advantages over conventional CFRP. The technology involves cutting a groove in the surface concrete, filling the groove with an epoxy adhesive, and positioning CFRP material (often a carbon fiber tape or precured laminates) in the groove. The installation requires substantially less labor and uses significantly less adhesive materials than alternative CFRP methods. Initial evidence showed NSM application of CFRP may have advantages over more common surface-bonded CFRPs because the adhesive is applied within the groove, which improves bonding between the two materials. Also, moisture cannot get trapped behind the material and lead to progressive strength loss from freeze-thaw exposure. However, there was little available data that showed how NSM-CFRP would perform in strengthening concrete bridge elements especially whether the material could maintain adequate strength and environmental durability over time.

ODOT contracted with Oregon State University to investigate NSM-CFRP. The researchers used ten large-size concrete beams to evaluate the shear strengthening effect of the material and its long-term performance under environmental and fatigue exposure. Beams designated for fatigue testing were loaded and unloaded 2.4 million times to simulate 50 years of service. For environmental testing, one fatigue beam was exposed to 400 cycles of freeze-thaw. Another beam was exposed to six months of water immersion. To measure the capacity, the strengthened beams were incrementally loaded to failure while instruments recorded the deformation at various locations in the beams. Tests were also performed on small specimens to determine the bond strength of the NSM-CFRP to concrete.

Cutting grooves for installing NSM-CFRP

The research produced design, detailing, and installation quality assurance recommendations for ODOT engineers to employ NSM-CFRP for shear strengthening. The outcome provided ODOT with another choice to economically keep existing bridges in full service and performing safely.



Strengthened beam undergoing moisture exposure.

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