FYFE®

PROJECT PROFILE: PENSTOCK REHABILITATION TYFO® SYSTEM

PENSTOCK REHABILITATION USING CFRP

Ontario, Canada

OVERVIEW

In 2012, power output dropped at Mississippi River Power Corp.'s 4.6-MW Brian J. Gallagher Generating Station, on the Mississippi River in Ontario, Canada. The turbine was taken offline inspected and found to be in good condition. Mississippi River Power then examined the 106-inch diameter penstock to discover it was partially blocked. The horizontal steel plate lining the penstock had delaminated in the rectangular transition section, causing the steel liner to buckle and deform throughout the concrete-encased pipe.

Full-out replacement and welding a series of internal steel patch plates onto the concrete encasement with a grouted annulus were considered alternatives for a solution and both ruled out due to a number of reasons including safety and cost concerns.
A carbon fiber-reinforced polymer (CFRP) solution, manufactured by Fyfe, Co., was chosen as alternative solution to provide a fully-structural rehabilitation solution.

Designed according to requirements from the American Water Works Association (AWWA), the CFRP liner resists the effects of the internal positive pressure, internal negative pressure, external groundwater pressure and temperature changes without relying on any strength contribution from the encasement. When designing for the top and bottom portions of the transition piece, SGH designed the Tyfo® vsystem to act compositely with the reinforced concrete section as a one-way slab to resist the combined effects of groundwater pressure and internal negative pressure in flexure. The general requirements of the American Concrete Institute's 440.2R-08 guide were followed for flexural strengthening with additional limit states investigated, such as CFRP debonding, steel reinforcement yielding and concrete crushing.

Interior of pipe with CFRP liner

Exterior view of pipes

CFRP liner applied

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REHABILITATING A BUCKLED PENSTOCK USING CFRP

Many of the hydroelectric generating stations across North America are 50-100 years old. As a consequence they are approaching or have exceeded their design life. One of the most significant assets in these generating stations are penstocks. Unlike most other generating station assets, these pipelines are comparatively inaccessible and difficult to replace. Owners are thus faced with the choice to replace, rehabilitate or run to failure.

COMPLETING THE WORK

Once Mississippi River Power approved the design, installation of the FRP was completed by Fyfe Company's certified FRP applicator, Fibrwrap Construction. Prior to the FRP application, Fibrwrap Construction hydroblasted all concrete surfaces receiving FRP to achieve the minimum ICRI concrete surface profile (CSP) level 3, defined as a uniform exposure of the core's coarse aggregate such that the surface will be void of latent materials. The materials were then applied with an epoxy using the wet layup method. These materials included Tyfo® SEH 51A (GFRP) over all exposed steel surfaces and Tyfo® SCH 41-2X (CFRP) in all other areas.

CHALLENGES

The project faced a variety of challenges during the project including leaks and water infiltration. Eliminating these leaks was critical to the success of this project, so leaks were repaired prior to installation, and water infiltration addressed throughout the course of installation.

Once the fiber cured for 24 hours, direct pull-off tests were performed and passed the manufacturer-recommended 200 psi tension value depicted in the specifications and drawings.

To verify that the design values of the CFRP installed in the field were above the design values, special panels were created and tested at a third party testing facility. The tensile test results demonstrated that the CFRP materials used for these repairs exceed the design values published by Fyfe Company and the values used in the third party SGH design calculations.

Applying FRP to hydroblasted concrete

Leak repair

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