

WATER SYSTEMS CATEGORY

Gold Bar Influent Channel No. 2 Repair and Long-Term Protection

EDMONTON, ALBERTA, CANADA
SUBMITTED BY READ JONES CHRISTOFFERSEN LTD.

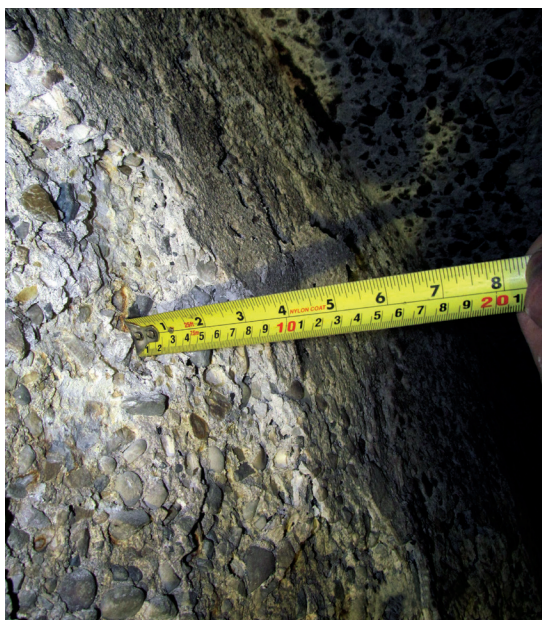


Fig. 1: Extensive depth of concrete deterioration on channel walls



Fig. 2: Column and ceiling deterioration

The Gold Bar Influent Channel No. 2, constructed in 1979, consists of a reinforced concrete rectangular tunnel that transports raw wastewater influent to the wastewater treatment plant’s screen and pre-treatment areas. The tunnel is in excess of 295 ft (90 m) long, with interior width varying from approximately 7 to 10 ft (2.1 to 3 m), and interior height varying from approximately 6.5 to 10.75 ft (2 to 3.3 m). The channel structure is entirely below grade, with 12 in (305 mm) side walls, a 15 in (381 mm) floor slab foundation, and a roof slab. Some portions where the channel roof structure also forms the main floor of a process building include 12 in (305 mm) wide reinforced concrete beams. Channel construction includes several expansion joints along the length of the buried concrete structure, a fiberglass-lined venture flume that aids in the measurement of wastewater flow rates, an isolation gate, and several roof access hatches.

UNIQUE CAUSES OF DETERIORATION IN WASTEWATER TREATMENT PLANTS

The repair and protection of concrete infrastructure in wastewater environments poses unique challenges to common restoration techniques and protection measures. Raw influent in wastewater treatment plants (WWTP) produces high concentrations of hazardous and corrosive gasses and acids that deteriorate concrete materials and metal components.

Concrete influent channels are often exposed to the harshest corrosive environments within the WWTP. These channels transport raw wastewater from the WWTP to grit tanks, screen chambers, and initial pre-treatment areas. Raw and partially treated wastewater contains high concentrations of hydrogen sulfide (H₂S) gas, which forms sulfuric acid in the presence of moisture, oxygen, and bacteria. Sulfuric acid attacks concrete by exposing the concrete matrix and underlying aggregate, and

eventually the embedded reinforcing steel. Typically, the concrete deterioration due to H_2S gas and sulfuric acid exposure is observed to be most severe within the enclosed portions of WWTP structures. The rates of concrete deterioration and microbial corrosion vary depending on the concentrations of sulfides in the wastewater, the flow rate and the level of turbulence, and the subsequent rate of H_2S release.

INSPECTION RESULTS

In 2014, an interior inspection of the tunnel identified significant concrete deterioration and erosion. The inspection identified between 1.25 and 3 in (32 to 76 mm) of deteriorated and unsound concrete on interior surfaces of the channel walls, columns and roof members (Fig. 1 and 2). Significant erosion and loss of concrete wall thickness, often to the depth of the reinforcing steel, was noted. The concrete cover on the underside of the roof slabs had deteriorated exposing the lower mat of reinforcing steel. Beam stirrups and bottom layer reinforcement steel were exposed and heavily corroded, with loss of cross-sectional area.

Original construction details showed approximately 1.5 to 2 in (38 to 51 mm) of concrete cover over the embedded steel reinforcing steel. The severe extent of concrete cover loss, the resulting reduction in concrete member thickness, and the loss of reinforcing steel cross-sectional area were considered of structural concern, indicating a significant reduction in load-carrying capacity.

The inspection also revealed that expansion joint seals were missing or damaged and no longer effective, and that metal gratings and handrails were severely corroded above the wastewater flow level.

REPAIR SYSTEM SELECTION AND EXECUTION

A repair protection program was planned and designed to restore the load-carrying capacities; to provide increased load-carrying capacity in localized areas for current loading and usage requirements; to incorporate enhancements that improve the overall structural durability and minimize the vulnerability of smaller-dimension structural members to sulfuric acid and cross-sectional loss; and to incorporate a protective coating or liner assembly that provides long-term protection for the concrete channel structure against H_2S and sulfuric acid exposure.

The structural restoration and protection program undertaken included the following measures:

- Removal of deteriorated and unsound concrete, and cleaning and preparation of substrate surfaces in preparation for the repair assembly;
- Installation of a cast-in-place, bonded, reinforced concrete overlay to the channel's interior roof and wall surfaces;
- Casting a proprietary high density polyethylene protective liner assembly into the surface of the concrete overlays, providing a significantly longer service life than that of typical surface applied coatings when exposed to H_2S and acid attack while providing improved wastewater influent flow rates;



Fig. 3: Reinforcing installation within channel



Fig. 4: Overlay reinforcement at overflow weir



Fig. 5: Wall liner, reinforcement, and formwork

- Providing a highly durable, sulfate resistant, self-consolidating concrete mix to provide a low shrinkage, low permeability concrete overlay construction; and
- Replacement of expansion joints with a multi-layer assembly, neoprene gasket, and proprietary rubber-encapsulated metal cover plate assembly in areas vulnerable to impact from stones and debris.

DESIGN DETAILS AND CONSTRUCTION CHALLENGES

The structural design of the new concrete overlay was intended to provide fully composite behavior between the undamaged



Fig. 6: Formwork and bracing

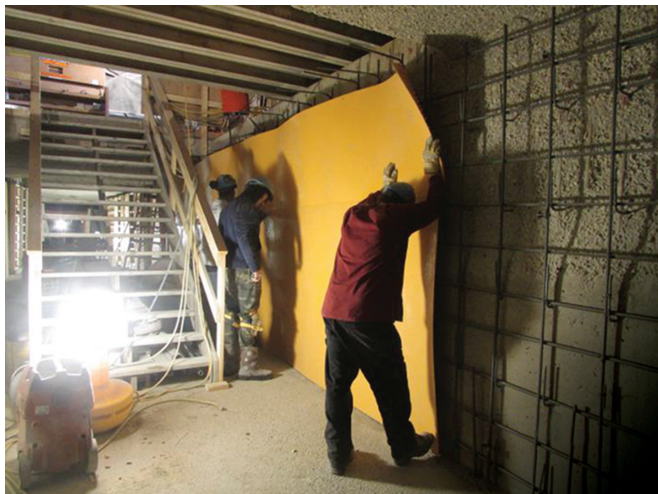


Fig. 7: Trial fit of HDPE liner prior to erection of formwork

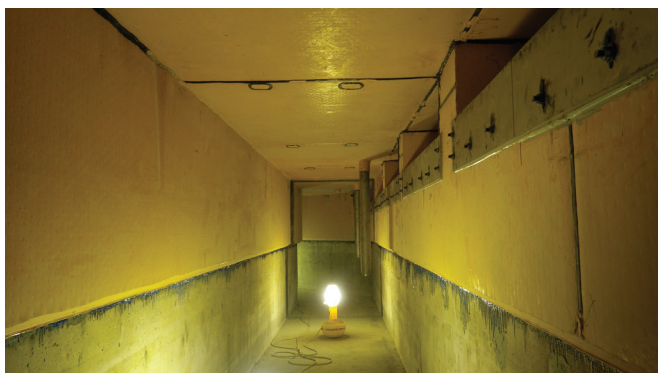


Fig. 8: Nearing completion of overlay and HDPE liner assembly at overflow weir

portions of the existing structure and the new concrete overlay through material bonding and sufficient reinforcement dowelling at the shear interface (Fig. 3 and 4).

Integration of the new HDPE protective liner into the outer surface of the concrete overlay provided some design and construction challenges. Although manufacturers' recommendations and guidelines were available for typical splices, corners and transitions, it was necessary to develop details for numerous project-specific requirements.

Construction of the bonded overlay and HDPE protective liner assembly provided further unique challenges for the contractor (Fig. 5 and 6). It was required that formwork and bracing systems introduce the fewest possible penetrations through the protective liner to minimize liner patching required before returning the channel into service. The lack of formwork tiebacks into the concrete substrate introduced the further challenge of ensuring that the HDPE liner did not wrinkle or warp during placement of the self-consolidating concrete overlay materials (Fig. 7).

CONCLUSION

The construction of a new bonded concrete overlay with integral HDPE protective liner assembly (Fig. 8) was successful in restoring and enhancing the channel's load-carrying capacity, and to provide appropriate long-term protection against the corrosive environmental exposure.

Repair construction began October 1, 2014 and was completed May 31, 2015, an ambitious schedule considering the magnitude of the project. The project was completed on time and on budget due to the collaborative efforts of the owners, design team and contractors. The facility owners expressed great satisfaction with the project results. ■

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SUBMITTED BY

Read Jones Christoffersen Ltd.
Edmonton, Alberta

OWNER

EPCOR Water Services Inc.
Edmonton, Alberta

PROJECT ENGINEER/DESIGNER

Read Jones Christoffersen Ltd.
Edmonton, Alberta

REPAIR CONTRACTOR

Sure-Form Contracting Ltd.
Edmonton, Alberta

MATERIALS SUPPLIERS/MANUFACTURERS

AGRU America Inc.
Georgetown, SC

Sika Canada Inc.
Edmonton, Alberta