WATER STRUCTURES CATEGORY

What's on Tap? Structuring Water Quality

Denton, TX

Submitted by JQ

Originally constructed in 1957 with a capacity of 4 million gal./day (15 million L/day), the Lake Lewisville Water Treatment Plant was constructed to serve the residents of Denton and Lewisville, TX. Subsequent expansions in 1964, 1972, and 1988 increased capacity by more than 750%. The plant consists of conventionally reinforced structures, including flocculation and sedimentation (floc/sed) basins, filters, treated water storage tanks, a high-service pump station, a wash water recovery basin, chemical feed and storage facilities, and an off-site intake pump station on Lake Lewisville.

A general view of the original floc/sed basin conditions

THE PROBLEM

A major capital investment was required to increase plant capacities and obtain the water quality requirements mandated by changes in federal and state water regulations. Process changes enacted in the early 1990s in response to the EPA Safe Drinking Water Act resulted in a much lower pH in the floc/sed basins and filters. The widespread pitting of the concrete surfaces was a direct result of the low-pH, acidic process water. This posed water quality issues, as the pitting holds debris, bacteria, and other contaminants.

THE SOLUTION

A complete evaluation of the existing facilities was performed which showed the embedded metal components, such as ladder rungs and pipe supports, exhibited severe corrosion and posed risk for further damage of the surrounding concrete. The concrete walls in the primary containing structures exhibited matrix loss up to 1/2 in. (13 mm) and subsequent aggregate loss causing severe surface pitting. To accurately determine the depth of deterioration at the wall surface and obtain the data necessary in evaluating various repair methods, petrographic and pH testing were performed at several locations throughout the basin complex.

Testing was performed to determine the quantity and type of admixtures, air content, water-cement ratio, and compressive strength. Ultraviolet scans and stain tests were performed to determine the depth of

A typical view of embedded metal corrosion

concrete carbonation. The testing revealed a maximum depth of 1/2 in. (13 mm) of carbonation of the concrete surface over the majority of submerged wall surfaces. An approximate pH value of 11.5 beyond the 1/2 in. (13 mm) indicated the carbonation was not as severe as initially assumed. Compressive strength of the core samples estimated the strength at more

than 7000 psi (48.3 MPa), indicating sound concrete beneath the surficial matrix loss.

The primary cause of the observed matrix loss, surface pitting, and embedded metal corrosion was determined to be the highly acidic process fluids in the floc/sed basins and filters, which have a pH in the range of 6.3. Isolated instances of exposed and rusting reinforcing steel and metal assemblies are a result of the aggressive service environment. Widespread isolated concrete cracking and spalling existed throughout the complex. Expansion joint material at multiple locations was in a state of disrepair and had failed due to age and exposure.

REPAIR SYSTEM SELECTION

The selection criteria for the repair system included:

- Compliance with the National Sanitation Foundation's NSF 61 certification for approval for use in contact with potable water;
- Removing unsound surface concrete and restoring the minimum concrete cover over the embedded reinforcing steel;
- Improve the water containment capabilities of the basins; and
- Extend the useful life of the structures.

Three repair systems were considered:

- Option 1—Chemical-resistant, trowel-applied, epoxy-based, quartz-reinforced composite overlay system with an NSF-approved epoxy topcoat;
- Option 2—100% solids, high-build, spray-applied epoxy liner system; and
- Option 3—Spray-applied, silica fume-enhanced, fiber-reinforced, shrinkage-compensating cementitious repair mortar.

Option 3 was selected based on the cost of material, installation efficiency, and the improved chemical resistance performance.

CONSTRUCTABILITY

Extensive coordination with plant operations was necessary during construction, as only partial shutdown of the plant was permitted. A total of eight floc/sed basins and 16 filter cells were scheduled for rehabilitation. The work was sequenced such that only two basins were taken out of service at any given time. The tight project completion schedule required the repair work to be performed during the hottest months of the year, and the contractor was required to erect temporary shading to minimize exposure of repaired surfaces from direct sunlight, ensuring optimum curing conditions of the applied repair mortars. Installation of temporary bulkheads in channels and flumes between the basins was also necessary to completely isolate individual basins.

Surface preparation in tight, enclosed areas was particularly challenging. Based on the initial pulloff tests of the existing concrete substrate, the field criteria for an acceptable mortar application were established. The contractor employed several means for surface preparations, including hydroblasting and mechanical abrasion. The rigorous field quality assurance program implemented on the project to ensure proper surface preparation played a key role in the subsequent successful bonding of the repair mortar system.

Temporary shading during repair

Confined space wall repairs before and after

REPAIR SYSTEM APPLICATION

Strict quality control and testing was performed during and after installation to ensure repairs met the required bond strengths. A minimum pullout value of installed repair mortar, varying from 120 to 150 psi (0.83 to 1.03 MPa) with 100% failure occurring in the concrete substrate, was used for determining acceptability of the application. Any pullout failure occurring in the concrete substrate was reviewed as such a failure may not indicate faulty application, but rather a limiting factor of the existing substrate. Any failure below 300 psi (2.07 MPa) at the bond line of the repair mortar to the substrate was retested. If the retest again failed at the bond line, the contractor was responsible for bringing the work into conformance. A number of engineering interpretations and decisions were required to

address the array of varying field conditions. Ultimately, the amount of rework due to misapplication was less than 5% of the overall quantity. Application of the repair mortars used predominantly spray-applied nozzle methods with trowel-applied hand methods for more isolated areas.

SPECIAL FEATURES

The following project characteristics make this project exemplary:

- The age of the structure will exceed 75 years before any major maintenance of repair systems needs to be considered;
- The rehabilitated structure contributes significantly to the reliability and delivery of quality water—two of the City's primary project objectives; and
- The scale of repairs was considerable and required significant due diligence to accurately estimate, sequence, and execute repairs while minimizing the effect on the plant operations, construction schedule, and the owner's budget. The following presents the various repair items and their associated quantity used on the project:
  - Spray-applied repair mortar applications: 4500 ft^3 (127 m^3) on over 57,000 ft^2 (5295 m^2) of wall surfaces;
  - Hand-applied repair mortar applications: 1100 ft^3 (31 m^3);
  - Confined space repairs at stacked conveyance channels: 300 ft^3 (8.5 m^3);
  - Crack injection repairs: 4000 ft (1220 m); and
  - Epoxy-based protective coating applications: 4700 ft^2 (437 m^2).

The accuracy in bid form quantities resulting from the extensive structural evaluations, coupled with the effective use of bid items in the project bid form, resulted in a project where all parties were able to maximize benefit and cost savings.

Finalized repairs

Completed project

BACK ONLINE

The $35 million Lake Lewisville Water Treatment Plant expansion and water quality improvements were completed after 4 years of design and construction. The structural rehabilitation was executed according to plan, working within the City's strict requirement to maintain plant service and customer water delivery during construction. In addition to the various process improvements performed on the project, the structural improvements played a critical part in achieving the City's goal of meeting state guidelines for water delivery and producing the highest possible quality of water. Denton was selected as the "2013 Best-Tasting Drinking Water in Texas" award winner in April during the Texas Water 2013 Conference sponsored by the Texas Section American Water Works Association and the Water Environment Association of Texas. This is a testament to the importance of structuring water quality.

Lake Lewisville Water Treatment Plant

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