REPAIRING AND PROTECTING A 1950s ERA WASTEWATER DIGESTER TANK

By **Leigh Besanger** and **Daryl Prefontaine**

The coating program involved the wall coating application in the first phase, followed by the floor coating application in the second.

Wastewater treatment plant (WWTP) maintenance and upgrading programs can sometimes unearth issues that may not be apparent during regular operation. Such an occurrence happened at a WWTP consisting of eight digesters constructed at various times between 1955 and 2010.

The plant had recently completed upgrades to a circa 1955 digester tank, requiring it to be taken out of service for an extended period of time, as part of ongoing maintenance and facility upgrading programs. As per code requirements, the upgraded digester had to pass a two-part tightness test, in accordance with industry requirements for environmental containment structures, before it could be returned to service.

Unexpectedly, the digester did not meet the leakage specifications, so the WWTP facility management engaged RJC Engineers, a specialty structural restoration consultant, to lead the diagnosis, design, and implementation of a suitable repair program.

DIAGNOSIS PHASE

The digester is one of the original structures at the WWTP. Constructed in approximately 1955 of reinforced concrete, the digester, approximately 30 metres in diameter, has a sloped conical-shaped floor, a circular perimeter wall approximately 9.5 metres high, and is enclosed with a roof slab.

The bottom two-thirds of it is buried below-grade, while the remaining wall portions are exposed to the exterior, or are shared with interior spaces, other buildings, or access areas at the plant. Along with the perimeter wall, 12 concrete columns support the roof structure from inside the digester's interior.

As part of the recent upgrade, an HDPE liner assembly was installed on the upper portions of the wall interior surfaces and the underside of the roof structure. It was generally assumed that the leakage was not occurring through the new liner. Therefore, the leakage repair program targeted waterproofing and protection solely on the 1950s-era concrete wall and floor surfaces below.

In order to establish the potential sources of leakage and the extent of any associated concrete repair required prior to waterproofing, an initial review of the digester's interior surfaces was performed by the consultant. The inspection uncovered many concrete issues, none of which were determined to be "the sole source of leakage". But, all were considered during the design of the new coating assembly as potential contributors to this digester's lack of water tightness.

During this initial review, concrete cracking, cold-jointing, loose form-tie hole plugs, large areas of poorly consolidated and non-encapsulated aggregate (honeycombing), and void-ridden pour-joints with debris embedded at the interface were visually identified.

Not only was it deemed important to visually identify the

continued overleaf…

various concrete issues, but establishing a likely cause of these issues was also imperative. While most of the above-noted concrete-related issues appeared to be the result of typical (1950s) construction practice and methodology, the observed concrete cracking was thoroughly investigated.

Was this cracking due to the "usual suspects" (i.e., shrinkage, reinforcing steel detailing, the original concrete mix, etc.), or was it caused by structural or thermal-related movements which would need to be accommodated by the new waterproof coating assembly? Prior to specifying and developing details for the coating, structural analysis determined that the as-constructed reinforcing steel in the digester wall was close to "on-par" with current concrete reinforcement provisions outlined by the "Requirements for Environmental Engineering Concrete Structures (ACI 350-06)".

However, thermal modelling determined that the digester wall was prone to large temperature-related stresses and cyclical/seasonal movements, due to both the internal process and exterior environment.

Additionally, based upon the initial review and testing results, the pre-existing coal tar coating was likely providing some level of waterproofing and concrete protection. Unfortunately, it was no longer performing as an effective means of waterproofing/containment, likely due to its extended service life. The observed conditions substantiated the water tightness testing results and aided in defining the potential sources of leakage and repair objectives.

DESIGN PHASE

The project team defined the following objectives and criteria:

- Fully remove the existing coal tar coating and any potential wastewater-related contaminants from the substrate surfaces.
- Remove and repair all areas of unsound concrete, including poorly consolidated and non-encapsulated aggregate to provide a suitable substrate for coating application.
- Fill, patch, and repair all surface voids, including localized injections of expanding polyurethane grout at pour-joint interfaces.
- Provide a flexible, yet durable, chemical-resistant coating assembly capable of preventing leakage and accommodating the digester's thermal-related movements.
- Incorporate a slip-resistant texture on the sloped floor surface for safety considerations.
- Maximize the remaining service life of the digester's concrete structure.

Voids and debris at pour-joint (bare concrete above joint, existing coal tar coating below).

Poorly consolidated and non-encapsulated aggregate.

Using the results of the inspection and the defined repair criteria and objectives, RJC Engineers developed site-specific details and specifications for the localized pre-coating concrete repairs, substrate preparation, and new waterproofing/protective coating assembly at the lower interior surfaces. The design was completed in the spring of 2020 and an ambitious goal of having the digester operational by year end was set.

SOLUTION

The coating program involved the wall coating application in the first phase, followed by the floor coating application in the second.

Scaffolding was constructed inside the digester for the cleaning, repair, preparation, and coating application on the lower seven vertical metres of interior wall surface (existing HDPE on the upper 2.5 metres).

Once the wall coating application was completed, reviewed and tested for conformance with project specifications, the scaffolding was deconstructed and floor surface cleaning, repair, preparation and coating application phase proceeded.

Cleaning and surface preparation was performed with abrasive blasting (sandblasting) followed by pressure washing. In order to fully remove the existing coal tar coating, aggressive abrasive blasting was needed. This surface cleaning and preparation method resulted in a suitably rough substrate with a concrete surface profile (CSP) greater than 5, as defined by the International Concrete Repair Institute (ICRI), for most of the 2,200 m² of coating application area.

Loose, non-encapsulated aggregate was then chipped away from the surface and patched. An epoxy mortar mix was applied to resurface and reprofile the substrate, which effectively filled all of the "peaks and valleys" of the abrasively blasted concrete. This pre-manufactured epoxy mortar mix was trowel applied to the surface to provide a uniformly textured substrate similar to CSP 3, which was the required surface profile for this coating application.

After priming the resurfaced substrate, a flexible polyurethane coating was applied using a heated, plural component sprayer to the specified dry film thickness, 100 mils. The contractor performed wet mil thickness testing during application to ensure conformance with specified requirements.

On the sloped floor surface, granular quartz was seeded into the wet coating with a subsequent tie-coat application to provide a slip-resistant surface. Wall and floor surface coating application mock-ups were specified before widespread application inside the digester. These mock-ups provided an opportunity for the project team to review and comment on the finished product and appearance, and helped establish a baseline quality expectation for the coating application.

In addition to the contractor's quality control, quality assurance testing was performed that included adhesion strength pull-off testing and holiday/spark testing by the consultant and third-party testing agencies. After each round of holiday/spark testing, pin-hole and coating discontinuity repairs were performed and retested.

Upon completion of the interior coating program, tightness testing was performed to industry requirements, and the digester passed with no measurable water loss. The WWTP facility's goal of recommencing commissioning prior to the end of the year was achieved.

CHALLENGES

RJC Engineers' design process included identifying anticipated challenges and developing mitigation strategies with the WWTP management and the contractor during the pre-design and coordination phase of the project, which resulted in

continued overleaf…

Quality Assurance testing – adhesion strength pull-off testing.

very few delays during construction.

However, WWTP repair and rehabilitation programs are never without site-specific surprises, so design and construction challenges were welcomed as learning breakthroughs. For instance, access to the digester interior was limited to a single 900-mm diameter access hatch, located below ground level. This meant that workers, materials, access scaffolding, and equipment passed through this small opening countless times during the project.

The only equipment that was not set up inside the digester was the plural component sprayer. The contractor housed the sprayer in a trailer that was parked on an access road adjacent to the digester. Fifty-five-gallon drums of coating were connected to the sprayer inside the trailer and hose was run from the sprayer to the point of application inside the digester.


There was only a 900-mm diameter access hatch into the digester.

During the wall surface coating assembly mock-ups, the originally specified water-based epoxy cementitious resurfacer performed poorly during pull-off strength testing. Being a water-based cementitious product, saturated-surface-dry (SSD) was required for optimal application.

Although the contractor made best efforts to keep the substrate SSD, the very thick concrete perimeter wall quickly absorbed any surface-applied water, and the resurfacing product experienced rapid moisture loss that significantly reduced material hardness and bond-interface adhesion.

This water-based cementitious resurfacer had been specified based on several successful applications across North America. However, due to site-specific factors, including the digester wall being shared with interior spaces at some locations, wall thickness of approximately 760 mm, and the low humidity environment conditions at the time of the application, the originally specified resurfacing product did not perform as anticipated.

Following this determination at the time of mock-ups, the choice was made to instead use a reinforced epoxy resurfacer that did not require an SSD substrate for application.

CONCLUSIONS

Pinpointing the sources of leakage following tightness testing in an existing concrete containment structure can be time-consuming, costly, and in many cases, unsuccessful. Sources of leakage could be due to many design and construction factors that are addressed by "industry standards" today, but were not necessarily considerations at the time of construction.

Mix design, shrinkage cracking, cold jointing due to antiquated concrete placement limitations or techniques, pour joints, outdated formwork methods and materials, and deteriorated existing coating/liner systems are among many potential contributors to leakage. Localized sealing and patch repair attempts can become as futile as identifying the sources of leakage.

When operational constraints leave a WWTP facility in a pinch, executing an interior coating program becomes one of the best options given that modern day coating assemblies are a proven means of waterproofing, containment and structural concrete protection.

WWTP managers can extend the operating life of digesters by ensuring that identified issues are thoroughly assessed by specialized professionals. Repair solutions can be designed to prevent leakage, protect the structure, and provide the facility management and operations team with confidence that their asset's operational performance will meet all requirements. ■

After each round of holiday/spark testing, pin-hole and coating discontinuity repairs were performed and retested.

Leigh Besanger and Daryl Prefontaine are with RJC Engineers. Email: lbesanger@rjc.ca, dprefontaine@rjc.ca