Repair Techniques for Prestressed Concrete Tanks

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Prestressed tanks, sometimes referred to as preload or wire wound (concrete) tanks, have been widely used in the UK in the water industry since the early 1950s, primarily as reservoirs. The use of high tensile steel tendons, or cables, to impart compressive forces into the structure confers the benefits of speed of construction, light weight, and low cost.

Instances of pre-stressing wire failure, however, have been fairly common. In December 1999, the domed roof of one tank collapsed at Lanner Hill in Cornwall, UK, causing a catastrophic structural failure. Since then, there have been other sudden failures as preload structures continue to deteriorate, presenting significant safety, environmental, and financial risks to their owners.

Against this background a specialist general contractor has developed specific techniques and site procedures for safe investigation, repair, and refurbishment of these structures. This article briefly describes the techniques.

Investigation

The principal investigation techniques used are the desk study of available “as-built” information and maintenance records, with visual inspection and hammer testing, assessments of carbonation, screening for chloride, cover surveys, half cell potential surveys, special metal detection surveys and/or ground probing radar surveys, and internal inspections using a remotely operated vehicle (ROV).

Influenced by knowledge of the specific structure, the initial visual inspection for deterioration, including cracking of the concrete and overlays, and corrosion of the wires, is complemented with hammer testing to detect areas of disbonding, delamination, and voids.

Hammer testing involves tapping the surface with a hammer or drawing it gently across the surface, then assessing the resultant sound(s) to get an indication of hidden defects.

Depths of carbonation are measured in-situ, using a solution of phenolphthalein indicator in ethyl alcohol, sprayed onto freshly broken surfaces.
which appear pink when not carbonated (pH >9) and colorless when the concrete has lower pH (carbonated).

Screening for chloride is carried out by chemical analysis, generally in a laboratory, on samples of the concrete.

Both the depths of carbonation and the chloride ion contents give a measure of the presence or ingress of the most common agents in, or causes of, the corrosion of encapsulated steel.

The measurement of half-cell potentials can detect corrosion, although care must be taken if galvanized wires have been used. The equipment and methodology, originally described in ASTM C876, has now been incorporated within many of the industry’s standard guidance documents.

More detailed information about the concrete sub-structure can be obtained from a survey made with a proprietary portable unit, essentially a metal detecting, measuring and mapping device that provides an instant image of the arrangement and position of reinforcement within the survey area and the depth of concrete cover. For more deeply hidden details, a ground probing radar survey is used. Ground probing radar also gives information about the location and detail of the reinforcement, but, in addition, it can locate deeper pre-stressing tendons, major construction features, and the presence of voids or cracks.

Through an ROV fitted with a video link, the concrete surfaces on the inside of the tank can be assessed, without the need for taking the tank out of service, emptying it, and entering it.

Using the methods above, one can...
identify areas of deterioration and make recommendations for remedial work.

**Repair Techniques**

Because the pre-stressing wires and post-tensioning tendons are sensitive, particularly where they may be corroded and damaged, hydro-demolition, rather than pneumatic breaking, is used to remove the gunite overlay on the tendons (Fig. 1).

“De-stressing” is generally carried out sequentially. Before deteriorated wires/tendons are de-stressed, the existing load is reduced by the installation of temporary, post-tensioned tendons (Figs. 2 and 3). The existing wires are then severed and preferably removed before the exposed concrete surfaces are repaired, and remedial tendons are installed and jacked to the required loading (Fig. 4).

Mastic joints are then installed along the junctions between old and new concrete surfaces where relative movements could initiate cracking and cause future problems. Conventional concrete patching materials, in accordance with EN 1504, are used to repair spalling and cracked areas of concrete. Patching is followed by the surface preparation and application of a surface coating to enhance the long-term durability of the structure.

![Fig. 2: Installation of temporary tendons will be followed by de-stressing and removal of existing failed wires.](image)

![Fig. 3: Temporary tendons installed around the dome band](image)

![Fig. 4: Conventional concrete repairs and installation of remedial post tensioning tendons](image)
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