

REPAIR OF LEAKING CRACKS IN WALLS OF LIQUID CONTAINMENT STRUCTURES

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Introduction

Nonprestressed reinforced concrete liquid containment structures—in particular, noncircular tanks—often exhibit vertical and diagonal cracks that are aesthetically objectionable. More importantly, cracks could result in loss of stored liquids, leakage of hazardous materials, concrete deterioration, and corrosion of reinforcing bars. Such cracks, however, are seldom indicative of structural failure. This *TechNote* reviews the methodology of repair in liquid containment structures.

Question

What are the typical causes of, and best practices to repair, vertical and diagonal cracks in liquid containment structures?

Answer

Vertical and diagonal cracks in liquid containment structures are usually the result of restrained movement of concrete due to shrinkage, differential thermal expansion, and contraction from moisture and temperature gradients over the wall height.

In the absence of corrosion, dormant but leaking cracks are typically repaired by pressure injection of epoxy or chemical grout, vacuum injection, or routing and sealing on the interior or exterior wall surfaces, or both. Active cracks are repaired by pressure injection with chemical grouts; by routing and sealing with a flexible sealant on the interior or exterior wall surfaces, or both; or by application of a flexible barrier membrane on the liquid retention side of the wall. ACI Concrete Terminology (ACI CT-13) defines an active crack as one whose width changes with time, and a dormant crack as the opposite—one whose width does not change with time.

Not all cracks require repair. Refer to ACI 224R, Table 4.1, for crack widths that require repair or remediation.

Discussion

Liquid containment structures, such as large rectangular tanks, often exhibit vertical and diagonal cracks that are usually the result of restrained concrete shrinkage and thermal contraction, typically spaced 4 to 10 ft (1.2 to 3 m) apart (Fig. 1). These cracks generally have an insignificant effect on the structural integrity. Cracking, however, can affect the performance, serviceability, or both, of a structure, making repairs necessary to assure liquid-tightness and long-term durability (ACI 350). Liquid containment concrete structures could have concrete roof slabs that should be kept liquid-tight to prevent contamination of the contents by exterior exposure. In these cases, differential shrinkage and thermal deformation of the concrete could result in significant wall and roof cracking if the appropriate expansion or contraction (movement joints) are not provided. Structures with movement joints in the walls and without matching joints in the base slab are prone to crack development not only in the walls adjacent to the joint, but in the base slab below the movement joint. The cracks typically



Fig. 1—Vertical cracking at the walls of a liquid containment tank.

extend diagonally, vertically, or both, and occur on both sides of the movement joints, resulting from the restraint of the base slab. The width and spacing of cracks depends on concrete shrinkage and creep, the size and spacing of horizontal reinforcement, wall thickness, height and length of each placement (distance between vertical construction joints), and length between movement joints, member restraints, and the concrete mixture.

Crack widths can be controlled with appropriate reinforcement and detailing that result in tight cracks that do not leak. In liquid-retaining structures, the internal sides of walls should be considered in repair selection and design.

For more concrete repair guidance, refer to ACI 562, ACI 546R, ACI 224.1R, and ICRI Guideline No. 340.1. Refer to ACI 224.1R for an assessment of the intrinsic nature of cracks. Before selecting a repair methodology, the licensed design professional should determine the cause of the cracks—if they are active or dormant and if corrosion is active in cracked areas. Because shrinkage of concrete continues over an extended period of time, resulting cracks should be considered active, especially if the structure is subjected to cycles of wet and dry periods. Dormant cracks usually result from an event of limited duration, such as temporary overload conditions during construction.

For dormant cracks, injecting a rigid epoxy product restores the structural integrity of the member (ACI 503.7; RAP-1; ASTM C881/CM881).

Conversely, except where it is needed for load-transfer purposes, rigid epoxy products should not be used in active cracks (Fig. 2). If the conditions that cracked the wall initially are not, or cannot, be changed, the wall will crack again near the same location if the wall is structurally bonded back together. A repair technique incorporating flexibility across the crack is the correct approach for this type of condition (ACI 224.1R). Crack injection should not be used to repair cracks caused by corrosion of steel reinforcement unless supplemental means are used to mitigate the cause of the cracks and corrosion.

If corrosion is present, it should be evaluated before making repairs. This *TechNote* does not cover repair of cracks resulting from steel corrosion. There are various methods to mitigate, prevent, and control corrosion of reinforcing steel in concrete (ACI 222R).

Active cracks can be repaired by: 1) pressure injecting of chemical grouts; 2) routing and sealing of cracks; and 3) installing a flexible barrier system (ACI 224.1R). These methods are considered serviceability repairs and not structural.

1) Chemical grout injection—Flexible hydrophobic polyurethane foam grout material is often used for the crack repair in containment structures. Polyurethane foam retains most of its volume after curing, even if the surrounding concrete should become dry, which is advantageous for repairing active cracks (Fig. 3 and 4). Hydrophilic grouts tend to shrink when allowed to dry out and lose volume, resulting in active leaking when the liquid is reintroduced at a later time. Note that some of these grouts might not re-swell sufficiently upon rewetting to fully prevent future leakage. Both types of chemical grouts can be used to mitigate leaking cracks with injection performed from the exterior side of a liquid containment structure so the tanks need not be emptied. Interior injection can also be accomplished without draining the tank by experienced divers performing the work underwater. Some excavation could be required to access cracks below grade. For extensive cracking below grade, the application of a waterproofing system might be necessary.

There are conditions, however, where injection from the inside wall face is recommended to prevent liquid exfiltration, which could require the tank be emptied. Injection from the inside, however, provides access for crack repair below grade for buried or partially buried structures without excavation.

The proper climatic condition is crucial for successful crack injection, especially if polyurethane chemical



Fig. 2—Example of an active crack improperly repaired.