

Shotcrete Construction Joints

by Dudley R. (Rusty) Morgan

Shotcrete construction joints are required in situations such as the following:

1. When the volume of shotcrete is greater than that which can be conveniently applied and finished in a single shift;

2. In construction of top-down shotcrete installations, such as soil-nailed walls, where the element is constructed in a series of horizontal lifts; and

3. In segmental shotcrete construction, such as is used in underpinning of buildings.

Section 5.7.2 of ACI 506R-90, "Guide to Shotcrete," states:

Construction joints—Square construction joints are generally avoided in shotcrete construction because they form a trap for rebound. However, where the joint will be subjected to compressive stress, square joints are commonly required, in which case the necessary steps must be taken to avoid or remove trapped rebound at the joint. The entire joint should be thoroughly cleaned and wetted prior to application of additional shotcrete.

Where a section of shotcrete is left incomplete at the end of a shift some provision must be made to assure the joint will not develop a plane of weakness at this point. The joint is therefore tapered to an edge, usually about one-half the thickness of the shotcrete, a maximum of 1 in. (25 mm). A better appearing joint may be constructed by sloping to a shallow edge using a 1 in. (25 mm) thick board laid flat.

These ACI requirements have left some confusion in the shotcrete industry as to what the best type of construction joint to construct is. More recent research and experience has demonstrated that the best type of construction joint for most applications is a simple 45-degree edge. A competent nozzle-man can quite easily shoot the shotcrete to a 45-degree edge. If the joint is too flat (tapered out over too long a distance) then it should be cut back to an approximately 45-degree edge with a trowel or cutting rod while the shotcrete is still fresh. If the joint has been shot too squarely, it can be cut to an approximately 45-degree edge.

Experience from field examination of existing structures has demonstrated that square joints

are not needed in most structures such as walls, columns, or tunnel linings subjected to compressive stresses. Square joints are both more difficult to construct and to shoot in subsequent shifts, as they provide ledges where rebound and overspray can accumulate, creating potential planes of weakness. The exception to this is circular prestressed concrete tanks with shotcrete linings, where joints can be subjected to very high compressive stresses. In such situations, the use of a properly constructed square construction joint reduces the risk of a compression failure at the joint.

A properly prepared 45-degree joint will provide load transfer in flexure, equivalent to that achievable in nonjointed shotcrete. For a clear demonstration of this phenomenon, refer to the paper by Trottier, Forgeron, and Mahoney.¹

Long tapered (featheredged) joints should be avoided, as they can result in peeling-type delaminations in shotcrete installations. In a comprehensive investigation, "Durability of Shotcrete Rehabilitation Treatments of Bridges in Canada," Morgan and Neill² examined some 60 shotcrete repaired bridges across Canada. They found that although most of the shotcrete repairs were displaying excellent to good performance, some bridges had localized peeling-type shotcrete delaminations as a result of featheredged joints. Also, in another investigation, "Performance of Shotcrete Repairs to Berth Faces at the Port of Saint John," Gilbridge, Morgan, and Bremner³ found that although the up to 10-year-old steel fiber-reinforced shotcrete repairs were displaying generally excellent performance in an aggressive marine environment with freezing and thawing, there were a few peeling-type delaminations in locations where the contractors had constructed long, tapered (feather-edged) joints rather than 45-degree joints.

After shooting a 45-degree construction joint, it is important that the joint and any adjacent surface be cleaned to remove any overspray, rebound, dust, dirt, or other material that could be detrimental to good bond of the next application of shotcrete. This can be done with techniques such as brooming with a stiff bristle brush, or water pressure blasting with a 20 MPa (3000 psi) water pressure sprayer while the shotcrete is still green (that is, has set

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- Shoot or cut shotcrete to a 45-degree edge.
- After shotcrete has hardened sufficiently, remove any overspray, rebound, laitance, or other material potentially deleterious to bond by brooming with a stiff bristle brush or green cutting with a 20 MPa (3000 psi) water pressure blaster.
- If shotcrete has hardened excessively for brooming or green cutting, prepare joint by either wet or dry grit-blasting.
- Presaturate shotcrete joint and adjacent surfaces about to receive shotcrete and then allow to dry back to a saturated surface-dry (SSD) condition, prior to application of shotcrete.
- Apply new shotcrete, finish, and then cure thoroughly (moist curing is preferred to membrane curing wherever possible).

but has not developed much strength). If rebound or overspray is allowed to harden for too long, then more vigorous cleaning methods such as dry or wet grit-blasting may be required. The joint and adjacent surfaces to receive shotcrete should be presaturated with potable water and then allowed to dry back to a saturated surface-dry (SSD) condition prior to the application of the new layer of shotcrete. Excess free water on the joint face can reduce the quality of bond at the joint.

Finally, with steel or synthetic fiber-reinforced shotcrete, the question has been asked as to whether fiber reinforcement provides a continuity of reinforcement, similar to that which could be expected in a mesh-reinforced shotcrete, where the mesh is continuous across the joint. Trottier, Forgeron, and Mahoney¹ carried out a comprehensive investigation of this issue, using the South African Water Bed test method. They tested 1600 x 1600 x 75 mm panels in flexure and found that the presence of construction joints did not have any detrimental effect on the load-carrying capacity and cracking behavior of panels reinforced with steel or synthetic fibers. They concluded that: "When steel or synthetic fibers are used in the field, no particular precaution, other than proper fabrication and preparation of the joint itself, is required at the construction joint locations."

References

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2. Morgan, D. R., and Neill, J., "Durability of Shotcrete Rehabilitation Treatments of Bridges in Canada," *Transportation Association of Canada Annual Conference*, Winnipeg, Manitoba, Canada, Sept. 15-19, 1991, 36 pp.
3. Gilbride, P.; Morgan, D. R.; and Bremner, T. W., "Performance of Shotcrete Repairs to Berth Faces at the Port of Saint John," *Odd E. Gjorv Symposium on Concrete for Marine Structures*, Third CANMET/ACI International Conference on Performance of Concrete in Marine Environment, St. Andrews-by-the-Sea, New Brunswick, Canada, Aug. 4-9, 1996, pp. 163-174.



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