

Concrete in Practice

What, why & how?



CIP 4 - Cracking Concrete Surfaces

WHAT are Some Forms of Cracks?

Concrete, like other construction materials, contracts and expands with changes in moisture and temperature, and deflects depending on load and support conditions. Cracks can occur when provisions to accommodate these movements are not made in design and construction. Some forms of common cracks are:

Figure A: Plastic shrinkage cracks (CIP 5)

Figure B: Cracks due to improper jointing (CIP 6)

Figure C: Cracks due to continuous external restraint
(Example: Cast-in-place wall restrained along bottom edge of footing)

Figure D: Cracks due to lack of isolation joints (CIP 6)

Figure E: D-Cracks from freezing and thawing

Figure F: Craze Cracks (See CIP 3)

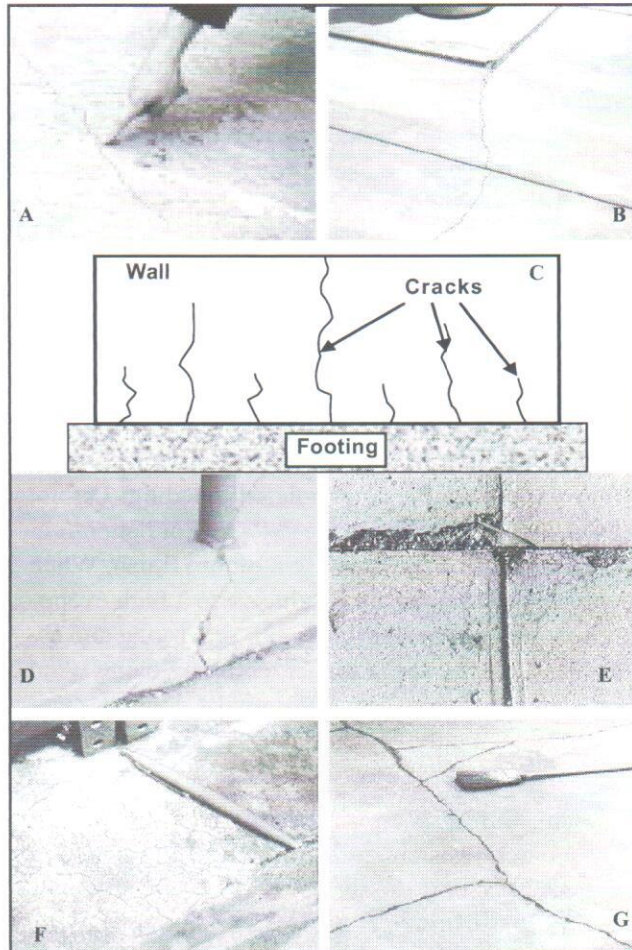
Figure G: Settlement cracks

Most random cracks that appear at an early age, although unsightly, rarely affect the structural integrity or the service life of concrete. Closely spaced pattern cracks or D-cracks due to freezing and thawing, that typically appear at later ages, are an exception and may lead to ultimate deterioration.

WHY Do Concrete Surfaces Crack?

The majority of concrete cracks usually occur due to improper design and construction practices, such as:

- Omission of isolation and contraction joints and improper jointing practices.
- Improper subgrade preparation.
- The use of high slump concrete or excessive addition of water on the job.
- Improper finishing.
- Inadequate or no curing.



HOW to Prevent or Minimize Cracking?

All concrete has a tendency to crack and it is not possible to produce completely crack-free concrete. However, cracking can be reduced and controlled if the following basic concreting practices are observed:

- Subgrade and Formwork.** All topsoil and soft spots should be removed. The soil beneath the slab should be compacted soil or granular fill, well compacted by rolling, vibrating or tamping. The slab, and therefore, the subgrade, should be sloped for proper drain-

- age. In winter, remove snow and ice prior to placing concrete and do not place concrete on a frozen subgrade. Smooth, level subgrades help prevent cracking. All formwork must be constructed and braced so that it can withstand the pressure of the concrete without movement. Vapor retarders directly under a concrete slab increase bleeding and greatly increase the potential for cracking, especially with high-slump concrete. When a vapor retarder is used, cover it with 3 to 4 inches of a compactible granular fill, such as a crusher-run material to reduce bleeding. Immediately prior to concrete placement, lightly dampen the subgrade, formwork, and the reinforcement if severe drying conditions exist.
- b. *Concrete.* In general, use concrete with a moderate slump (not over 5 inches [125 mm]). Avoid retempering concrete to increase slump prior to placement. Higher slump (up to 6 or 7 inches [150 to 175 mm]) can be used provided the mixture is designed to produce the required strength without excessive bleeding and/or segregation. This is generally accomplished by using water-reducing admixtures. Specify air-entrained concrete for outdoor slabs subjected to freezing weather. (See CIP 2)
 - c. *Finishing.* Initial screeding must be promptly followed by bull floating. DO NOT perform finishing operations with water present on the surface or before the concrete has completed bleeding. Do not overwork or over-finish the surface. For better traction on exterior surfaces use a broom finish. When ambient conditions are conducive to a high evaporation rate, use means to avoid rapid drying and associated plastic shrinkage cracking by using wind breaks, fog sprays, and covering the concrete with wet burlap or polyethylene sheets between finishing operations.
 - d. *Curing.* Curing is an important step to ensure durable crack-resistant concrete. Start curing as soon as possible. Spray the surface with liquid membrane curing compound or cover it with damp burlap and keep it moist for at least 3 days. A second application of curing compound the next day is a good quality assurance step.
 - e. *Joints.* Anticipated volumetric changes due to temperature and/or moisture should be accommodated by the construction of contraction joints by sawing, forming or tooling a groove about $\frac{1}{4}$ to $\frac{1}{3}$ the thickness of the slab, with a spacing between 24 to 36 times the thickness. Tooled and saw-cut joints should be run at the proper time (CIP 6). A maximum 15 feet spacing for contraction joints is often recommended. Panels between joints should be square and the length should not exceed about 1.5 times the width. Isolation joints should be provided whenever restriction to freedom of either vertical or horizontal movement is anticipated—such as where floors meet walls, columns, or footings. These are full-depth joints and are constructed by inserting a barrier of some type to prevent bond between the slab and the other elements.
 - f. *Cover Over Reinforcement.* Providing sufficient concrete cover (at least 2 inches [50 mm]) to keep salt and moisture from contacting the steel should prevent cracks in reinforced concrete caused by expansion of rust on reinforcing steel.

References

1. *Control of Cracking in Concrete Structures*, ACI 224R, American Concrete Institute, Farmington Hills, MI.
 2. *Guide for Concrete Floor and Slab Construction*, ACI 302.1R, American Concrete Institute, Farmington Hills, MI.
 3. *Concrete Slab Surface Defects: Causes, Prevention, Repair*, IS177, Portland Cement Association, Skokie, IL.
 4. Grant T. Halvorson, *Troubleshooting Concrete Cracking During Construction*, Concrete Construction, October 1993.
 5. *Cracks in Concrete: Causes, Prevention, Repair*, A collection of articles from Concrete Construction Magazine, June 1973.
-

Follow These Rules to Minimize Cracking

1. Design the members to handle all anticipated loads.
2. Provide proper contraction and isolation joints.
3. In slab on grade work, prepare a stable subgrade.
4. Place and finish according to recommended and established practices.
5. Protect and cure the concrete properly.

1978, 1989 AND 1998

