

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:

Fig. A: Plastic shrinkage cracks (CIP 5)

Fig. B: Cracks due to improper jointing (CIP 6)

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

Fig. D: Cracks due to lack of isolation joints(CIP6)

Fig. E: D-Cracks from freezing and thawing

Fig. F: Craze Cracks (See CIP 3)

Fig. G: Settlement cracks

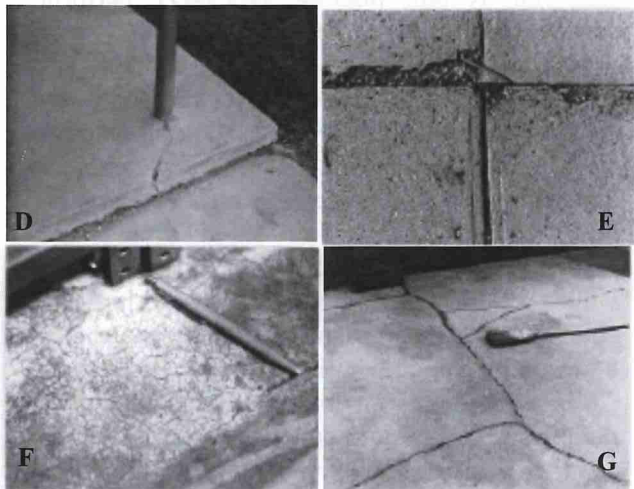
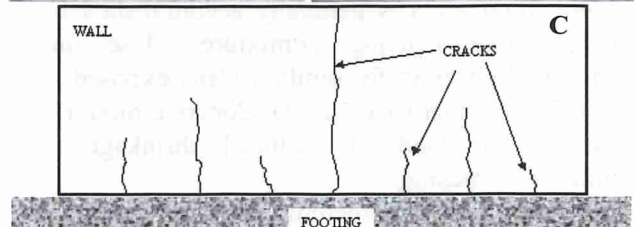
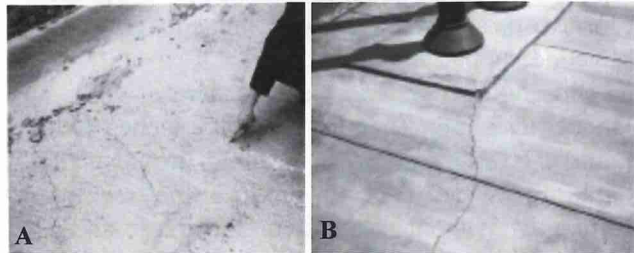
Most random cracks that appear at an early age, although unsightly, rarely affect the structural integrity or the service life of concrete. Two exceptions are:

- D-cracks, which occur due to freeze-thaw deterioration of some types of porous aggregate in concrete. These cracks initiate at joints at the bottom of exterior slabs and typically appear at later ages.
- Cracking due to alkali aggregate reactions will lead to long term structural damage (CIP 43).

WHY Do Concrete Surfaces Crack ?

The majority of concrete cracks 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.
- Rapid loss of moisture from newly placed concrete in dry conditions
- 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 followed:

- 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 drainage. In winter, remove snow and ice prior to placing concrete and do not place concrete on a frozen subgrade. Smooth, level and uniformly compacted

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 it is required to place concrete directly on polyethylene vapor retarders (CIP 29) take special care to ensure that finishing operations are performed after all bleed water has dissipated from the surface. In dry conditions lightly dampen subgrade, formwork and reinforcement immediately prior to concrete placement.

- b. *Concrete.* In general, use concrete with a moderate slump (not to exceed 5 inches [125 mm]). Higher slump 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. Use air-entrained concrete for outdoor slabs exposed to freezing weather (See CIP 2). Concrete mixtures can be designed for reduced shrinkage to minimize cracking.
- c. *Finishing.* Initial screeding must be promptly followed by bull floating. DO NOT perform subsequent 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 volume changes due to temperature and/or moisture should be accommodated by contraction joints saw cut or tooled at the proper time with a depth of about $\frac{1}{4}$ to $\frac{1}{3}$ the thickness of the slab, and with a spacing between 24 to 36 times the slab thickness. 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 to the full thickness of the slab should be provided whenever restriction to freedom of either vertical or horizontal movement is anticipated—such as where floors meet walls, columns, or footings. See CIP 6 for information on joints.
- f. *Reinforcement.* Wire mesh and reinforcement in slabs cannot prevent cracking. When placed at the proper location, reinforcement can reduce crack width. 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.
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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 uniformly compacted subgrade.
4. Place and finish according to recommended and established practices.
5. Protect and cure the concrete properly.

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