Concrete Atlantic béton Atlantique

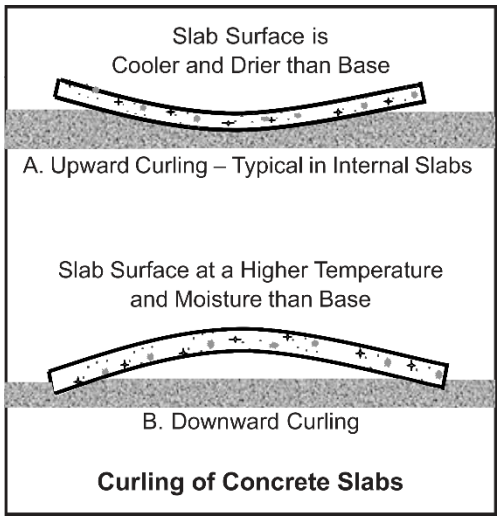
Concrete Tech-Tip #24

Curling of Slabs

What is Curling?

Curling is the distortion of a slab panel into a curved shape, caused by upward or downward bending of edges and corners at joints and cracks. It occurs primarily due to differences in moisture or temperature between the top and bottom surfaces of the concrete slab. This distortion can lift the edges or middle of the slab from the base, leaving portions unsupported.

When loads exceed the slab's capacity, cracking may occur, and upward-curled edges can chip or spall under traffic. Curling often becomes apparent at an early age, but it can develop over time. The terms curling and warping are often used interchangeably.



Example of upward and downward curling

Why Do Concrete Slabs Curl?

Curling occurs when differential changes in the top and bottom surfaces of a slab cause the edges or corners to bend upward or downward. These changes are mainly due to moisture and temperature gradients.

Cause: Differences in volume changes between the top and bottom surfaces, primarily from drying shrinkage.

Factors that increase curling:

- High water content or high paste volume in the mix
- Aggregate type
- Thin slabs or long joint spacing
- Slabs placed on vapor barriers or non-absorptive subgrades

Common patterns:

- Upward curling: Top surface dries and shrinks more than the bottom, typical in interior floor slabs on ground. Excessive bleeding or surface water increases this effect.
- Downward curling: Top surface heats and expands more than the bottom, common in exterior slabs exposed to sun or high temperatures.

Effects: Curling can lift edges or middle portions, causing unsupported areas that may crack under traffic or heavy loads. Joint spacing should balance the risk of random cracking against curling.

Mitigation: Use absorptive subgrades to reduce bleeding, optimize slab thickness, control joint spacing, and manage moisture and temperature differentials during placement and curing.

How to Minimize Slab Curling?

Curling is primarily influenced by drying shrinkage, slab thickness and joint spacing, construction practices, subgrade moisture, and temperature gradients. Curling typically diminishes over time as moisture and temperature differences even out.

The following are best practices to minimize curing:

- Use the lowest practical slump and avoid retempering water, especially in hot weather.
- Maximize coarse aggregate size and content to reduce drying shrinkage.
- Prevent excessive bleeding by using a damp but absorptive subgrade; avoid placing concrete

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directly on polyethylene vapor barriers unless covered with at least 50 mm of damp sand.

- Limit cementitious content to reduce paste volume and shrinkage.
- Moist cure the slab after placement, or apply a high-solids curing compound to reduce moisture loss.
- Consider heavy wax floor sealers for areas prone to curling (note: tile adhesives may not bond to these surfaces).
- Keep joint spacing ≤ 24 times slab thickness and ensure proper edge reinforcement.
- Thicker slabs and reinforcement in the upper third of the slab, perpendicular to edges, reduce curling. Use studs, wire mesh, and load transfer devices at construction joints, and dowels when connecting to existing slabs.
- For applications intolerant of curling, consider shrinkage-compensating concrete or post-tensioned slabs, ideally decided during design.

Remedies for Slab Curling

Methods to address curling include adding additional contraction joints, grinding existing joints to restore a level surface, and injecting grout beneath the curled slab to fill voids, restore support, and prevent break-off of uplifted edges.

Three Rules to Consider:

1. Minimize moisture and temperature differences between the top and bottom of the slab through proper curing and placement practices.
2. Reduce drying shrinkage by limiting water and paste content and by using appropriate slab thickness and joint spacing.
3. Provide good subgrade support and joint detailing with proper reinforcement and load transfer to limit the effects of curling.

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