CONCRETE TECH-TIP 19

Curling of Concrete Slabs

1. **WHAT** is Curling?

Curling is the distortion of a slab into a curved shape by upward or downward bending of the edges. This distortion can lift the edges of the slab from the base leaving an unsupported edge or corner which can crack when heavy loads are applied. Sometimes, curling is evident at an early age. In other cases, slabs may curl over an extended period.

2. **WHY** do Concrete Slabs Curl?

Typically, upward curling of the edges of a slab is caused by shrinkage or contraction of the top relative to the bottom. When one surface of the slab changes size more than the other, the slab will warp at its edges in the direction of relative shortening. This curling is most noticeable at the sides and corners.

Changes in slab dimensions which lead to curling are most often related to moisture and temperature gradients in the slab. One primary characteristic of concrete which affects curling is drying shrinkage. The most common occurrence of curling is when the top part of the slab dries and shrinks with respect to the bottom. The slab edges curl upward (Figure 1A). Immediate curling of a slab is most likely

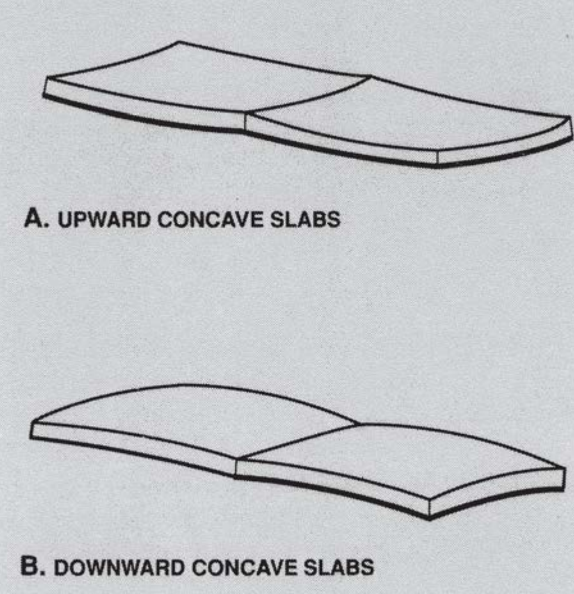

Figure 1. Curling of Concrete Slabs

related to poor curing and rapid surface drying; and anything that increases drying shrinkage will tend to increase curling.

In slabs, bleeding and poor curing both tend to produce surface concrete with higher drying shrinkage potential than the concrete in the bottom of the slab. Bleeding is accentuated in slabs on polyethylene or topping mixtures placed on concrete slabs; and shrinkage differences from top to bottom in these cases are larger than for slabs on an absorptive subgrade.

Thin slabs and long joint spacing tend to increase curling. For this reason, thin unbonded toppings need to have a fairly close joint spacing.

In industrial floors, close joint spacings may be undesirable because of the increased number of joints and increased joint maintenance problems. However, this must be balanced against the probability of intermediate random cracks and increased curling at the joints.

The other factor that can cause curling is temperature differences between the top and bottom of the slab. The top part of the slab exposed to the sun will expand relative to the cooler bottom causing a downward curling of the edges (Figure 1B). Alternatively, during a cold night when the top cools and contracts with respect to a warmer subgrade, the curling due to this temperature differential will add to the upward curling caused by moisture differentials.

3. **HOW** to Minimize Slab Curling

The primary factors controlling dimensional changes of concrete which lead to curling are drying shrinkage, construction practices, moist or wet subgrades, and day-night temperature cycles. The following practices will help to minimize the potential for curling:

1. Use the lowest practical slump and avoid adding retempering water, particularly in hot weather.
2. Use the largest practical maximum size aggregate and/or the highest practical coarse aggregate content to minimize drying shrinkage.
3. Take precautions to avoid excessive bleeding. Use a damp, but absorptive, subgrade so that all the bleed water is not forced to the top of the slab.
4. Avoid using polyethylene vapor barriers unless covered with at least 25 - 50mm of damp sand.
5. Avoid a higher than necessary cement content if the subgrade is wet in service. Dense, impermeable concrete will produce larger top to bottom moisture differentials and curl more. Use of fly ash is preferable to a very high cement content, and consideration should be given to specifying strength at 56 or 90 days.
6. Cure the concrete thoroughly, including joints and edges. If membrane curing compounds and used, apply at twice the recommended rate in two applications at right angles to each other.
7. For floor areas where curling tends to be a problem, cure the concrete with a heavy wax floor sealing compound of the type used on terrazzo. (Note: Tile adhesives will not stick to these materials).
8. Use a joint spacing of approximately 25 to 30 times the slab thickness (see table below).
9. For thin toppings, clean the base slab to ensure bond and consider use of studs and wire around the edges and particularly in the slab corners.
10. Use a thicker slab.
11. The use of properly designed and placed slab reinforcement may help reduce curling.
12. Use dowels when placing a slab adjacent to an existing slab

Maximum Spacing of Control Joints*

Slab thickness mm	Slump 100 mm to 150 mm: Less than 20-mm aggregate: spacing, m	Slump 100 mm to 150 mm: 20-mm or larger aggregate: spacing, m	Slump less than 100 mm: spacing, m.**
100	2.4	3.0	3.6
125	3.0	3.8	4.5
150	3.6	4.5	5.4
175	4.2	5.3	6.3
200	4.8	6.0	7.2
225	5.4	6.8	8.1
250	6.0	7.5	9.0

* Given spacings also apply to the distance from control joints to parallel isolation joints or to parallel constructions joints.

** 20 mm and larger maximum size aggregate.

From CPCA "Design and Control of Concrete Mixtures" Fifth Canadian Metric Edition.

Atlantic Concrete Association / Association béton Atlantique

TELEPHONE (902) 443-4456 FAX (902) 404-8074

www.atlanticconcrete.ca

e-mail:info@atlanticconcrete.ca