Concrete Floors on Ground, EB075.04

Errata Sheet

Page iv, **Acknowledgements**, paragraph 5, line 2:

…Insight Engineering; Craig Dahlgren, Greenstreak, Inc.; ~~Nigel Parkes, PNA Construction Technologies;~~…

Page 96, **Figure 6-11**, Replace existing image with new figure below and modify caption:

***Figure 6-11.** Armored joint nosing (Photo courtesy of Canzac and Greenstreak) ~~(Photo courtesy of PNA Construction Technologies)~~.*

Page 100, **Table 6-2**, row 2, column 4, line 4, Remove "2" from dimensions:

…(1/4 x 3 1/2~~2~~ x 6 1/2)…

Page 102, **Figure 6-11**, Remove right bottom image and modify caption:

***Figure 6-19.** Plate dowels can be properly positioned in construction joints using either slotted forms or pocket-forming inserts. (Photos courtesy of McTech Group, Inc., and Greenstreak Group. Inc.~~, and PNA Construction Technologies.~~)*

Acknowledgements

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without causing extensive cracking within floor panels or joint widening beyond that needed by design.

Historically, joints have successfully been spaced farther apart in thicker slabs. Joint spacing has been investigated for many years in the concrete pavement industry (Smith 1990). Since fewer joints require less maintenance, many State Departments of Transportation have experimented with increasing joint spacing by the use of temperature steel and steel dowels for load transfer. In practice, regardless of the slab thickness or the use of steel reinforcement and load transfer dowels, the most common transverse joint spacing remains 4.5 m (15 ft) for the typical longitudinal joint spacing (lane width) of 3.75 m (12 ft). States have found that the risk of random cracking (and corresponding maintenance) is too costly with longer joint spacings.

For slabs on ground with large joint spacing or high shrinkage concrete, armored edges are often used to prevent spalling at construction joints (Figure 6-11). Armored joints with steel bars are generally sealed with an elastomeric sealant. Metallic aggregate mortar can also be used to armor joints, however, a semi-rigid joint filler is used to prevent joint spalling.

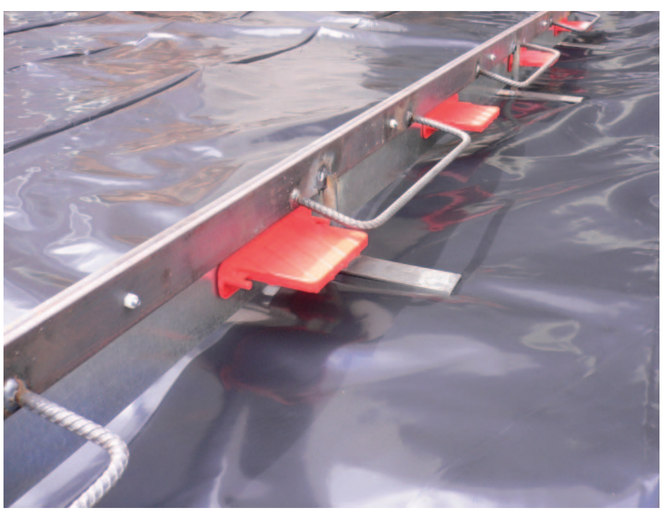
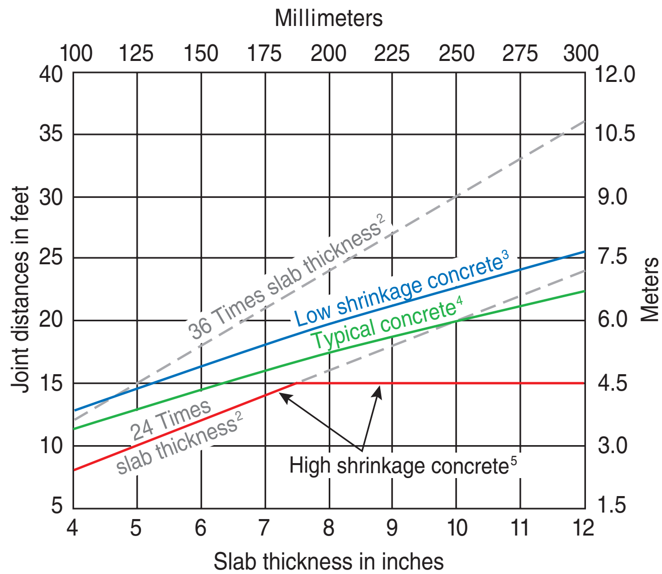


Figure 6-11. Armored joint nosing. (Photo courtesy of Canzac and Greenstreak.)

Joints should be spaced closer together if concrete cools significantly at an early age. Early-age cracking caused by cooling may occur if the difference between first-night surface temperature and maximum concrete temperature after placement exceeds 6°C to 8°C (10°F to 15°F). Later-age cracking caused by drying shrinkage may occur if high-shrinkage concrete is used or if the concrete is not adequately cured. Even at the suggested spacing, extensive cracking may occur if the concrete has a high-shrinkage potential, if it is improperly cured, or if it is exposed to early-age temperature drops mentioned above. Therefore, it is highly advisable that these conditions be considered when determining joint spacing. The American Concrete Institute (ACI 360R) recommends joint spacing based on the ultimate shrinkage potential of the concrete as shown in Figure 6-12. Joint spacing for three different categories of ultimate concrete shrinkage (low, typical, and high) are shown within the range of 24 to 36 times the slab thickness. The ultimate shrinkage potential can be determined from early-age test data using the prediction equation in ACI 209. The early-age data can be obtained using a shrinkage test such as ASTM C157 recommended by ACI 302 (see Chapter 4 for additional information on shrinkage).



NOTES:

1. Joint spacing recommendations based on reducing the curling stresses to minimize mid-panel cracking (Walker-Holland 2001). See discussion in Section 5.2 for joint spacing for aggregate interlock.
2. Joint spacing criteria of 36 and 24 times the slab thickness which has been utilized in the past is shown for reference.
3. Concrete with an ultimate dry shrinkage strain of less than 520 millionths placed on a dry base material.
4. Concrete with an ultimate dry shrinkage strain of 520 to 780 millionths placed on a dry base material.
5. Concrete with an ultimate dry shrinkage strain of 780 to 1100 millionths placed on a dry base material.

Figure 6-12. Joint spacing recommendations based on ultimate concrete shrinkage potential (ACI 360R).

Load Transfer by Dowels

When joint openings become wider, load transfer by aggregate interlock generally becomes less effective. Joint openings will be larger when longer joint spacings or high shrinkage mixes are used. To keep joint widths small, the spacing between successive joints should be kept small. For many industrial floors, however, contraction joint spacing is dictated by the location of columns or racks within the structure. The cost of forming and filling joints or the owner's desire to limit the number of joints may also result in larger joint spacings.

Steel dowels positioned at slab mid-depth can be used to transfer load between adjacent slab panels. Dowels are recommended for load transfer at butt-type construction joints. They can also provide load transfer at contraction joints when less effective aggregate interlock is anticipated. Smooth steel dowels can be round bars, bars with a square cross-section, or plates with a rectangular cross section. The most current industry recommendations for the size and spacing are shown in Table 6-2. Note that many factors affect the performance of dowels including joint widening, insufficient consolidation of concrete surrounding dowels, the use of an ineffective installation device of excessive greasing, and inappropriate installation methods. Designers should specify the size, shape, spacing and method of installation of dowels, In some applications the recommendation spacing of dowels may be conservative. Note that the sizing and spacing of some plate dowels is for a maximum joint opening of 5 mm (0.2 in.) so the shrinkage of the concrete should be evaluated to estimate potential joint widening and corresponding bearing stresses and long-term joint stability.

When properly installed, dowels transfer shear and help to reduce deflections and stresses as loads cross the joint. To be effective, concrete around dowels must be well-consolidated.

Table 6-2. Dowel Size and Spacing for Smooth Bars (Round and Square) and Plates[1]

	Dowel dimensions, mm (in.)				Dowel spacing center-to-center, mm (in.)			
Slab depth, mm (in.)	Round bars	Square bars	Plates at construction joint	Plates at control joints	Round bars	Square bars	Plates at construction joints	Plates at control joints
130 to 150 (5 to 6)	19 x 360 (¾ x 14)	19 x 360 (¾ x 14)	6 x 110 x 110[2] (¼ x 4½ x 4½)	9½ x 50 x 305[4] (⅜ x 2 x 12)	300 (12)	360 (14)	460 (18)	480 (19)
			6 x 90 x 165[3] (¼ x 3½ x 6½)				610 (24)	
			5 x 90 x 165[3] (3/16 x 3½ x 6½)				460 (18)	
180 to 200 (7 to 8)	25 x 410 (1 x 16)	25 x 410 (1 x 16)	9½ x 110 x 110[2] (⅜ x 4½ x 4½)	13 x 64 x 300[4] (½ x 2½ x 12)	300 (12)	360 (14)	460 (18)	460 (18)
			6 x 90 x 165[3] (¼ x 3½ x 6½)				610 (24)	
			8 x 90 x 165[3] (5/16 x 3½ x 6½)				610 (24)	
230 to 280 (9 to 11)	32 x 460 (1¼ x 18)	32 x 460 (1¼ x 18)	19 x 110 x 110[2] (¾ x 4½ x 4½)	19 x 64 x 300[4] (¾ x 2½ x 12)	300 (12)	300 (12)	510 (20)	460 (18)
			9½ x 90 x 165[3] (⅜ x 3½ x 6½)				610 (24)	
			13 x 90 x 165[3] (½ x 3½ x 6½)				610 (24)	

[1]Table values based on a maximum joint opening of 0.20 in. (5 min). Dowels must be carefully aligned and supported during concrete operations. Misaligned dowels may lead to cracking. (ACI Committe 325).

[2] Sides tapered 45°

[3] Cushioned sides without taper.

[4] Either tapered or rectangular. For tapered plates, the width shown is at the center of the plate and the taper angle is 4 degrees on each side. Rectangular plates should have compressible material securely attached on both vertical faces.

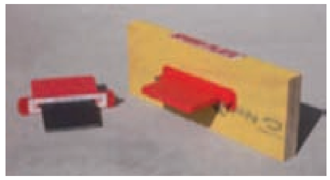


Figure 6-19. Plate dowels can be properly positioned in construction joints using either slotted forms or pocket-forming inserts. (Photos courtesy of McTech Group, Inc., and Greenstreak Group. Inc.).

geometry of the plate (45° tapered sides) or by cushioned sides (either on the steel plate or within the plastic insert) similar to the square dowel bars with clip-on attachment. Unlike conventional round dowel bars which extend farther into the slab, plate dowels can be positioned closer to slab corners (construction joint intersections) than conventional round dowel bars. This allows for load transfer at the intersection of construction joints where warping is often greatest (Figure 6-20). Under certain circumstances, round dowels can

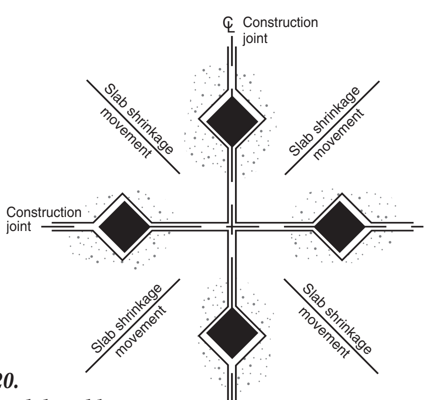


Figure 6-20. Unlike round dowel bars, plate dowels can be positioned near slab panel corners at construction joint intersections to provide load transfer at corners. Dowels have either a 45 degree taper (above, from ACI 302.1R) or cushioned sides (right) to allow unrestrained movement. (Photo courtesy of McTech Group, Inc.)

cause restraint to lateral movement perpendicular to the bars and parallel to the joint. This movement will create internal stresses and cracking (Schrader 1991).

Compared to the traditional round smooth dowel bar, plate dowels (with sleeves or forming systems):

- are easier to place properly;
- allow lateral horizontal slab movement parallel to the joint;
- minimize stress concentrations both on the slab and on the dowel; and

Dowels must not be confused with tie bars. Because dowels are smooth, they allow joints to open and close and are used at construction joints and, when necessary, contraction joints. Joints that contain tie bars, on the other hand, can not function as contraction joints. Tie bars are fabricated from deformed reinforcing bars so they bond to concrete on both sides of the joint. Tie bars are not recommended for joints intended to open and relieve the stresses in the concrete. The restraint of movement across the joint increases the potential for mid-panel random cracking.

Load Transfer by Keyways

Keyed joints are also known as tongue-and-groove joints. They consist of a projection on one joint face with a matching indentation on its abutting face. In theory, this keys the slabs together. Keyways should never be used in floors exposed to hard-wheeled traffic. In the past, keyed joints were recommended for load transfer at construction joints in some floors.

In practice, keyed joints do not remain tight enough to provide substantial load transfer. As the floor slabs shrink, the key loses contact with its matching recess (Figure 6-21). Slab edges then deflect as loads roll over the joint. This loss of load transfer is an inherent weakness of keyed joints, especially in heavily loaded floors. In addition, breakage frequently occurs in the unsupported upper shoulder of the female side of the joint.

FILLING AND SEALING JOINTS

There are three options for treating joints: they can be filled, sealed, or left open. Joint filling minimizes spalling in joints exposed to hard-wheeled traffic. Where the traffic loading is lighter, joints can be sealed instead. The difference between a filler and sealer is the hardness of the material; fillers are more rigid and provide compressive lateral support to slab edges (joint walls). When insect infestation or radon exposure