Sawcutting Joints in Concrete

Learn why sawcut joints are needed and where, when, and how to make the cuts

By Bruce A. Suprenant

Before 1925, most concrete slabs were built without joints of any kind except for construction joints. Sawed joints were first used as a substitute for formed joints in 1949 on concrete pavements in Kansas. Today, sawed joints are widely used and specified for both paving and industrial floor construction. That's why it's important for contractors who build commercial and industrial floor slabs to understand the why, where, when, and how of sawcutting joints.

Why Sawcut Joints

Sawcut joints minimize random cracking due to drying shrinkage and temperature changes. The weakened sections created by the joint cause the cracks to form at these locations. Cracking occurs beneath the sawed slot when the shrinkage stress exceeds the tensile strength of the concrete.

Sawed joints are widely used in both paving and industrial construction for efficient and cost-effective crack control. The benefits of sawcut joints include:

- Consistent joint dimensions (same width and depth at each cut)
- Straight, clean cuts
- Good joint sealant performance
- No interference with concrete finishing operations
- Cost-effective for concrete placements of any size
- A longer window of sawability than the window for jointing by hand

Where to Sawcut

Sawcut joints in the same locations as hand-tooled joints (Figure 1). Contraction or control joints should be sawcut on or at the center of column lines, with intermediate joints between column lines as necessary to keep the maximum distance between joints at 24 to 36 times the slab thickness. The resulting panels should be as square as practical, dividing a large floor area into relatively small panels. Never make the long side of a panel more than 1½ times the short side.

In general, joint spacing to control drying and thermal shrinkage should range from 12 to 25 feet in unreinforced and lightly reinforced concrete floors. Variations in joint spacing result from differences in local conditions such as concrete materials and mixes, climate, construction practices, and subgrade or subbase restraint. However, avoid elongated or L-shaped panels, reentrant corners, and sharp corners. Also, decrease joint spacing when using concrete suspected of having high shrinkage characteristics.

Make sawcuts continuous, not staggered or offset. If an engineer has designed the slab, locate the joints according to the plans. In concrete floors that contain continuous steel reinforcement, don't continue the bars across the joint unless the bars are close enough to the surface to be cut by the saw. Unless the slab is only lightly reinforced, the sawcut will be relatively ineffective in controlling crack location if continuous bars aren't cut.

Joint spacing on commercial or industrial floor slabs subject to forklift traffic is usually wide, about 36 times the slab thickness. Though a few random cracks may occur because of the wide joint spacing, this is usually preferable to the cost of maintaining a large number of joints. Typically, the more joints a floor contains, the more it costs to maintain the joints. The joints are also more likely to spall under forklift traffic.

When to Sawcut

The timing of sawing joints in concrete is crucial (Figure 2). Correct timing depends on many variables such as weather conditions, concrete mix design, aggregate size and hardness, blade type and size, curing, and subgrade conditions. Sawing too early causes raveling, or the dislodging of aggregate, which results in joint spalls. Sawing too late results in uncontrolled cracking.

Industrial floor slabs usually are sawed four to 12 hours after finishing. In hot weather, the sawcut time is about four hours after final finishing. In cold weather, joints are sometimes not sawed until 48 hours after final finishing. The saw operator typically makes trial cuts a few hours after final finishing. If aggregate particles come loose, it's too soon to sawcut the joints. Begin sawcutting as soon as the raveling stops during the trial cuts.

Because sawcutting green concrete decreases blade life, some sawing contractors delay sawing to

maximize blade life. Sawing, however, should not be delayed so long that the concrete develops significant tension from shrinkage. If it is delayed, as the saw moves across the floor cutting a joint, tension in the slab is resisted by less and less concrete until, as the saw approaches the edge, the concrete can no longer sustain the tension. The result is an unsightly crack that develops ahead of the saw.

Use an experienced saw operator to assure that sawing is done at the proper time. A good operator relies on experience to determine when the concrete is ready to cut. If the concrete isn't ready, the operator will delay sawing. The operator should be prepared to saw at any time of day or night in any type of weather; equipment should be available for any contingency, including a standby saw in case of equipment failure.

To ensure a quality job and avoid large labor-overtime costs, many concrete contractors subcontract the sawcutting to specialty contractors.

Unacceptable raveling. Sawcutting too early in concrete, before the cement completely hydrates, causes unacceptable raveling. Most saw operators determine the earliest time to sawcut by judging the degree of raveling in trial cuts made in the slab. Recent research (Ref. 1), however, provides the approximate minimum compressive strength of concrete required before joints can be sawcut with minimal raveling (0.12 square inch per 24 lineal feet of sawcut joint).

The maturity method and the pulse velocity technique were also found to provide reasonable field estimates of concrete compressive strength to determine the earliest time to sawcut joints. As Table 1 shows, the earliest sawcutting occurs in concrete with high cement contents and rounded, soft, coarse aggregate. Sawcuts through these aggregates are less likely to break the surrounding strong bond created by the high cement content. As the saw blade cuts through crushed, hard aggregate, the concrete needs a higher compressive strength to maintain paste-aggregate bond and to minimize undesirable raveling.

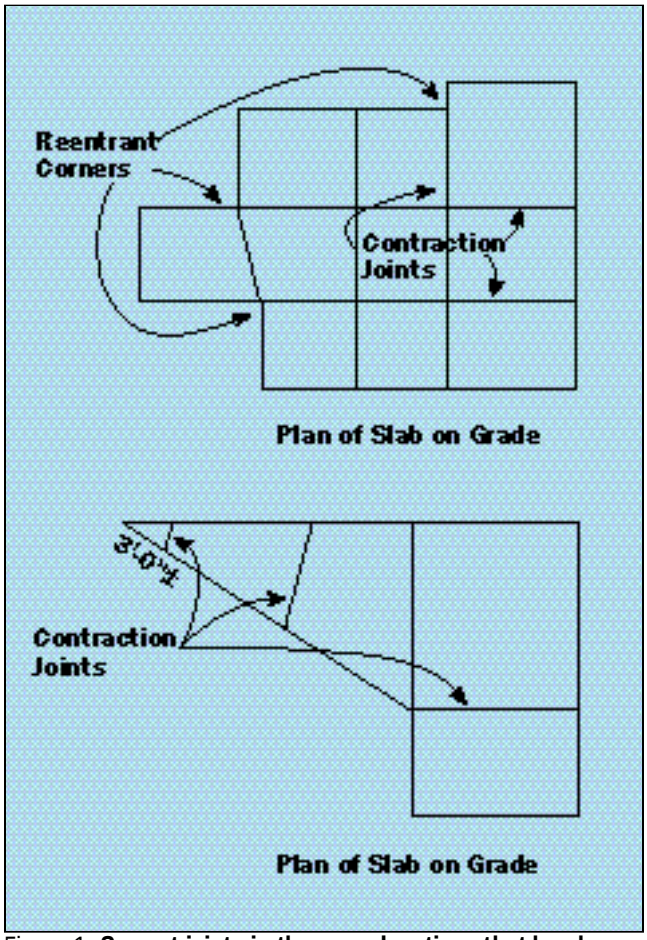

Figure 1. **Sawcut joints in the same locations that hand-tooled joints require. Be sure to locate a contraction joint at all reentrant corners to prevent radial cracking of the slab.**

Uncontrolled cracking. Joints must be sawcut before random cracking occurs. Experience and research (Ref. 1) show random cracking occurs as the top slab

Table 1. Compressive Strength, Pulse Velocity, and Maturity Values for Acceptable Sawcut Joints

Aggregate Geometry	Aggregate Hardness	Cement Content, pcy	Compressive Strength, psi	Pulse Velocity, fps	Arrhenius Maturity, hrs	Nurse-Saul Maturity, °F-H
Crushed	Soft	500	730	11,101	18.4	530
		650	530	10,376	14.5	440
Crushed	Hard	500	1,270	12,353	33.8	817
		650	1,010	11,835	25.1	667
Rounded	Soft	500	470	10,105	13.5	414
		650	310	9,163	10.8	343
Rounded	Hard	500	920	11,624	22.7	621
		650	690	10,973	17.6	512

Maturity relationships based on equivalent age at 68° F and a datum temperature of 32° F.
Source: (Reference 1)

surface cools during the early evening or night immediately following the concrete placement. Random slab cracking can also occur if the surface is cooled by rain after concrete placement.

Test results show cracking occurs when concrete immediately below the slab surface cools more than 15° F. Because of cooling rates and safety factors, Reference 1 suggests sawcutting all joints before the concrete surface cools 7° F. However, in some climates concrete can cool 15° F in one hour. Instead of waiting for a 7° F surface cooling, consider waiting until the latest time possible to sawcut joints after the surface starts to cool. Measuring surface cooling is easy and inexpensive with a thermometer.

Equipment affects timing. The saw and blade type are also important in the timing of joint sawing. Diamond blades last longer when concrete is stronger. Early sawing dislodges loose diamond particles. Some contractors delay sawing as long as possible, just before random cracking occurs, to minimize excessive blade abrasion. Silicon carbide blades, on the other hand, wear less when sawing is performed sooner. However, be sure to wait until the concrete can be sawed without unacceptable raveling.

Occasionally, contractors are faced with a situation where concrete is too green to sawcut without raveling, but random cracking is occurring. When this occurs, make sure the blade is matched to the concrete. Most experienced saw operators carry different saw blades to each job so the blade can be matched to the concrete and saw timing requirements. Sometimes even an asphalt cutting blade works best.

Even if the concrete strength is adequate, joint raveling can be caused by using the wrong equipment or an inexperienced saw operator. If the concrete seems strong enough, make sure the saw operator isn't causing joint raveling by:

- Using an improperly tensioned or balanced blade that creates vibrations
- Pushing the blade too hard through the cut
- Running the saw at high blade revolutions per minute (slow speeds are preferred for green concrete)
- Using a saw with a loose or bent spindle

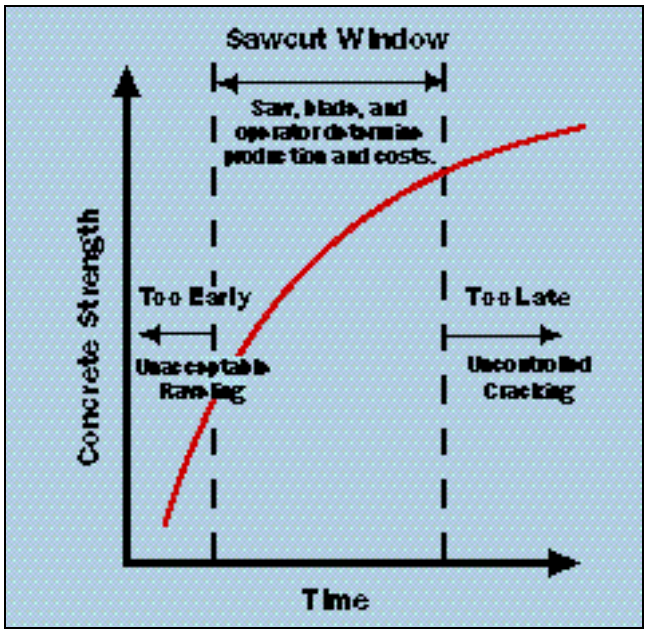

Figure 2. **Careful timing of joint sawing is important. Sawing too early can cause raveling. Sawing too late can result in uncontrolled cracking. Factors that affect timing include weather conditions, concrete mix design, aggregate size and hardness, blade type and size, curing, and subgrade conditions.**

How to Sawcut

Mark all proposed joints to be sawcut with a chalk line. After checking the equipment and examining the blade, position the saw at the line. Start the saw, but turn the water cooling system on before the blade contacts the concrete. Maintain adequate water flow at all times; usually 2 to 5 gallons of water per minute are needed to cool the blade. Let the blade contact the concrete, and guide the saw along the chalk line. Without forcing, allow the blade to sharpen itself on the material being cut.

Maintain steady, even cutting pressure. Avoid twisting the blade in the cut and never force it beyond its cutting capacity. If forced, the blade will become polished, stop cutting, and may become distorted. Also, don't let the blade spin in the cut. This practice, called "babying" or "sandbagging" the blade, increases wear on the bond, causing diamonds to pop out before they've done much work.

Stand at the rear of the saw, not at the side or front of the blade, while the machine is operating. Wear safety glasses, hearing protection, hard hat, and safety shoes. Operators using dry-cut blades may also need respirators.

Depth of cut. Current accepted practice is to cut the joint one-quarter to one-third the slab thickness. This forms a plane of weakness in which the crack forms. Vertical loads are transmitted across the joint by aggregate interlock between the opposite faces of the crack, providing the crack is not too wide.

Always check sawcut depth. If the joint is too shallow, random cracking can occur; if the joint is too deep, aggregate interlock may be insufficient to transfer vertical loads. A worn blade or riding up of the saw over coarse aggregate can also cause cuts to be too shallow.

Though little research has been done to verify the effectiveness of these guidelines, experience indicates satisfactory joint performance when these recommendations are followed. The depth of the joint is important, but other factors such as time of sawing, slab design (thickness, base type,

and slab length and width), curing conditions, and sawing techniques also influence the initiation and propagation of uncontrolled cracking.

One statistical study (Ref. 1) verifies the adequacy of currently acceptable sawcut joint depths (Figure 3). As Figure 3 shows, for a sawcut depth of about 30% percent of slab thickness, cracks occur below sawcuts with a probability of 88% for shrinkage stresses and about 98% for warping or curling stresses.

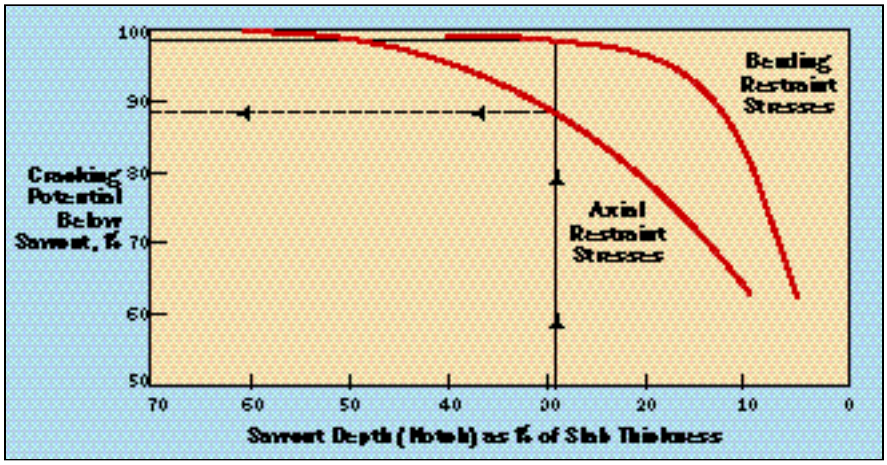

Figure 3. **Probability that a crack will occur below a sawcut when the depth of cut is about 30% of slab thickness: 88% for shrinkage stresses and about 98% for warping or curling stresses.**

Sawcut joint sequence. Transverse joints perform best when joints are sawed consecutively, starting where the concrete was first placed and finished. This permits all joints to begin opening at about the same time and makes joint movements more uniform, improving sealant performance and load transfer. In hot weather, it may be necessary to saw every third or fourth joint (spacing them no more than 60 feet apart) to create a relief joint to prevent early random cracking. The intermediate joints can then be sawed later, but usually no later than three days after the relief joints are cut. This is only an emergency procedure to reduce uncontrolled cracking and has the disadvantage of causing larger joint openings at the relief joints.

Joint curing. Sawed joints are particularly susceptible to damage if concrete strength is low because of insufficient curing. Spray the joint with a curing compound if the joint won't be sealed. If the joint is to be sealed, curing compounds can't be used because they prevent bond between the joint sealant and the concrete.

One common method of curing the exposed concrete in the joint is to apply the joint sealant immediately after the joints are sawed and cleaned. However, if the joint is immediately sealed after sawing, be prepared to reseal the joint six to 12 months later because the joint widens once the majority of concrete shrinkage has occurred.

Other methods of curing joints to ensure maximum strength and reduce potential curling include a wet burlap covering, wet sand, plastic coverings, and a wet rope inserted into the joint. If wetting methods are used, be sure to rewet the materials as needed.

References

1. *Guidelines for Timing Contraction Joint Sawing and Earliest Loading for Concrete Pavements, Volumes I and II: Final Report,* FHWA-RD-91-079, Federal Highway Administration, Research and Development, Turner-Fairbank Highway Research Center, 6300 Georgetown Pike, McLean, VA 22101, February 1994.

Editor's Note

Another method of sawcutting joints not discussed in this article uses a special type of dry-cut saw that can cut joints in concrete soon after placement. Joints cut by this method also minimize random cracking in slabs due to drying shrinkage and temperature changes.

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