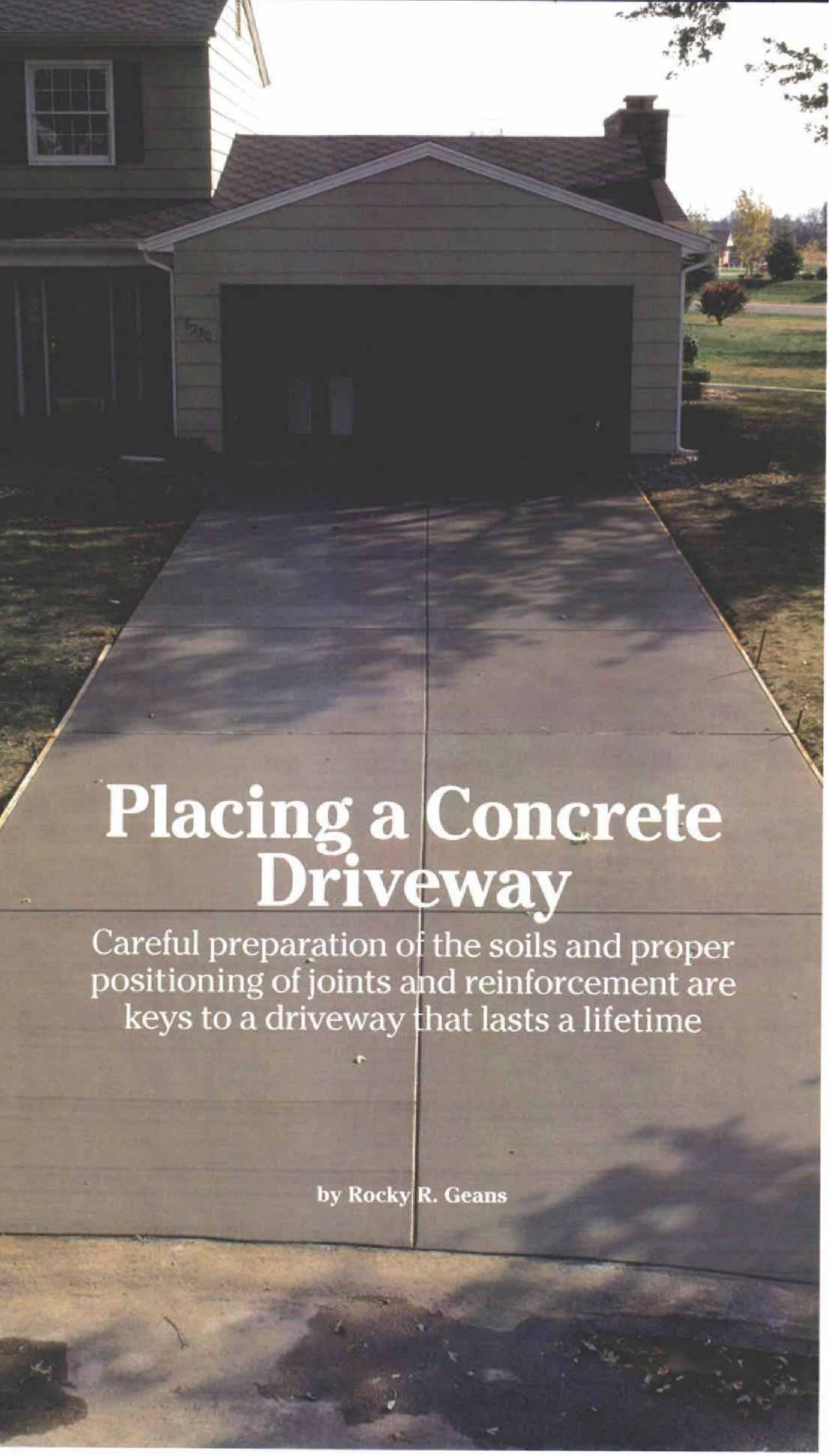


Placing a Concrete Driveway

Careful preparation of the soils and proper positioning of joints and reinforcement are keys to a driveway that lasts a lifetime

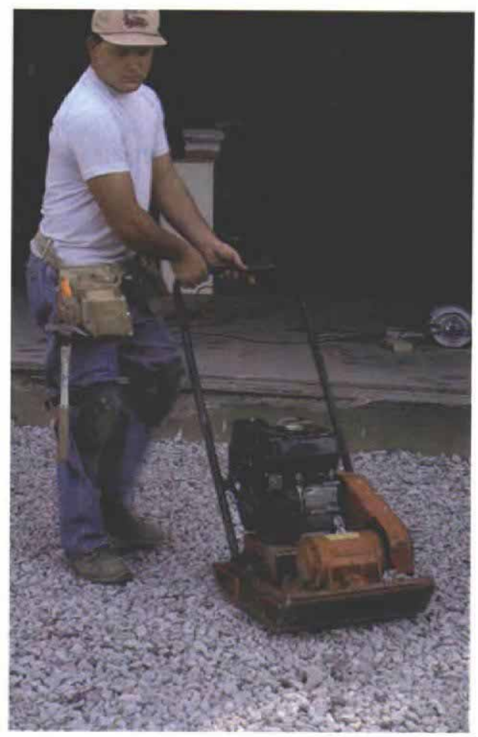
by Rocky R. Geans

An attractive, long-lasting alternative to asphalt. Properly installed, a concrete driveway will stand up to lifetime of vehicular traffic with minimal maintenance.

A few years back, we had just finished a driveway at a house in South Bend, Indiana. We were about to call it a day when the homeowners' dog got loose, burst into the garage and used our freshly placed concrete drive as his escape route. When the dog heard us holler, he stopped in the middle of the driveway. Then we tried to get him back inside, which made him scamper back and forth on top of the concrete, making a bad situation worse. We ended up refinishing the whole driveway and giving that dog a scrubbing he'll never forget.

A driveway is only as good as the soils beneath it—We've been putting in concrete driveways for 30 years, and a crucial part of proper driveway design is making sure the materials below the concrete are adequate (drawing facing page). The first 6 in. to 8 in. of material directly below the concrete is the base. The subbase is the soil 8 in. to 12 in. below the base, and the subgrade is usually the native or naturally occurring soil below the subbase. The design thickness of each layer depends on the soil being built on. Acceptable natural soils such as sand and gravel let moisture drain. If the subgrade consists of this type of soil, then it can be compacted to serve as the base and subbase, and more excavating and filling are unnecessary.

However, if the subgrade is clay, peat or fine-grained silty soil that holds moisture and drains



Recycled concrete forms the subbase. Coarsely crushed concrete is compacted to provide a drainage layer and a capillary break to prevent moisture from wicking up.

poorly, removal of up to 20 in. of subgrade soil might be necessary, depending on the support value of the soil. If you have doubts about the soil characteristics in your case, it's worth hiring a soils engineer to do an evaluation.

Establish driveway elevations early for proper drainage—Prior to excavating and backfilling, the exact elevation of the top of the drive should be established. Then, as earthwork is being done, base grades can be brought up with equipment usually to within an inch of their required height, which saves on hand-grading later. For the best drainage, we try to drop the driveway at least ¼ in. per running foot away from the house.

Some situations prevent proper drainage, such as an area of concrete that is locked between a house and a garage. In these cases a catch basin may have to be installed as part of the driveway's drainage system.

The best way to remove water from a catch basin is to use a drain pipe at least 4 in. in dia. that returns to daylight or to a storm sewer that is located safely away from the house. A second method is connecting the catch basin to a dry well. In the most extreme cases, a sump pump is installed to pump collected water to a safe place. The last solution is the most costly and probably should be used only with the recommendation of an engineer.

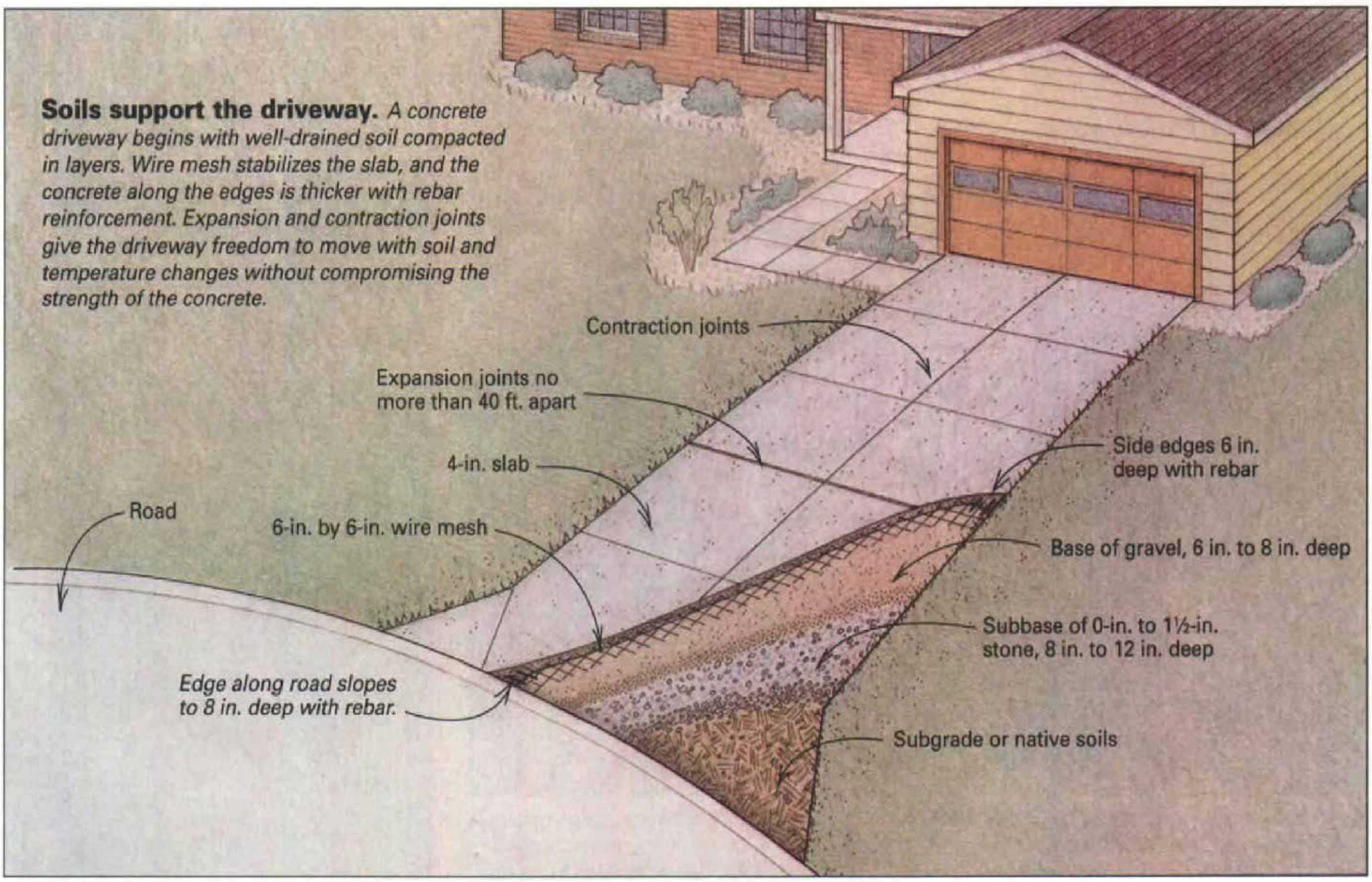
Soils must be compacted to support the driveway—I check soil compaction initially by walking over the area to get a feel for firmness. Additionally, I shove a ¼-in. to ½-in. dia. smooth steel rod into the soil in several places to check the resistance. If the soils are properly compacted, the rod should encounter firm, even resistance over 2 ft. to 3 ft. However, if the rod meets resistance, say, in the first 6 in. and then can be pushed farther into the soil with ease, it's a sure indication that only the top 6 in. of soil is compacted and that the lower layers of soil are loose. Over time, loose, uncompacted soils will settle as storm water drains through them. Soil settling leaves voids that greatly increase the odds for driveway cracking, sinking or even collapsing in certain areas.

If testing reveals uncompacted soil layers below a top layer that is compacted, then the top soils need to be removed and lower levels compacted properly before the base layers are replaced. In many instances the top 12 in. may be properly compacted while the next 3 ft. to 4 ft. are loose. Ideally, the soils should be excavated down to solid native soil (usually no more than 4 ft.). The soil is then replaced and compacted in 6-in, layers called lifts.

In new construction where excavation has occurred for a foundation, soils should be backfilled and compacted in 6-in, lifts all of the way to final grade. Otherwise, concrete work such as driveways, sidewalks and patios will settle over time and slope or fall inward toward the house. If there are doubts about compaction in any situation, some companies perform on-site compaction tests, a minor investment that can buy peace of mind.

In addition to being properly compacted, the subbase and base need to be made out of materials that will form a capillary break. A capillary break is a layer of soils large and coarse enough to prevent water from being drawn up into them through capillary action the way lamp oil is drawn through a wick. Moisture allowed to wick up and accumulate in soils beneath the driveway slab will freeze, expand and create frost heaves in the slab. Zero-in, to 1½-in. stone or recycled concrete (see Cross Section, p. 38) for a subbase compacts well (photo right, facing page) and creates a good capillary break.

The forms determine the final grade of the driveway—After the soils have been layered and compacted satisfactorily and the proper grades established, the driveway forms can be laid out and installed. We usually make our forms out of 2x4s if the driveway is to get a 4-in, slab or 2x6s for a 6-in. slab. The forms need to be staked strongly enough to hold the concrete and to withstand screeding without movement, so we drive our stakes every few feet. Wooden stakes are okay, but they don't hold up well to



Soils support the driveway. *A concrete driveway begins with well-drained soil compacted in layers. Wire mesh stabilizes the slab, and the concrete along the edges is thicker with rebar reinforcement. Expansion and contraction joints give the driveway freedom to move with soil and temperature changes without compromising the strength of the concrete.*

Drawing: Vince Babak

The base layer is graded to the proper height. The laser level in the background is used to set the forms to the correct height. The crew then grades the base to the forms, and the base gets compacted one last time.

Expansion joints get a plastic cap for installation. Expansion joints act as buffers between driveway sections. After the concrete has cured, the plastic cap is removed, and sealer fills the joint to keep out moisture and light.

Wire mesh is pulled up on top of a thin layer of concrete. A crew member pulls the wire-mesh reinforcement up to the proper height with a rebar hook. A bead of concrete laid first supports the mesh during placement.

Screeding cuts concrete to the right height. A long, straight 2x4 or aluminum box beam is pulled across the surface of the concrete while it is moved in a side-to-side motion. Screeding brings the level of the concrete down to the top of the forms and consolidates it at the same time.

being driven and generally can be used only once. On most jobs we use commercially available round metal stakes with predrilled holes for nailing the stake to the form.

The driveway featured here was placed on a nice, gently sloping lot. We began by setting the forms to the natural grade along one side. On the opposite side we ran a string at the exact width of the finished slab. We staked the forms for this side along the string at roughly the correct height. Next, we leveled from one side to the other to set the exact height of the opposite forms, driving the stakes deeper or pulling them up to adjust the height. We've found that a laser level is the quickest and easiest tool for setting the height of our forms, although a transit or even a water level can be used.

Our forms usually receive a coating of release agent (a special oil available from concrete-supply houses) to provide better consolidation of the adjacent concrete and to make removal easier. After the forms are set, we grade the base layer of soil to its exact elevation (photo top left) and run the compactor over it one last time. Then we dig the edges of the driveway down a couple of inches. The thicker concrete along the perimeter provides additional support as well as protects against erosion of the soils next to the drive. We also incorporate a double run of rebar along the edges for additional support.

Expansion joints allow the concrete slab to move with changes in weather—Another crucial part of the driveway layout is planning for contraction and expansion joints. Contraction joints are added during placement, so I'll discuss them later. Expansion joints, installed

before concrete placement, allow the driveway to move both horizontally and vertically. Most people think concrete is solid and unmoving. However, concrete not only moves in relation to other solid structures, such as foundations and roadways, but it also expands and contracts with temperature changes and moves as soil conditions beneath the slab change.

Expansion joints provide a full division between different sections of concrete placement. For the driveway featured in this article, expansion joints were placed between the driveway and the sidewalk to the front door, between the driveway and the garage apron, and between the two main-driveway slabs that were placed or poured separately. We didn't need an expansion joint between the driveway and the asphalt roadway, but a joint is required if the roadway is concrete. An expansion joint consists of a thin layer of energy-absorbing material such as asphalt-impregnated fiberboard, plastic foam, wood, cork or rubber. For most driveways, we use ½-in. thick fiberboard installed with a plastic cap strip on top (photo center left, facing page), flush with the finished height of the slab. After the concrete has set up, the cap strip is removed, and we fill the top of the joint with a joint sealant, SL-1 (Sonneborn, Chem-Rex Inc., 899 Valley Park Drive, Shakopee, Minn. 55379; 800-433-9517), which protects the joint from moisture penetration and UV-degradation. The joint sealant also matches the color of the concrete to add a more pleasing look to the joint.

Expansion joints serve several functions in a concrete driveway. First, the expansion joint provides relief between slab sections as the concrete expands and contracts with temperature changes. This movement is horizontal, and the joints that serve this function should be placed no more than 40 ft. apart in any direction. To facilitate this horizontal movement, the base that rests below the slab has to be smooth and well-compacted, with no obstructions such as rocks or holes, which can fill with concrete and restrict movement.

The concrete slab needs to be able to slide back and forth over the base. Any restriction of this movement will contribute to cracking. Even the thickened edge at the roadside is designed with a gradual slope from 4 in. to 8 in. rather than having an abrupt 90° excavation that would restrict slab movement.

Expansion joints also serve as a buffer between the driveway slab and the adjoining rigid structures, in this case the sidewalk and the garage. Movement at these points is vertical; the driveway moves in reaction to changes in the soils beneath the slab. An example is the soil swelling that occurs when moisture in the slab freezes. Without the aid of the expansion joint, the slab would chip or crack as it slid by slight imperfections in the abutting concrete.

Another way we restrict vertical movement is by drilling and installing steel dowels into adjoining rigid cement work, such as a foundation just below the driveway slab. A ⅜-in. by 12-in, dowel works well in most situations.

The foundation, which is bearing on a footing below frost level, should not move. However, the driveway, which rests on soils only 4 in. to 6 in. below grade, will almost certainly experience some degree of movement. We want to give the drive the freedom to move up but not to drop any lower than the dowel.

We also use dowels to maintain alignment between the driveway and existing flat work, such as sidewalks. The dowel should be smooth and installed parallel to the concrete, not at an angle. Rebar can be used for this application, but it won't work as well because of its rough texture. We drill a hole into the existing flat work slightly larger than the diameter of the dowel, which allows for expansion and contraction. These dowels should be installed a minimum of 2 ft. o.c.

Wire mesh is the best reinforcement option–Next we place the reinforcement. We use 6-in, by 6-in, wire mesh throughout the slab as reinforcement. Wire mesh is not designed to prevent concrete from cracking. However, it does prevent widening or horizontal separation of cracks that form.

There are many claims that cracking can be eliminated by mixing nylon or steel fibers with the concrete. I've used fiber mesh on a couple of large parking lots, and I have mixed feelings about the long-term results. I still think that wire-mesh reinforcement installed correctly is best.

In most cases wire mesh is pulled up into the wet concrete while it's being poured, ideally 1 in. to 1½ in. above the bottom of the driveway slab. We have the concrete truck place a bead of concrete at a uniform height that supports the wire mesh while the rest of the concrete is being poured (photo center right, facing page). Another method that I prefer (although it's probably more time-consuming) is setting the wire mesh on 1½-in. chairs that keep the wire at a more consistent height.

When the wire mesh is in place, I make sure everything has been prepared properly and that

Working the edges. A crew member with a flanged edging tool works along the perimeter of the slab to consolidate material and to rough-cut the rounded edge.

A bull float smooths the concrete and fills voids. As the crew member in the foreground pulls the wide blade of the bull float over the concrete, surface tension is created to bring water to the surface and fill in imperfections from screeding.

every tool needed for finishing the slab is on hand. The next step is ordering the concrete.

Order the right concrete mix–Concrete mixes vary depending on the application. But for most driveways, we use a six-bag limestone mix (4,000 psi) with approximately 6% air entrainment. Air entrainment is the incorporation of microscopic air bubbles throughout concrete to help prevent scaling, the flaking or peeling that occurs on cured-concrete surfaces.

The mix order should also include the slump requirement, or the wetness of the concrete when it's delivered. Slump is measured on a scale of 1 to 12 with 1 being the driest mix. For most driveways, we request *a* slump of 4 to 5, which is easy to spread but can be worked shortly after it is poured. After a mix has been prepared to specifications, adding water can weaken it. The concrete supplier is responsible for the slump as well as the strength of the mix, and the concrete should arrive as ordered. If concrete arrives too wet, it can be sent back.

Screeding creates the level of the slab– Trucks in our area are able to distribute concrete pretty evenly by controlling the flow of material and the direction of the chute. We work the concrete along the edges to consolidate it and to remove any voids. Then the concrete is raked to a rough elevation just slightly higher than the forms and expansion joints. We make sure we never get too far ahead of the screeding process so that any excess can be easily raked down to areas waiting for concrete.

Screeding cuts in the grade of the slab and consolidates the concrete before bull floating (photo bottom left, p. 84). It's usually done with a long, straight 2x4 (we sometimes use an aluminum box beam screed rail), slightly longer than the width of the driveway. The 2x4 or screed rail that rides on the forms is pulled across the wet concrete with a side-to-side reciprocating motion.

After two or three yards have been placed, the edges should be hand-floated and cut in with an edging tool (photo right, p. 85). The screeded concrete can now be bull-floated (photo left, p. 85). A bull float is a wide, flat metal float mounted on the end of a long handle. As the float is pushed and pulled over the screeded concrete, the leading edge must be elevated to keep from digging in. If the float is mounted on the handle at a fixed angle, bull-floating can be a real workout. The best bull floats have a blade that rotates back and forth by simply twisting the handle; this design allows the operator to keep the handle at a constant, comfortable angle. As the bull float rides over the concrete, it creates surface tension that brings water to the top, which smooths the slab and fills in minor voids at the same time.

After bull-floating, the concrete should be left alone until all bleed water on top of the wet concrete has evaporated. At this point the concrete should be strong enough to support a crew member on kneeboards, which I'll describe later, and is ready for finishing. Finishing the concrete too early can trap water and create a weak surface with a high water/cement ratio.

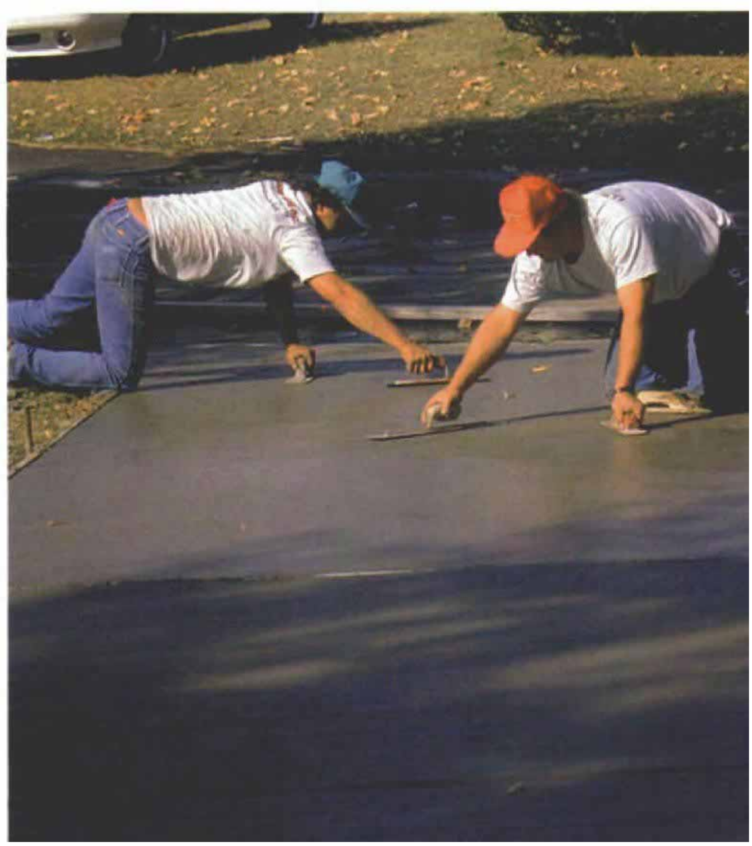
Contraction joints give the slab a place to crack–The first part of the finishing process is laying out and cutting the contraction or control joints (photo bottom left). Contraction joints act as score marks in the concrete; they create weak points and encourage any cracks that might develop to occur at the joints. To understand how contraction joints work, I need to explain why concrete cracks.

Concrete begins to crack before receiving any loads whatsoever. As the concrete cures and dries, water is absorbed into base materials and evaporates through the surface, which causes the concrete to shrink or contract. Cracks form in the concrete as a result. Contraction joints provide the relief needed so that these cracks form along a joint instead of randomly in the surface of the slab.

Maximum spacing of contraction joints should follow this rule of thumb. Multiply the thickness of the slab by 2½, and that number represents the maximum distance in feet between joints in any direction. The slab for this driveway was 4 in. thick, so the maximum distance between the joints is 10 ft. (4x2.5 = 10).

The depth of the joint should be no less than one-quarter of the thickness of the slab and should be cut in either during the finishing process or immediately afterward. For this driveway we cut the joints with special tools called groovers. We begin by stretching a string between our layout lines and snapping it to leave an impression in the wet concrete. We work the groovers along straightedges to cut in the joints. Thicker slabs require deeper joints that are cut

A special tool cuts the contraction joints. Contraction joints score the slab so that cracking from the curing process occurs at these points rather than at random.



with saws equipped with blades designed to handle fresh, or green, concrete.

Kneeboards distribute body weight when you're finishing fresh concrete—After bull-floating, all of the steps in finishing concrete, including cutting in the contraction joints, require a crew member to work in the middle of the slab on top of the uncured concrete (photo below). To keep from sinking into the fresh concrete, this crew member works on a pair of kneeboards. We make our kneeboards out of ½-in. plywood about 24 in. long and 16 in. wide. We cut the corners off to keep them from digging into the fresh concrete, and we put a handle on one end that helps a lot when the crew member is moving them around on the slab.

After the contraction joints have been cut, the crew works the surface of the slab one last time. For most driveways one crew member works the center of the slab while two work the edges. First they go over the surface with an aluminum or magnesium hand float with a thick blade slightly round in section. This process, known as magging, releases air that might be trapped in the concrete from bull-floating and leaves a smooth, open texture on the uncured concrete.

As a final step, a trowel with a thin, broad metal blade is passed over the surface in large circular strokes. Troweling should leave the surface of the slab smooth and flat. If any slurry from the magging gets into the contraction joints, it will be necessary to go back over them with the groover and blend the edges of the groove into the rest of the slab with a trowel.

A broom gives the driveway a rough surface—We give most of our exterior flat work, including driveways and sidewalks, a broom finish for traction. Right after troweling, a crew member drags a wide broom over the slab in smooth, parallel strokes (photo right). We use a fine-bristled broom made either of nylon or of horsehair. A coarse broom will dig into the surface too deeply and dislodge the aggregate. Because this driveway was double wide, the crew member started at the middle and dragged the broom to the outer edge for each side of the slab. The broom should be cleaned by dipping it in water after each stroke to keep excess concrete from building up in the bristles and changing the texture.

Right after we finish, we spray on Kure-N-Seal, (made by Sonneborn; see address p. 85), a combination curing and sealing compound. Used to prevent water from evaporating too rapidly, curing compounds form a membrane on the surface of a slab. Application of curing compound effectively slows the curing rate, and the longer concrete takes to cure, the stronger it becomes. Concrete treated with curing compound also has better resistance to scaling. Sealing compounds prohibit moisture from getting into the concrete once the concrete has cured. Because the concrete's curing takes several days, we recommend not allowing vehicular traffic on the slab for a week. □

Rocky R. Geans is the owner of L. L. Geans & Sons, concrete contractors of Mishawaka, Indiana. Photos by Roe A. Osborn.

A broom finish provides traction. A broom finish is applied to the still-wet concrete after it is troweled. A wide, fine-bristled broom is dragged slowly in parallel strokes from the middle of the slab out and is cleaned with water between strokes.

Kneeboards keep the middle man from sinking in the concrete. The crew works the surface for the last time, going over it first with magnesium floats and then doing a final smoothing with flat-bladed trowels. The crew member in the middle works on plywood boards that distribute his weight and keep him from sinking into the slab.