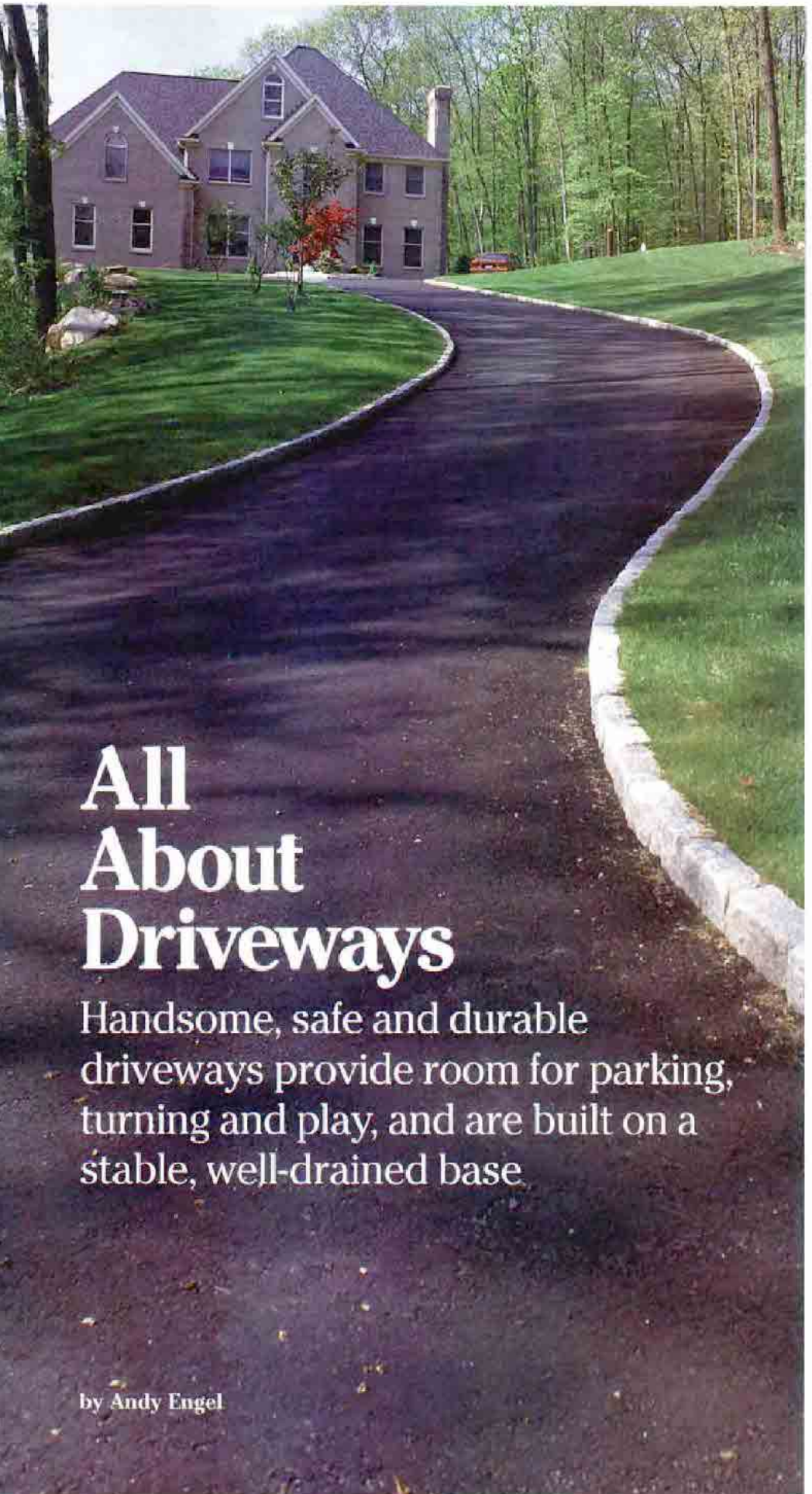
Fine Homebuilding
August/September 1998 No. 118



All About Driveways

Handsome, safe and durable driveways provide room for parking, turning and play, and are built on a stable, well-drained base

by Andy Engel

I've lived in three houses with bad driveways. The first drive was gravel and subject to washout. After every major downpour, I'd be out on the street, shoveling and wheelbarrowing a couple of tons of my driveway back into place. The second was paved, but it was long, steep and north-facing. In winter, ice was a recurring problem. Although sledding down it was fun, driving on it could be terrifying. The third house's driveway feeds into the intersection of three streets. It has no turnaround area. If there is no traffic when I come home, I quickly back in. If there is traffic, well, I drive straight in and hope there's none when the time comes to back out.

The third is an older house, and its driveway likely wouldn't be permitted today. Most municipalities have ordinances that prescribe where driveways may intersect streets, maximum grades, turnaround areas and sight distances at the street. Ordinances often specify where storm runoff must drain; how much, if any, of the driveway must be paved; and how driveways may cross sidewalks and curbs.

Often, towns are concerned only with the driveway's intersection with the street. Most driveway ordinances are weighted heavily toward this topic. Because there is no uniform national code governing driveways, local requirements vary greatly. The first guideline that should be applied to driveway design is your local code.

But there's usually more to a good driveway than is specified in local ordinances. In researching this article, I talked to engineers, excavators, inspectors and architects. I read driveway ordinances from places as diverse as Warren County, New Jersey, and Brisbane, Australia, as well as excavation textbooks and manuals published by trade associations. This article springs from the common ground between these various sources.

Driveways are for more than cars–After finding out what the town requires, the next stage in planning a driveway is to think about how it will be used. Will all the cars always be parked in the garage? If not, you should plan for parking that leaves room to turn cars around. Do the kids need a place to shoot hoops? More room. Does it snow where you live? If so, where will you put the snow that's cleared from the driveway? Where will you park that motor home you've dreamed about?

And what if you should need to get a fire truck close to the house? If the driveway's curves are

too sharp or if the drive becomes a quagmire in the spring, firefighters may be forced to watch the house burn from afar. The drawing at right illustrates minimum requirements for three common driveway configurations. You'll have to add space for other needs.

Minimize slopes at the garage and at the street—Driveways should be as straight and as short as possible. The exception to this rule is a drive on a steep lot. Lengthening such a driveway lessens its grade. Grades shouldn't exceed 12%, or a 12-ft. rise in 100 ft. of length. My steep driveway was 15%, and I've seen grades as steep as 20%. Neither is ideal.

If a steep driveway can't be avoided, try to reduce the grade at curves, where tires are more likely to spin in bad weather. Make the curves as gentle as possible. Centerline radii as small as 15 ft. may be fine for curves in parking areas, but on steep areas, radii should be larger, if topography allows. On long drives where getting a fire truck to the house could be a concern, 50-ft. radii should be used.

Parking areas should be almost level, sloped no more than 4%. As a minimum, there should be one car length of driveway that slopes no more than 4% in front of the garage and one car length at the street sloping less than 6%. Level steep driveways gradually where they meet parking areas. This increases visibility over the hood of a car in an area where children play.

Driveways shouldn't be totally level, either. Surface water has to drain. That means a minimum slope of about 2%.

Driveways start with dirt—No matter how fancy the finish surface will be, driveways start with dirt. That dirt has to be able to support heavy construction vehicles as well as the eventual light traffic of a residential driveway.

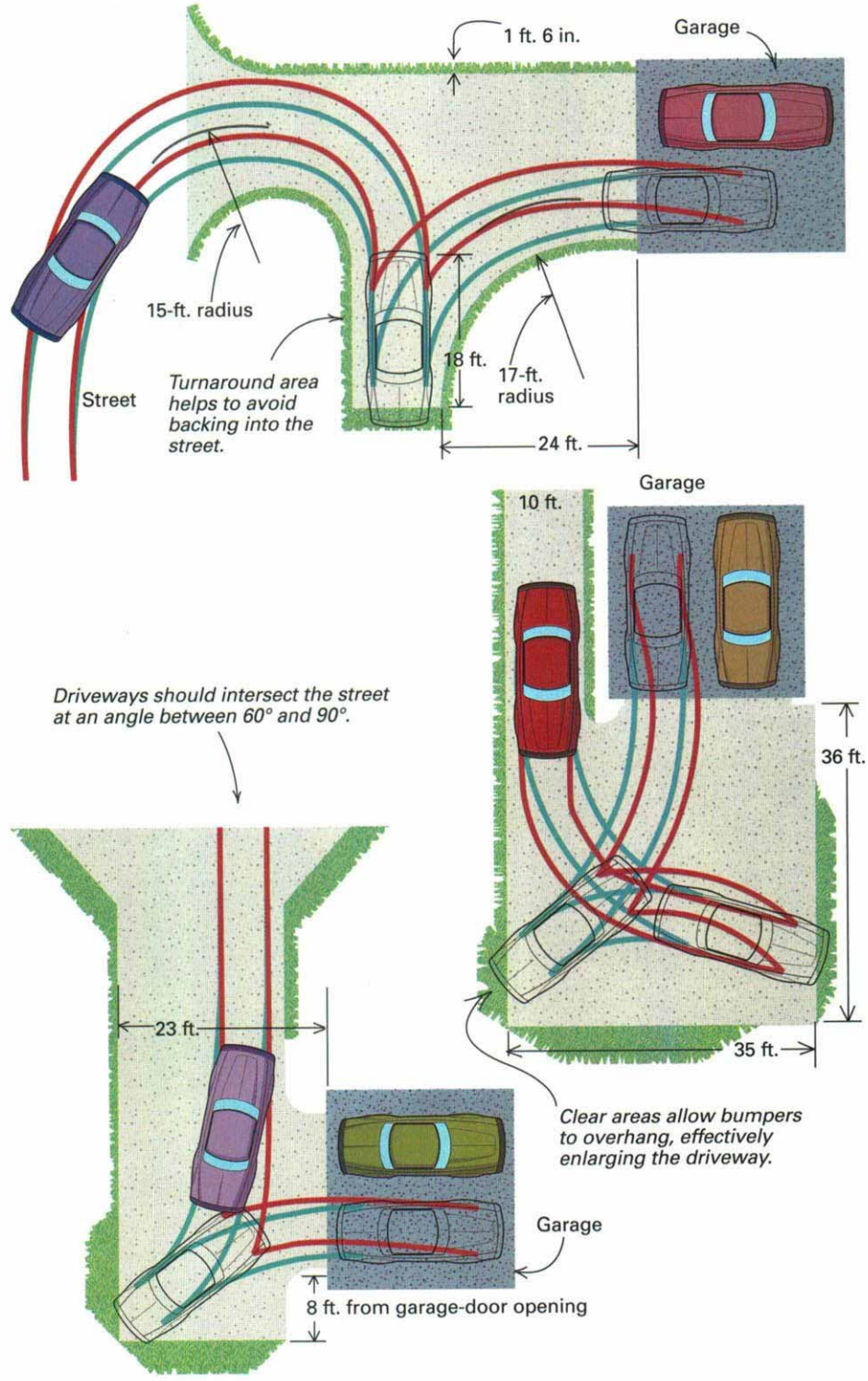
Different dirts behave differently. Organic soils such as peat are terrible at bearing loads and are unsuitable under driveways. Clay and silt soils turn to mud at the least provocation. They make lousy driveway subsoils. Sandy, gravelly soils drain well and are great under driveways. Soils that blend clay or silt with sand or gravel will most likely be adequate, if well drained. How do you know which you've got?

You can have a soils engineer come out and test the soil. That can be expensive, but you'll be certain. If the lot is to have a septic system, you might be able to learn what soils you have from

Backing out of driveways is dangerous

Driveways should be planned so that cars can turn around in them

These are the minimum widths and turning radii needed for midsize cars. Add room for larger vehicles. If additional parking is needed, figure on a 10-ft. by 18-ft. stall for each car, plus 3 ft. for walking at each end stall. There should be at least 1 ft. 6 in. of lawn or clear area along all the driveway edges. Increase this to 3 ft. at turnarounds so that the car's bumper can overhang the pavement if need be. (Illustration based on Building Research Council Notes, University of Illinois at Urbana-Champaign.)



Drawings: Scott Bricher

the soil log or from deep-hole tests, assuming they've been done in the same soil that the driveway will be in. Your county agricultural agent may be able to refer you to a soils map of the lot.

Then there's the old-fashioned test. Strip a patch of topsoil, and see how the subsoil drains in a heavy rain. When damp, does the soil support the weight of a backhoe without pumping up around the tires? Slight rutting is normal, but if the ground pumps, or moves in a wave in front of and behind the tires, you'll need to modify the soil.

Finally, you can hire an experienced local excavator and ask his opinion. Odds are that he won't know the geological taxonomy of the soil, but he'll have a fair idea of its character.

Stone improves questionable soils—If your soil is organic, you'll have to dig it out down to a soil layer with better bearing capabilities. On most lots, at least the topsoil is organic. But what if there are no better soils at a reasonable depth? Having an engineer design the drive is a good idea. A typical fix might be to excavate about 2 ft. below your planned driveway base and fill the excavation with 8-in. to 10-in. cobbles. The cobbles are covered with a choke layer of 2½-in. dense graded aggregate (DGA), a mix of crushed stone varying in size from dust to the specified size, in this case 2½ in. (Local names

Driveway-surface sampler

Asphalt is usually the least-expensive pavement.

Gravel bonded to an asphalt base adds a wearing layer, making a more durable finish.

Asphalt is a fairly inexpensive and durable finish course

But it's definitely not a do-it-yourself project. Typically a blend of various aggregate sizes up to ⅜ in. bonded together with viscous asphalt, it must be placed while still hot (300°F to 400°F) from the tar plant. Asphalt is dumped from the delivery trucks into a paving machine that spreads it in an even layer, usually of about 2 in. It is compacted with a roller before it cools down (photo left).

Starting at about $1 per sq. ft., asphalt is one of the less expensive driveway surfaces, but it isn't as durable as concrete is.

Asphalt softens and is easily gouged in hot temperatures. Gasoline and motor oil dissolve it, and spills can leave permanent soft spots.

Asphalt's dark color makes it a good choice in cold climates. It absorbs heat from the sun quite well, and any bare spots quickly melt surrounding ice and snow.

Rhode Island contractor Ed Marchetti gives asphalt driveways the look of a country road. A layer of emulsified liquid asphalt goes atop a traditional asphalt base. He then spreads and rolls a finish layer of pea gravel. Marchetti says this treatment protects the underlying asphalt and results in a longer-lasting finish (photo bottom left).

for DGA vary.) A choke layer fills the upper voids between the larger material below and stops overlying layers from working their way down. The choke layer gets compacted, and the rest of the driveway is built normally.

If your soil isn't organic but fails the pump test, you'll need to do some remedial work before placing the driveway base. After the excavator strips the topsoil and rough-shapes the drive, have him scarify, or break up, the soil's surface with the ripper teeth on the back of a bulldozer or with the teeth on the bucket of a loader. Mix clean 2½-in. crushed stone into the furrows left by the scarification. You can use shale for this process, too, if it's solid and not crumbly. This stabilized area should extend 1 ft. or 2 ft. beyond each edge of the driveway.

The amount of stone needed for stability depends on how bad the subsoil is. An engineer can save you money here by specifying how much stone needs to be blended into a particular subsoil. Otherwise, you're guessing. If, after the stone is added and the soil compacted, damp subsoil doesn't pump up next to the tracks of the excavation equipment, you got the blend right the first time. If you got it wrong, you'll have to repeat the process. At, say, $75 an hour, you probably don't want your excavator repeating too many tasks. You can stabilize soft subsoil by blending in dry portland cement or

Properly detailed concrete is extremely durable.

Exposed-aggregate concrete offers great traction.

Concrete makes a long-lasting driveway

A basic slab costs about $2 per sq. ft., about twice what asphalt does. It is a project that can be undertaken by a talented amateur, and if you value your own time at nothing per hour, the cost comes into line with asphalt.

There's a lot that can go wrong in a concrete pour, though. And a poorly detailed concrete slab can self-destruct in a few short years. There isn't space here to discuss the ins and outs of concrete work, but "Placing a Concrete Driveway" in *FHB* #102 (pp. 82-87) does just that.

Exposed aggregate is an alternative to the standard white-concrete slab. This work requires experience, which you'll probably have to hire. But the look is eye-catching, and the rough finish gives good traction.

On the surface, the process is simple. Rounded, decorative aggregate is used in the concrete mix. The concrete is placed, leveled and allowed to set partially. Then the top is scrubbed with water and stiff brushes to remove some of the cement and to expose the aggregate. But timing is critical. Wait too long after the pour, and it just doesn't work. Prices start at around $5.50 per sq. ft.

Bottom photo this page: George Matarazzo

lime. This requires engineering and generally costs more than stone.

If underground utilities such as electric, sewer, water or feeds for sprinklers or landscape lighting will cross under the driveway, it's best to trench and place conduits under the driveway for them before stabilizing the subsoil. The conduits should extend far enough beyond the driveway's edge so that further trenching won't disturb the driveway. Compact the backfill in 6-in. lifts. These trenches will have the entire time of construction to settle, reducing the chance of settlement after the driveway is placed.

This work should be done at about the time that a new home's foundation is being dug. You'll need access for the construction vehicles anyway. After the subsoil is compacted, it's a good idea to spread a couple of inches of 2-in. crushed stone or shale on the drive. It will help to keep vehicles from getting stuck, and it will go a long way toward keeping mud from tracking onto the street. The balance of the driveway should be built after the heavy-truck traffic of construction is finished.

Water is a driveway's worst enemy—Water turns dirt to mud. Even if the subsoil isn't saturated, water can soften it so that its load-bearing capacity is reduced. This leads to ruts. Ruts trap water, and a vicious cycle ensues. If the sub-

Driveway-surface sampler (continued)

Dyes and surface patterning belie that this driveway is essentially a concrete slab.

Patterned concrete can resemble the cobbles on an old European street

Other patterns are available, bricks to flagstone. Heavy rollers imprint the designs in freshly poured, dyed concrete. I was skeptical when the process was first described to me. Mimicking a different material rarely works. But when I saw the cobblestone pattern, I imagined bulls chasing a drunken Hemingway down similarly paved streets in Pamplona.

Dyes and rollers are available, and at least one distributor offers training. But the rollers and techniques are specialized, and many are proprietary. So this is a job that most hire done. Check with the contractor before starting work on the driveway. Some proprietary systems won't guarantee the job if the base isn't built to their specifications. Prices start at about $6 per sq. ft.

Edging keeps most of this driveway's gravel off the lawn.

Gravel is an inexpensive but high-maintenance surface

If you buy clean gravel from your local quarry, the finish course on your driveway could cost as little as 50¢ per sq. ft. The price goes up if you want fancy gravel from 100 miles away.

Gravel isn't perfect. If you don't keep runoff away, you could be shoveling your driveway off the street. Keeping gravel on grades of more than about 8% is difficult. Regular grading is needed to keep it looking good. Gravel gets into lawns, wreaking havoc with mowers.

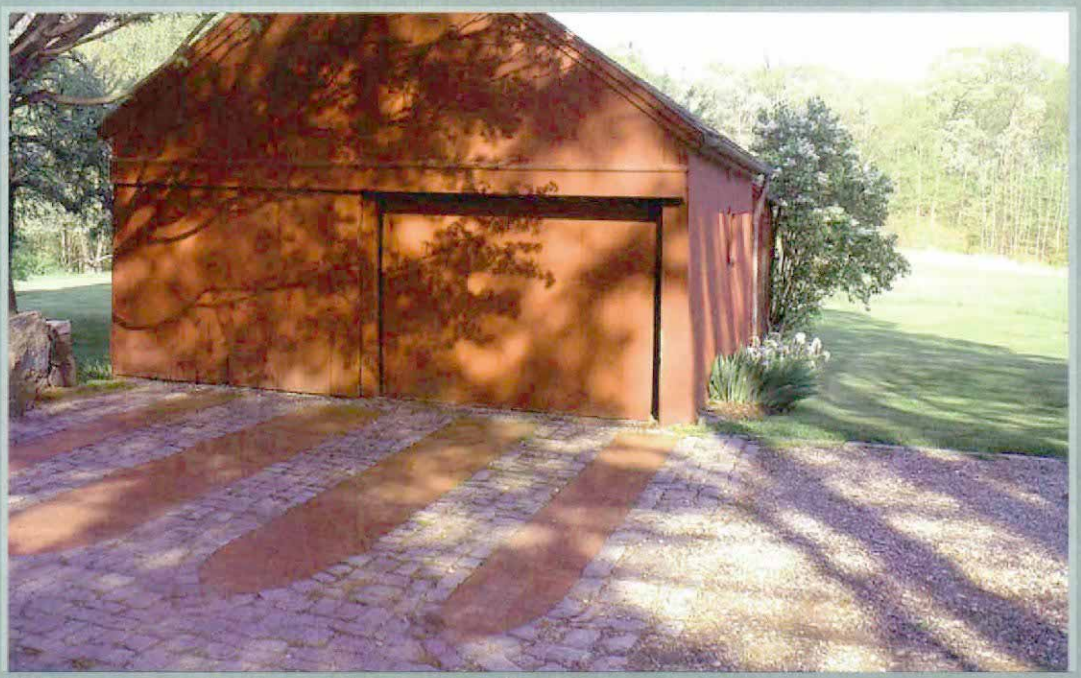
Gravel doesn't add to the driveway's strength. If you want a gravel finish course, make your base an extra 2 in. to 4 in. thick. And don't make the finish-gravel layer more than 2 in. thick. Unlike DGA, gravel doesn't consolidate. The more gravel you put down, the worse the traction will be.

soil softens, ruts can telegraph through pavements such as asphalt, brick or cobblestone. Concrete isn't very flexible, so if the soil supporting it softens, ruts don't form. Instead, concrete cracks, creating a new path for water to get in, adding to the cycle. And gravel-surfaced driveways simply wash out or turn to mud. Good drainage is the single most-important factor for long, trouble-free driveway life. In cold areas, frost-heaving destroys pavement. Frost-heaving happens only in wet soil. Saturated soil expands about 8% when it freezes, cracking the pavement. Keep the underlying base and subsoil dry, and frost-heaving won't happen.

If your lot has a high water table (groundwater near the land's surface), consider raising the driveway base above the natural grade so that it can drain. Or run a French drain along the driveway's edge. A French drain is a trench whose bottom is lower than the driveway base. The trench's bottom is compacted and pitched to drain someplace lower, preferably to daylight. The trench is filled with clean, crushed stone that laps over the edge of the driveway base.

The lot should be graded to divert water from the driveway. Driveways that cross a slope, in particular, collect and concentrate runoff and are subject to erosion. Here, it's a good idea to place a swale uphill of the driveway to divert the bulk of the runoff. To catch what water the

Another form of concrete, precast pavers, come in a variety of shapes.



Cobblestones topped ancient paved streets, and still work today.

Pavers are an innovation that began with the Romans

Needing to move Legions all over Europe, even in muddy conditions, the Romans built roads with packed aggregate bases and cobblestone pavers. This technology still keeps our feet and tires dry.

We're no longer limited to cobblestones, however. In fact, their irregular shape makes cobblestones one of the more difficult and expensive pavers to install. The regularity of brick and concrete pavers makes them simple, but still time consuming, to install. Largely because of the time factor, installed pavers are expensive, about $6 per sq. ft. Material cost starts around $2 per sq. ft. for concrete pavers, $3.50 for cobblestone and $1.50 for brick.

Pavers require a layer of compacted stone dust between them and the base. This provides a smooth, level base that eases installation. Because water easily passes the cracks between pavers, detailing the base so that it drains well is critical.

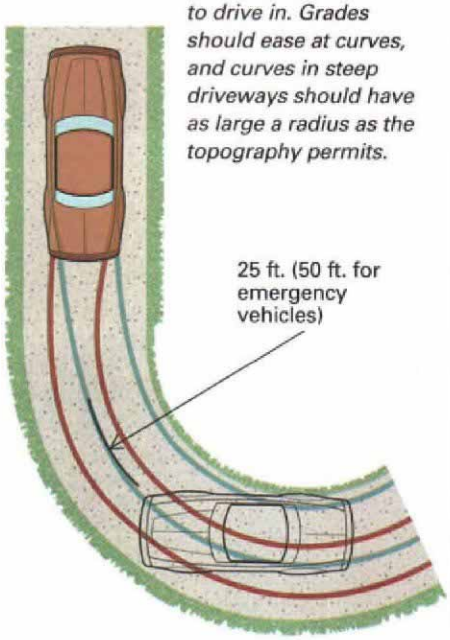
Installing pavers is a possibility for anyone with construction experience. Both brick-paver and concrete-paver manufacturers supply how-to manuals.

Top photo this page: Norman Nemec

Gentle curves and transitions are best

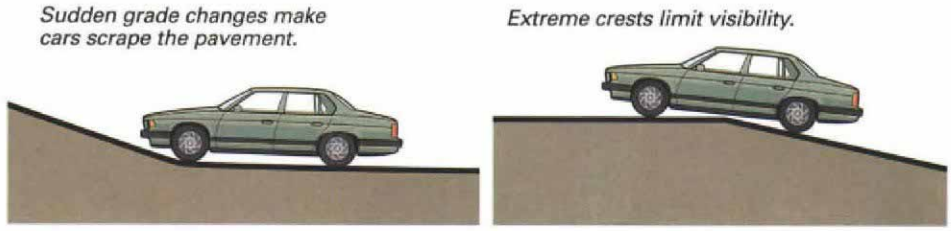
Large-radius curves are easier

Outside of parking areas, curves should have a minimum centerline radius of 25 ft., 50 ft. if the house is far enough from the street that emergency vehicles might have to drive in. Grades should ease at curves, and curves in steep driveways should have as large a radius as the topography permits.

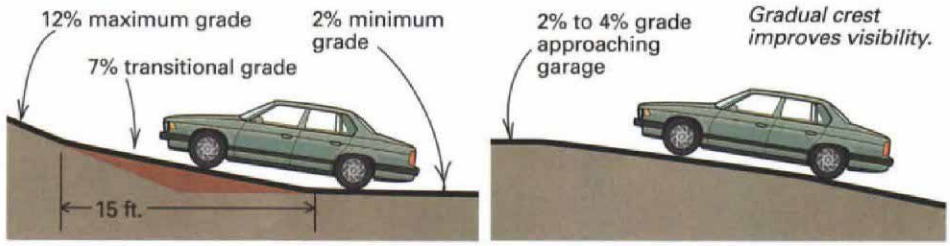


Driveways shouldn't change grade abruptly

And their maximum grade should be 12%, or a 12-ft. rise in 100 ft. of length. Parking areas and garage approaches should be graded between 2% and 4%.



Grades should be 4% or less approaching garages. And grade changes should be limited to 5% over 15 ft.



swale misses, dig a gutter along the uphill edge of the driveway, and line it with riprap—baseball-size and larger-size rocks that won't erode.

Grade all layers to avoid ponding—The next step after the last big truck leaves is regrading the construction driveway so that it drains and so that no water will be trapped under the finished driveway. In fact, every layer of the driveway must be graded so that it drains. After regrading, the driveway should be compacted with a vibratory roller or walk-behind compactor. Compaction improves the subsoil's bearing capacity and makes it less water permeable.

Subsoil can be neither saturated nor bone dry for best compaction. Water lubricates the soil particles and helps them to slide past each other into a dense, firm mass. If the subsoil is too wet, though, it'll compact about as well as Jell-O. The soil should just hold together when you squeeze a lump of it in your hand.

Crushed aggregate makes the best base—The next layer, the base, should be at least 4 in. of compacted 1½-in. DGA. If your subsoil is questionable, use a thicker layer of DGA. The sharp shapes and variety of particle size in DGA cause it to knit together when compacted. Loads placed on it spread out in a cone shape called a prism. The thicker the layer of DGA, the broader the area of subsoil that supports the load.

If your soil drains poorly, place a geotextile, a heavy synthetic fabric that filters fine particles, between the compacted subsoil and the base. The fabric will stop mud from pumping up into the base and reducing its ability to drain water.

Four in. to 6 in. of compacted DGA is normally enough to support the relatively light loads common to residential driveways. Making this layer thicker for a car length or so where the driveway meets the street is a good idea, though. Sooner or later, a heavy truck will turn around in your driveway. A couple of extra tons of DGA may prevent damage to your driveway's expensive surface layer.

For the same reason, you might thicken the finish course in high-traffic areas. If you plan a 4-in. thick concrete driveway, make it 6 in. at the road. If you are using 2 in. of asphalt, thicken it to 3 in. or 4 in. there. This is impossible with pavers, though, so in that instance, it's doubly important to add to the base.

Thickening the base to a minimum of 6 in. is also a good idea if you plan to use a nonstructural finish course, such as gravel. Finish courses such as concrete, asphalt or pavers spread out loads so that the weight of traffic, when it reaches the base, is less concentrated. Decorative gravel doesn't have this effect.

You won't go wrong putting down and compacting extra base. Interstate highways use as much as 2 ft. of DGA, compacted in 6-in. lifts, as a base. If you don't use enough, though, your driveway may fail prematurely.

For maximum strength, work DGA as little as possible—DGA makes a strong base because the smaller particles surround the larger stones and lock them in place. If it is handled excessively, the larger aggregate ends up on top, and smaller particles land on the bottom. This segregation reduces the DGA's bearing capacity. The best way to place DGA is to talk the dump-truck drivers into spreading it. If it is dumped in a pile, the excavator has to move it, segregating the aggregate. Drivers sometimes won't spread stone, though. If a dump truck carrying 25 tons of stone raises its body on steep or bumpy ground, it can roll over.

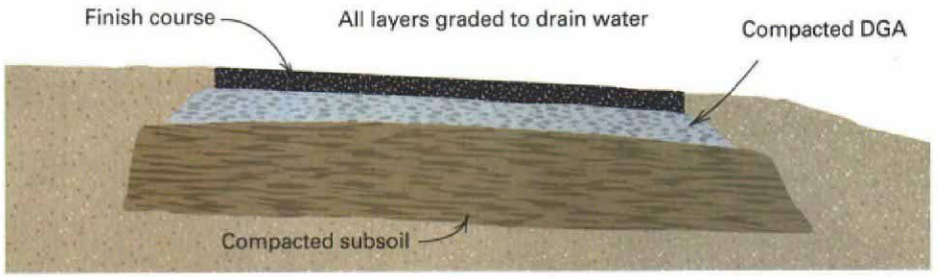
After the trucks spread the DGA, it should be graded to a depth of about 20% more than the desired compacted thickness. Minimize the number of passes with the excavation equipment that it takes to reach this thickness. The DGA should be rolled or compacted as soon as possible after spreading.

In some areas, it's common practice to use blends of sand and gravel from deposits left by glaciers or rivers in place of crushed stone. These materials may not work as well as DGA because the aggregate's rounded shape permits movement. Imagine trying to compact a pile of ball bearings. But if you have good subsoil, and

Customize driveway construction to the site

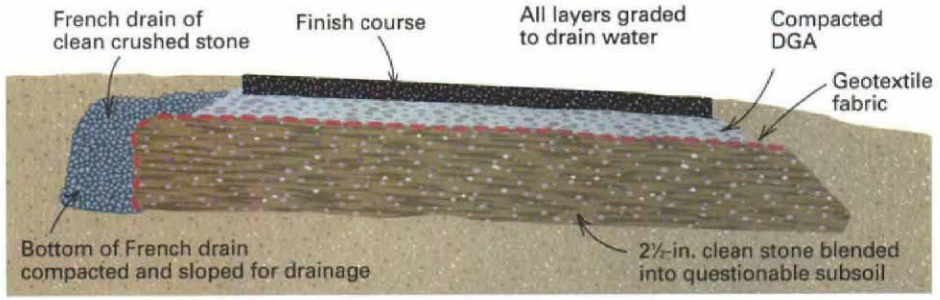
Good driveways start with compacted subsoil

The next layer should be a minimum 4 in. of compacted 1½-in. dense graded aggregate (DGA), a blend of crushed stone ranging in size from dust to 1½ in. A thicker layer of DGA spreads traffic loads over a broader area. If the subsoil's bearing capacity is questionable, use more DGA.



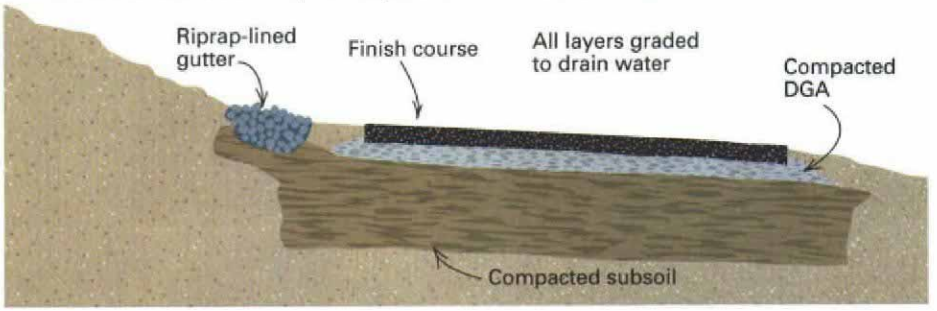
Questionable or poorly drained subsoil requires remedial work

Clean 2½-in. crushed stone blended into subsoil before compaction can improve its bearing capacity. A French drain can keep the subsoil and base from softening due to saturation, as can raising the base above the adjacent grade. Geotextile fabric prevents mud from pumping into the base and reducing its strength.



Runoff from slopes can erode driveways

Riprap (baseball-size stones) filled gutter placed uphill of a driveway collects runoff to keep the driveway from washing out. On a hill subject to heavy runoff, a swale should be cut in farther up the slope to divert most of the water.



particularly if the edges of your base will be enclosed in a cut, this material may work fine.

Recycled concrete is a material worth considering for base. Old concrete hauled from demolition sites is crushed and graded in the same way as stone. It's often relatively inexpensive, and using it saves on landfill space.

Ready for the finish course—These guidelines should have you prepared for finish courses such as concrete slabs or asphalt. If you're using brick or interlocking concrete pavers, another layer is needed. Typically, this consists of 1 in. of screeded, compacted stone dust, but you should check with your supplier to be certain. And if you plan to install one of the proprietary patterned concrete finishes, it's a good idea for you to verify that your preparations will meet their guidelines. □

Andy Engel is an assistant editor at Fine Homebuilding. *Photos by the author, except where noted.*

Trouble often develops where the driveway meets the house

The whole purpose of driveways is to get cars from the street to the house. But trouble often begins where the driveway approaches the house. For example, driveways that settle where they meet the garage slab are common. They do this usually because they are built over poorly compacted backfill. Once settling begins, the problem compounds. The driveway is often just about level here, and once it settles, it pitches toward the house. Water flows down through the joint between the garage slab and the driveway, and settles the fill even more. This causes cracks in the finish surface that let in even more water.

Winter comes, and this now-saturated fill freezes and heaves. It can even freeze fast to the garage stemwall and heave it, cracking the slab. Avoiding this problem is dirt simple: Compact the backfill to avoid settling, and pitch the drive away from the garage.

If the driveway runs downhill toward the house, raise the garage floor or grade the drive so that the final 10 ft. or so slopes away from the garage. If this isn't possible, catch basins resembling feeding troughs are made for this situation where the drive and the slab meet.

Driveways should be kept as far from basements as possible. As a minimum, they should never be placed on the backfilled area next to a house. Over time, the weight of traffic can compact the backfill and push basement walls, especially those made of block, inward *(FHB* #117, pp. 98-103).

Areas enclosed between a house and its driveway require care. Water that drains there can be trapped and saturate the driveway base. And if the water here isn't running to the driveway, it's probably draining into the basement of the house *(FHB* #111, "Details for a Dry Foundation," pp. 98-103). If downspouts must drain between the house and the driveway, lead them to pipes that drain to daylight beyond the drive.—*A. E.*