

# Soil compaction in residential construction

*Low-cost insurance against high-cost problems*

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It's not hard to spot some of the results of poor soil compaction around a house. Cracked foundations. Concrete steps that lean away from the house. A cracked and settled garage slab with one part higher than the other. Rain water running toward the foundation instead of away from it.

All these flaws mar appearance and reduce resale value for the property but could have been easily avoided without spending a lot of money. Compacting the soil during construction costs much less than correcting settlement problems after they occur.

## Why compaction is needed

Compaction reduces the amount of air pockets or voids in soil by packing the solid particles closer together. Forcing as many solids as possible into a given space increases soil density and strength. Increased strength lets the soil carry greater loads on footings of a fixed size or permits using smaller footings for a fixed load.

Well-compacted soils won't settle as much as poorly compacted soils. Excessive soil settlement under footings and slabs can cause major structural problems, but settlement is undesirable even if there's no structure on the soil. Failure to compact the backfill next to a wall, for instance, can cause the fill to settle, creating a low spot that traps water next to the wall. Many leaking basement problems are caused by this

kind of drainage problem.

Slowing water movement into and out of the soil is another compaction benefit in areas with swelling soils or soils that heave when frozen. Swelling soils expand when they get wet and shrink when they dry. Frost-susceptible soils, if they freeze while saturated, can cause enough pressure to crack a wall or push up a slab. Well-compacted soils don't give up water as easily and shrink during dry weather. Nor do they soak up water as fast during wet weather. Thus they don't swell as much as poorly compacted soils and aren't as likely to cause damage when frozen.

## Where is compaction needed?

Use compaction whenever the

soil is disturbed during construction or when it's used for fill. If organic soils are present, remove them first. Then compact disturbed soil beneath footings, slabs, basement floors, patios, garage floors, driveways, concrete steps and sidewalks. If a sand, gravel, or crushed stone base is used beneath a slab, compact it too.

Always compact fill soils before placing footings or slabs on them. Compact soil under and around buried water and sewer pipes. Also compact backfill next to footings and foundation walls. Soils in fills will settle if they're not compacted.

Sometimes it's more economical to replace soft cohesive soils with clean granular fill rather than having to compact many thin lifts of the



For fills over large areas, highest production rates are achieved with rollers. Use vibratory rollers for compacting granular materials and sheepfoot rollers for cohesive soils.



Use vibrating plate compactors for granular soils or base materials. Low-frequency vibrators work best for coarse-grained granular materials.

cohesive soil. But don't make the mistake of just dumping a load or two of gravel, crushed stone, or sand into the hole without compacting it. Whether the material is of a single size such as pea gravel, or a graded material, it still has to be compacted. A thick, uncompacted layer of granular material may settle an inch or more.

### Effect of soil type and moisture content

For compaction purposes, soils are considered to be either granular or cohesive.

*Granular soils* contain primarily gravels, sands, and silts and feel gritty when rubbed between the fingers. They have little or no plasticity when wet and no cohesive strength when dry. The dried material crumbles readily. Well-graded granular

soils (good particle size distribution) compact to a higher density because smaller particles fill the voids between larger particles.

*Cohesive soils* contain clay and feel smooth and greasy when rubbed between the fingers. Cohesive soils are plastic and sticky when moist and have a high dried strength. Highly plastic cohesive soils are hard to compact.

Dry cohesive soils don't compact at all. Adding water to the dry soil lubricates the particles and makes the soil compact better. For a fixed compactive effort, density increases as moisture content increases up to a point. But if too much water is added it starts taking up space that could be occupied by solid particles. Then the density goes back down. The best or optimum moisture content for compaction is the one that produces the highest density.

To determine the optimum moisture content, soil samples are mixed with differing amounts of water and compacted using a standard method. The dry density and moisture content are measured and plotted on a graph. The moisture content giving maximum dry density is the optimum moisture content.

Tests for determining maximum dry density and optimum moisture content should be run by a qualified testing laboratory. A laboratory inspector also should measure soil density and moisture content of compacted fills to ensure adequate compaction.

### Choosing and using the right compaction equipment

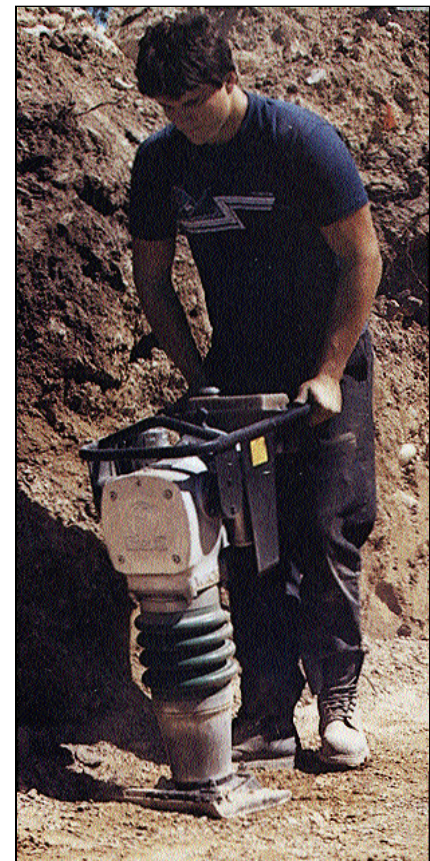
Strip away organic or spongy soils before beginning to compact fills. Compaction must start on a layer that is itself sound and compact. Don't try to dispose of construction debris, branches, or other organic materials by covering them with the fill.

For large fill areas, rolling is the fastest, most efficient compaction method. Use a smooth-wheeled or grid-wheeled vibratory roller for granular soils and a sheep's foot roller for cohesive soils. Cohesive

soils must be compacted at or near optimum moisture content. Water may be added to the soil to increase the moisture content, or the soil may be aerated with a disc harrow to dry it.

Hand-held compactors can be used in smaller areas and for places that larger mobile equipment can't reach. When compaction is needed near foundations or walls, hand-held equipment is less likely to damage newly placed concrete. For best results, though, you still need to match equipment with the soil type being compacted.

For granular soils, vibrating plate compactors work best. Vibration decreases friction between particles, allowing fines to sift downward and fill voids between larger particles. For most vibrating compactors, frequency (number of blows per minute) ranges from 1,600 to 6,200. Use vibrating compactors with a



Use rammers for compacting cohesive soils. A high shoe lift on the ramming machine increases impact and improves compaction.



## HOME BUILDER USES COMPACTION AS A SELLING TOOL

Some homebuilders think the cost of soil compaction is a needless expense, especially for spec houses. But Dave Rodrigues, president of David & Goliath Builders in Waukesha, Wisconsin, takes a different approach. His subcontractors use compaction equipment at all the company's homesites regardless of whether or not a fill is involved.

They compact disturbed soils beneath footings, the basement floor, garage slab, sidewalks, and drives. Even though the effects of poor soil compaction may not show up for months or even years, the company doesn't want to take a chance on losing long-term customer satisfaction.

Rodrigues uses the soil compaction efforts as a marketing method. At last year's Greater Milwaukee Parade of Homes, a sign at the David & Goliath Builders' home called attention to the extra steps taken during construction.

"It's the person buying a new house for the second or third time who's most likely to recognize the added value," says Rodrigues. "If they've tried to repair a badly cracked driveway or a basement problem caused by poor compaction they know how frustrating it can be. Prevention is a whole lot more satisfying than repair."

high frequency for fine to medium sands. Use heavier weight, lower frequency compactors for coarse sands, gravels, and mixes containing some clay.


Rammers or impact type machines are used for cohesive soils.

Rammers pound the ground with a much lower frequency than vibrating plate compactors, but the amplitude (vertical rise) is higher. Rammers work through a jumping action that squeezes the soil particles together. They deliver 450 to

800 blows per minute through a spring mechanism in the hand-held versions.

Rammers also can be used to compact granular materials, but only if the material is in a confined area such as a trench. If the area is unconfined, a rammer pushes the granular soil to the sides rather than compacting it.

Vibrating plate compactors and rammers can be rented from construction supply companies. If you need higher production rates for large areas, vibratory rollers also can be rented.

Some builders view the equipment and labor costs for soil compaction and testing as an unnecessary expense. But compaction certainly costs less than the repairs needed to correct problems caused by inadequate compaction. 

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