SOIL COMPACTION

EXPERT TIPS

Despite its simple appearance, soil compaction can be one of the most difficult elements of any construction project. Many manufacturers offer options on their compaction equipment that allow the operator to adjust machine vibration, frequency and amplitude to meet job specifications.

There is no easy way of adjusting the working parameters of a compactor according to the material it is compacting. Trial-and-error is often he best method. Obviously, the user will need to select a compactor of the appropriate size (drum width, weight, etc.) to match the production requirements. But, achieving the maximum compactive effort is usually accomplished by experimentation with the variables that the operator can control—frequency, amplitude and rolling speed—then analyzing performance and making adjustments.

Manufacturers are building more technology into their machines that can assist the operator in maximizing efficiency. But, even with increasing technology and sophistication, to achieve the best soil compaction results you may have to review some basic principles of soil compaction that have proven themselves on construction projects for years. Following are some soil compaction tips to provide basic guidance.

WHICH ROLLER FOR THE APPLICATION?

COHESIVE MATERIAL
Thin layers
Single-drum roller (padfoot)

FINE MATERIAL
Water sensitive
Single-drum roller, smooth or padfoot

FRICTION MATERIAL
(sand 0,063-2 mm/0.002-0.07 in)
Free draining if fine content < 7%
Single-drum roller, tandem roller, pneumatic tire roller

COARSE GRAINED, FREE DRAINING
Friction material
Single-drum roller, tandem roller

COARSE GRAINED
(gravel 2-63 mm/0.07-2.5 in)
Free draining
Friction material
Single-drum roller, tandem roller

COARSE MATERIALS
Heavy particles
Large plates, large single-drum roller (>12.7 tons)

	Permeability	Foundation support	Pavement subgrade	Expansive	Compaction difficulty
Gravel	Very high	Excellent	Excellent	No	Very easy
Sand	Medium	Good	Good	No	Easy
Silt	Medium low	Poor	Poor	Some	Some
Clay	None+	Moderate	Poor	Difficult	Very difficult
Organic	Low	Very poor	Not acceptable	Some	Very difficult

Uniformity of Lift, Speed and Rolling Pattern – The structure of buildings and roads depends on soil bases that are not only compacted to specification, but are compacted uniformly as well. Variations in base density can lead to potholes or wheel ruts in roads and foundation settling under buildings. One of the biggest causes of soil density variations is the use of different soil types that are placed side by side.

Because different soil types will compact differently and yield different compaction results, effort should be made during construction to utilize similar material for each lift. If different types of material are required, try to use the same type for each lift—do not use different material in a horizontal spread. This can be critical in achieving uniform compaction results.

Another cause of density variation is inconsistent moisture content. Because it is more difficult to compact soil that is too dry or too wet, the optimum moisture content as determined by the Proctor Test should always be targeted during compaction throughout the entire jobsite. This will help achieve the most uniform and dense results possible.

Lift thickness is usually not tightly controlled, except perhaps for a base course beneath a pavement surface. If all other factors, such as moisture content and material type, are kept constant, uniform lift thickness will lead to uniform density across the jobsite. Neglecting lift thickness could result in failing to meet the job specifications.

Other factors that can affect compaction and are often given inadequate attention are the coverage and pass counts. Parameters such as the number of passes, compactor speed and vibratory settings can be easily controlled. Intelligent compaction technology, such as Cat Compaction Control with GNSS mapping capability, can provide a visual reference to ensure that proper coverage and pass counts are maintained. Uniform coverage is more efficient and will be more successful than randomly compacting the material.

Lift Thickness – Compactor technology is continually advancing and offering more options and variations to the compaction process. However, after equal compaction effort is applied—even with the most advanced compactor—relatively thick lifts of material will be less dense than thinner lifts. There are exceptions to this rule, but a lift thickness should be sought which optimizes production rates based on required density and minimum compactor passes.

The condition of the previous lift or underlying base will also have an effect on achieving compaction. If a sub-layer has not been compacted thoroughly, it will contain areas that are relatively soft. In turn, compaction on the next lift will have varied, undesirable results. Each lift should be uniformly and thoroughly compacted to ensure subsequent lifts can be successfully compacted as well.

Compactive Effort – Compactive effort is the amount of energy imparted to the soil in order to rearrange and compact the soil particles. Varying machine parameters such as weight, width, tire pressure, vibration amplitude and frequency can change compactive effort. Some of these parameters can be adjusted on a single machine. Others, such as width, may require a different machine in order to alter compactive effort. Certain magnitudes of these parameters are necessary for any given project.

Working Speed – In general, travel speed plays an important part in construction productivity; the faster the machine, the faster the job is complete. However, with vibratory compactors, unlike all other types, productivity will generally increase by decreasing the travel speed. There is an optimum economical speed that will allow a compactor to achieve required compaction.

General Rules of Soil Placement and Compaction – Following are general rules that you, your jobsite management and operators should consider at the start of each compaction project.

- When placing a new lift of soil material, spread material over the entire area uniformly. Avoid placing soils that have excessively high moisture content. Spread the material with a slow-moving dozer and shape the appropriate profile. Do not bury saturated layers with new materials.
- Surface cavities or areas with visible segregation should be remedied by adding well-graded material of the same composition.
- Immediately after spreading is complete, compact the soil, starting from outside and working toward the middle of the area.
- Embankment/shoulder areas must be compacted as well; compact the shoulder from the outside edges and work toward the middle areas. Smooth and seal the surface.
- When working with materials that are susceptible to weather, all placed soil should have a side slope of about 6 percent to prevent the accumulation of surface water.
- When poor weather occurs, compact each lift by working a single drum-width strip until it is fully compact. Then move over to the next strip, repeating the process and working your way across the lift until the entire area has been compacted. Be sure to smooth and seal the surface at the end of the day to prevent further water penetration.
- When compacting a flexible base, it is advantageous to use low amplitude with high frequency if the base is adequately rigid. Use high amplitude and medium-to-low frequency when the base is being compacted together with the first lift.
- Using a combination of static and vibratory compaction—vibratory first followed by static—may yield the best results.