An Introduction to Soil Compaction and the Subsoiling Practice

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Introduction

Two essential elements of effective storm water management are: 1) an understanding of how compaction occurs in the soil, and 2) the knowledge of how the effects of compaction can be reduced. This paper was prepared to give general information on these elements and is outlined in three sections. The first section explains the properties of soils with good or poor physical condition, the second section details the factors that cause compaction, and last section describes subsoiling, a practice that can be implemented to reduce compaction.

Physical Condition of Soils

Definition of a soil with good physical condition. The solid portion of soil is made of sand, silt, and clay particles, along with organic matter. The organic matter bonds particles together, forming aggregates. Large pore spaces, filled with air or water, surround the aggregate (Figure 1). A soil with good physical condition contains 50 % solid material, 25 % water and 25 % air.

Definition of a soil with poor physical condition. A soil with poor physical condition resulting from compaction has smaller pore spaces and soil particles packed closer together (Figure 1). The compaction process is the change in volume for a given mass of soil. This change is referred to as a change in porosity.

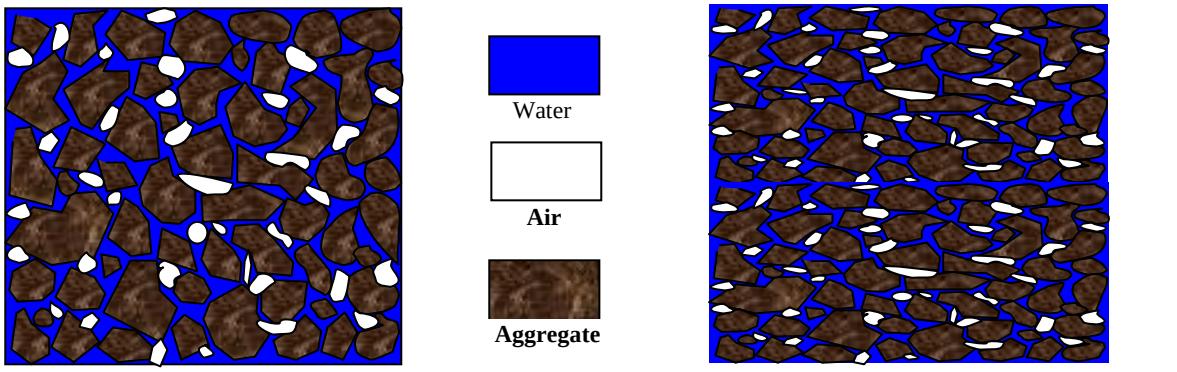

Figure 1. Different physical condition of soil.

Factors Causing Compaction

Soil compaction occurs when heavy pressure on the soil (from animals, farm equipment, trucks, construction equipment, etc.) reduces pore space and closely packs particles in the soil. Soil that contains a significant portion of clay or about equal proportions of all particle sizes, is more easily compacted. In addition, water acts as a lubricant, letting soil particles compress together easier. This is the reason why wet, clay soils compact more easily. Some soils are also known to have natural compaction, called hardpans, due to special chemical or physical properties.

Surface vs. subsoil compaction. Surface compaction occurs within the top 8 to 12 inches of soil (Figure 2) due to contact pressure to the soil surface by truck and heavy machinery traffic during construction. Tests have shown that the first pass of a wheel on loose, tilled soil, will cause 80 to 90 % of the total compaction experienced during construction.

Subsoil (deep) compaction is caused by total load as well as contact pressure. Axle loads above 10 tons, carried on high pressure tires over wet soils, can cause compaction below the root zone (1 foot); loads of 20 tons (heavy construction equipment and cement trucks) can compact wet soils as deep as 2 feet (Figure 2).

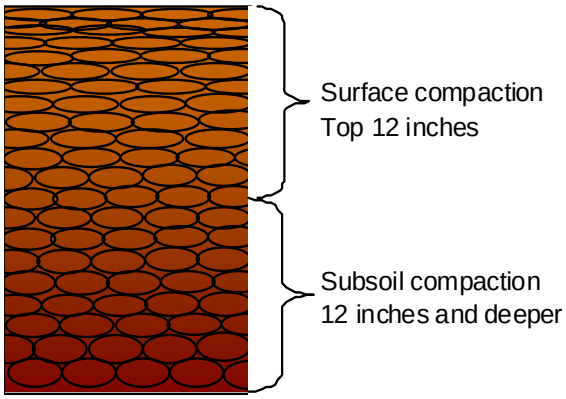

Figure 2. Compaction of the soil surface and subsurface.

The effects of urban development on compaction. Compaction is a problem because it inhibits water and air storage by reducing the pore space in the soil. For most urban areas, lawns and wooded lots, problems appear when air space in the soil drops to 10 to 15 % of total soil volume. These problems include: root growth restriction, lack of water storage, excessive runoff, reduced nutrient availability. Some soils become so dense that roots simply cannot physically penetrate the compacted zone, even if pore spaces contain air. Urban area construction may cause the slow death of large trees due to the disturbance of the root zone as well as pore space reduction during construction.

Reduce Compaction by Subsoiling

Compaction can be reduced by subsoiling, a process of deep tilling (ripping) the construction area soil to a depth ranging from 12 – 18 inches to 2 to 3 feet (Figure 3), perpendicular to the direction of flow. One way to create the rips is using heavy machinery (tractor) with two shanks (curved metal bars). Subsoiling enhances or reestablishes the soil profile structure to conditions prior to urban development. It allows for rapid infiltration and breaks up the formation of sheet and rill flow before it reaches scouring velocities.

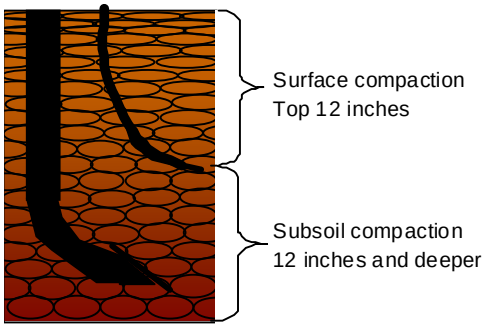

Figure 3. Subsoiling depths to reduce soil compaction.

Areas to subsoil. Areas that should be subsoiled at at depth of 2 to 3 feet *before* construction are the construction area as a whole and individual lots. It is important to subsoil final graded building lots *after* construction at a much shallower depth of 12 – 18 inches because of the compaction needed for the integrity of the building foundation.

Choosing the right subsoiler. When choosing a subsoiler to reduce compaction, determine the depth of compaction by visual observation, measuring the bulk density, or penetrometer measurments. Then use a subsoiler tool that has the capability to rip 1 to 2 inches below the compacted zone or below a highly permeable substratum.

Summary

Many construction activities compact the soil surface and subsurface. Subsoiling is a simple, low cost practice which reduces soil compaction by increasing the pore space and improving the infiltration capacity of existing soils. Also, we decrease runoff by breaking the soil compacted barrier and reaching the more permeable substratum. Subsoiling is recommended before initial construction and again after the final grading of individual lots. This will enhance the ability of the soil to transmit water to streams as base flow and provides deep percolation of the water to aquifers in the zone. In conclusion, the future of urban erosion and runoff control is subsoiling rather than silt fences because of its low maintenance, availability, simplicity, and low cost.