What is in a Word? Actually, A Lot!

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Let's take 'density' for example – the choice of its meaning can have serious implications in the construction of an athletic field. A scientist defines density as mass per unit volume. The standard is the density of water which is one gram per cubic centimetre. All other materials are related to this standard. Organic materials have a density of less than one; hence they float on water. Sand particles have a density which averages 2.65; hence they sink rather rapidly in water.

Engineers and agronomists differ rather widely on their interpretation of the meaning of the word 'density,' which can have very significant effects on athletic field construction and the future performance of the field.

In the engineering concept of the word, 'density' of a soil material is measured in terms of Procter Density – defined as that density which can be achieved when a series of samples of the soil are compacted under standard laboratory conditions over a range of moisture contents. As the moisture content is increased, the *dry* density (the density expressed on a moisture free basis) increases to a moisture content beyond which the dry density decreases due to the high water content causing the soil to become plastic. Generally the desired density for engineering construction is 95% of this maximum, i.e., 95% Proctor Density.

To achieve the required Proctor Density under field conditions, the soil is sprayed with water and compacted by a roller or other mechanical compacting device. To determine if the desired density that was measured in the laboratory has been achieved, an *in situ* measurement of density and water content is made with a portable nuclear density meter.

Standard Proctor Density is designed to achieve maximum load bearing capacity and to minimize pore space, thus minimizing water movement through the soil. Densities in the order of 2.0 g/cm^3 are obtainable. At this density, the total pore space in the soil would be 25%. This porosity restricts the movement of water in the soil and provides the engineering characteristics of the soil desired for building and road construction. The non-capillary pore space through which air and gravitational water movement would be a minimum.

In the agronomic concept of soil, 'density' is considered to be the density of the soil in its natural state and is called the apparent density of the soil. It is determined by inserting a metal ring of known volume into the soil, removing the ring plus enclosed soil, determining the dry weight of the soil contained in the ring, and reporting the results as g/cm^3. The optimum soil density for plant growth is 1.33 g/cm^3 which will have total porosity of 50%. At this porosity, water and air will move freely through the soil pores and root proliferation will be optimal. At apparent densities of 1.7 g/cm^3 or greater, root growth will be greatly restricted.

The total porosity of the soil in its natural state is divided into pores of two sizes based on the flow of water. Both are important in good plant growth. The larger pores, through which water flows due to the forces of gravity, are known as macro pores or non-capillary pores. The smaller pores, through which water moves by capillary forces, are known as micro pores or capillary pores.

Water movement through macro pores is relatively rapid and it is through these pores that drainage water flows and air is contained when all the drainage water has been removed. It is essential for plant growth that the macro pores are drained as rapidly as possible and air returns to the soil. Furthermore, it is essential to remove this excess water due to its significant effect on lubricating the soil particles, allowing them to move into closer association through compaction from athletes' feet and maintenance equipment.

Movement of water through micro pores is relatively slow and is the source of the majority of water used in plant growth. In general, during compaction the removal of macro pores is greater than micro pores, therefore the influence on drainage is greater than the influence on available water for plant growth.

In the design of the subgrade and root zone for an athletic field, it is essential that the architect understand the difference between the two concepts of density. The specifications written for the construction should be reviewed carefully to ensure that all references to density and compaction are using the agronomic concept; otherwise the field is doomed to failure.

In summary, the engineering concept of soil density is the complete antithesis of the agronomic concept of soil density; the former designed to minimize porosity and the latter to maximize porosity.

The engineering concept of soil density is the complete antithesis of the agronomic concept of soil density; the former designed to minimize porosity and the latter to maximize porosity. If the engineering concept is applied to the design of the subgrade and root zone, the field is doomed for failure.

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