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THE SOIL COMPACTION UNDER THE WHEELS OF THE AGRICULTURAL MACHINERY

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Abstract: *Soil compaction is considered to be a multi-disciplinary problem in which machine; soil, crop and weather interactions play an important role. This has dramatic, economic and environmental consequences in world agriculture and crop production. For understanding of soil compactions process, is necessary to scientific analysis of interaction between machine and soil. The interaction between soil and machine is very complex; they depend on the structural properties of the soil and the running gear process. The techniques for characterizing of running gear in relation with soli compaction problems are suitable for designing and advising on machinery.*
Keywords: *soil compaction, modeling;*

1. INTRODUCTION

In agriculture, soil compaction generally refers to the negative aspects of volume decrease and deformation of soil by mechanics causes. Among these the most significant is field traffic, which often is not properly adapted to soil type, structures and water content. During process of soil compaction, soil water is usually not displaced owner macro-distances, but water potential is changed. Soil particles do not change in volume, but the clay pallets, changes in the shape of organic matter. The soil compaction effects may change in time the soil structure and this change cause irreparable damage of soil. At the prezent study, relates the technical activities to research the impact of soil tillage and field traffic. In this study we considered soil as a continuous and homogeneous material. If properties are independent of the direction in which they are measured, the material is called isotropic. The stresses and strains in homogenous material, do not change from place to place. The volume of homogeneous material in a larger soil mass which is subjected to homogeneous stress and strain, and is called in an elemental volume. Trough the establishing condition and connection of the elementary volumes, we will make possible to study this process with Finite Elements Method and special software (ANSIS, PATRAN, COSMOS etc.)

2. MODELING OF SOIL COMPACTION AS A RESULT OF THE USE THE AGRICULTURAL MACHINERY

The soil compaction is produced by wheel tractors and the agricultural machinery and is a composite indicator of soil quality assessment. This indicator considers soil quality taking into account the several parameters, such as: soil porosity, soil texture and bulk density. The indicator used in assessing soil compaction is "the level of compaction of the soil" (GT).

$$GT = \frac{PMN - PT}{PMN}[\%] \tag{1}$$

PMN =Minimum necessary porosity;
PT =Total porosity;
The cause of soil compaction is the force with which the wheel (tire) of the tractor and the machinery of soil that hit. The vertical component of forces is generated by the tractor, while performing agricultural work. When a tire of the tractor running up the rigid surface, by the contacting surface is generated the shear stresses.
Consider a small plane (from tire mark on the soil), with area A. If the soil is a continues material, we can define the pressure on the ground that "p":

$$\lim_{A \to 0} \frac{F}{A} = p \qquad (2)$$

F = forces will act on the plane.
Because the forces are not perpendicular to the plane, we can resolve with parallelogram law.
The two components of a force vector F will correspond to two components of a vector normal pressure p. The pressure "p" is not normally on the plane so it decomposes after a normal and a tangential axis.
This concept may be expended to a three-dimensional of coordinate system. The small plane becomes the small cube. The position of the cube is chosen such that the edges of the cube may be parallel with the axes (x, y, z). Each component of the stresses can be resolved in to normal and tangential components. The each component of the other sides, have the same absolutes values as the components of the opposite side.

$$\tau_{xy} = \tau_{yx}; \tau_{yz} = \tau_{zy}; \tau_{zx} = \tau_{xz}$$

The entire nine components can be put together in next matrix:

$$\begin{bmatrix} \sigma_x & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_y & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_z \end{bmatrix}$$

Each component has the fixed place in the matrix. This place depend of choice the coordinate system. Is possible to calculate the stress component, after a rotation of coordinate system, if we know the original system. The condition of equilibrium forces related to the imaginary center of the small cube requires:

$$\sum \frac{1}{2} l \tau_{ij} A = 0$$

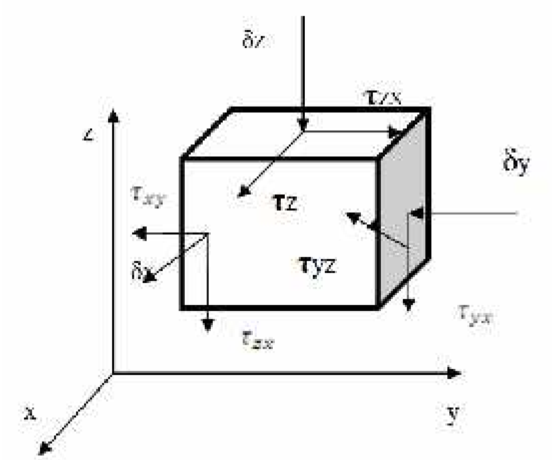

Figure 1. Stress components in the infinitely small cube.

For to simplicity, we consider that the forces, ware action upon a sides of cube, be produced by the weight of tire, tractor and machinery. Also for simplicity we consider that the soil is a continuous, homogenous material and flowing under effects of the tire rotation.
Flows can be presented graphically through the mesh as in Figure 2.
We are define a cylinder of soil, so, what will be subjected to deformation (compaction), following the passage of tractor wheels.

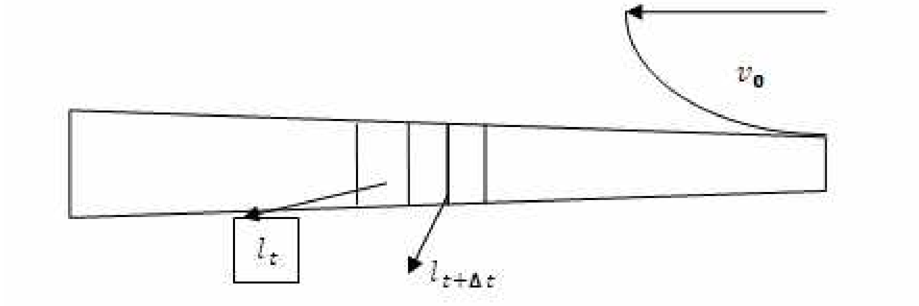

Figure 2. Deformation of elementary cylinder (dA) subject to forces action settlement

We denote (de_t) specific strain of the element „l_t", under the action of forces F.

$$de_t = \frac{lt - lt + \Delta t}{lt};$$

$$\rightarrow \varepsilon_t = \int_{lt}^{lt+\Delta t} de_t;$$

ε_t - Vertical deformation of the element l_t under the action of forces generated by moving the tractor wheel of l_t la $l_{t+\Delta t}$.

$$\rightarrow \varepsilon_t = \int_{l_t}^{l_{t+\Delta t}} \frac{dl}{l} = \ln(l_t / l_{t+\Delta t})$$

Normal stress component generating the soil compaction and may be defined by the relation:

$$\varepsilon_t = \frac{l_t - l_{t+\Delta t}}{lt}$$

Therefore we have:

$$\varepsilon_t = \ln(1 - \varepsilon_{t+\Delta t});$$

Since we studied a finite element of the soil deformation under the action of the vertical component of forces, it results:

$$\varepsilon_t = \sum_{1}^{n} (\Delta\varepsilon_t);$$

Moving from each nodal point because of the external forces applied is calculated using a function of moving. Most times Finite Element Method provides models for calculating the compaction of the soil. Stress-strain relationship is determined considering the soil characteristics to be similar to those of a linear-non elastic material.

3. MODEL STUDY OF SOIL COMPACTION USING FINITE ELEMENT METHOD

Based study of soil compaction using finite element meshing, is made up of soil in a finite set of elements that are interconnected on a network of nodal points. If the soil is a material linear, non elastic and non-homogenous may have the relation:

$$\sigma = [C] * \{\varepsilon\}$$

σ = Stress vector,

ε = Specific strain vector,

C= Young – Poissons constitutive matrix;

ν = Poisson module =Axial strain/ transversal strain

$$\upsilon = \frac{d\varepsilon y}{-d\varepsilon x} = \frac{d\varepsilon z}{-d\varepsilon x}$$

Measurements have determined that the Poisson ratio is between values 0.11 and 0.65; depending on the physical and mechanical properties of soil.

To perform the finite element simulation model of soil compaction, we define the Poisson ratio as:

$$\upsilon = (\Delta\varepsilon_1 - \Delta\varepsilon_2) / 2\Delta\varepsilon_1$$

$\Delta\varepsilon_1$ = Axial elementary strain.

$\Delta\varepsilon_2$ = Elementary volumetric strain.

Young's Modulus can be explained by the relationship:

E = δ/ε

More models that incorporate Young's modulus in the finite element analysis of soil compaction have been suggested in the literature.

$$E_1 = \left[1 - \frac{(Rf(1 - \sin\emptyset)(\delta^1 - \delta^3))}{\square}\{2c\cos\emptyset + 2(\delta^3 + Pa)\sin\emptyset\}\right]^2 K * Pa \left[\frac{\delta^3 + Pa}{Pa}\right]^n$$

R_f = Failure ratio;

Ø = Internal frictions angle,

c = Cohesion of the soil coefficients,

n = exponent being determined by the rate variation of the E with Pa (atmospheric pressures). For simplicity we consider that n=1.

The variation of the soil stress is proportional whit tire inflations pressure ant the total weight of agricultural machinery as seen tensions arise in the soil increases with increasing tire inflation pressure but decreases with increased tread depth

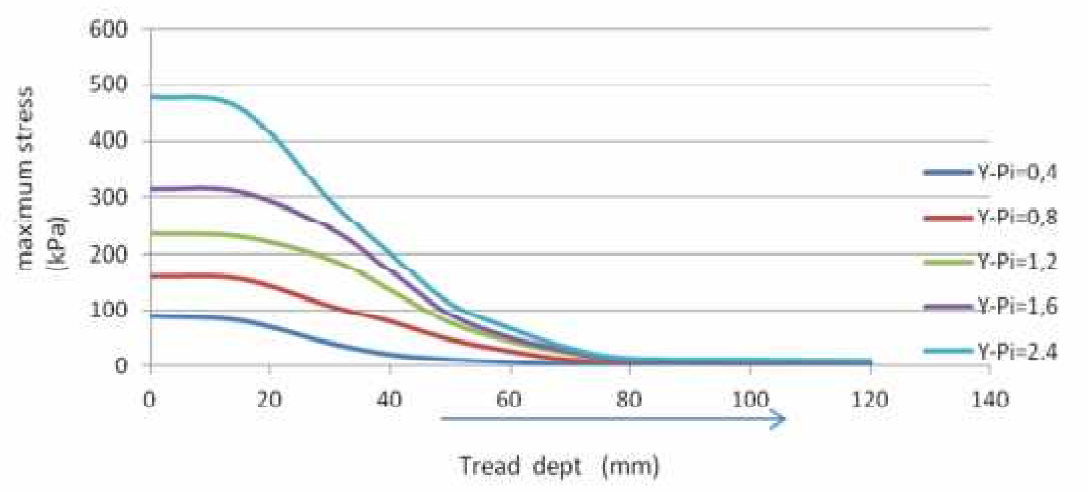

Figure 3. Maximum stress determined for total weight 50[kN] and tire pressure Pi [bar]

4. CONCLUSIONS

Soil compaction by tractor wheels is produced by the destruction of soil structure by decreasing its porosity and degree of the aeration. The water potential, bulk density and soil aeration rate are influenced the soil compaction. By knowing the phenomenon that occurred in the soil compactions due to the phenomenon of avoid the permanent damage to soil structure. By simple relationship we predict the surface strain from easily measurable tire and machinery characteristics. The tire condition can predict the stress distribution and the soil compaction. The construction of a soil compaction mathematically model include a:

-Modeling an elemental surface and applied the force caused by agricultural machinery.
- Representation of the stress and strain relationship.
- Modeling the propagation of the stresses.
- Determining of the optimal agricultural machinery.

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