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Analysis Of Off-Road Vehicle Performance On Deformable Terrain

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Terramechanics is the study of soil properties, specifically the interaction of wheeled or tracked vehicles on various surfaces. It is not a novel topic and the first studies date from the 50's and the main papers are [1], [2] and [3] . However, nowadays there is still interest in the subject, as shown in [4], [5] and [6]. Areas such as spatial and military trafegability have special interest in terramechanics due to its need to keep moving at any cost.

The importance of this study lies in the fact that the rolling resistance is strongly dependent on the behavior of the soil when it is considered deformable with plastic behavior. So, the objective of this paper is to present the rolling resistance of a tire on soft ground. To do so, the following components may be analysed: soil compaction, the displacement of soil particles and the bulldozing effect. We will focus on the two first parameters.

For homogeneous terrain, the Pressure-Sinkage relationship is defined in Eq. 1:

$$p = \left(\frac{k_c}{b} + k_\phi\right) \cdot z^n \tag{1}$$

Where: p - pressure; b - width of tire/ground contact area; n, k_c and k_ϕ - soil parameters; and z - sinkage.

Some values for terrain parameters are presented in Tab. 1:

Table 1: Terrain parameters[7].

Soil type/Parameter	k_c	k_ϕ	n
Clay	$12.7 \cdot 10^3$	$1555.95 \cdot 10^3$	0.13
Loamy soil	$13.19 \cdot 10^3$	$692.15 \cdot 10^3$	0.5
Sand	$12.7 \cdot 10^3$	$1528.43 \cdot 10^3$	1.1
Snow	$4.37 \cdot 10^3$	$196.7 \cdot 10^3$	1.6

Using Eq. 1 and parameters listed in Tab. 1, we obtains Fig. 1. One can observe the sinkage for some kind of soils, namely clay, loamy soil, sand and snow.

Considering a rigid towed wheel over off road terrain, the motion resistance is derived due to the terrain reaction at all points on the purely radial contact patch as presented in Eq. 2 :

$$R_c = b \cdot \left(\frac{k_c}{b} + k_\phi\right) \cdot \left(\frac{z_0^{n+1}}{n+1}\right) \tag{2}$$

We can observe in Eq. 2 that increasing the wheel diameter D reduces the motion resistance more effectively than increasing wheel width b. Another conclusion is R_c approaches infinity as the n value approaches 3, an obviously anomaly.

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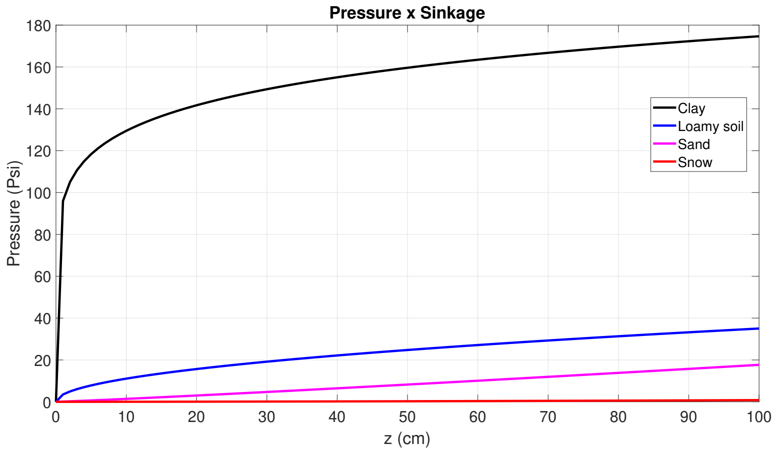

Figure 1: Pressure *vs.* Sinkage. Source: The authors.

The importance of soil analysis in vehicle performance over off-road terrain is extremely needed despite of considering non deformable soil.

Further analysis will be developed taking into account the inflation tire pressure and average ground pressure applied to a real vehicle to determine its performance.

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