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DIFFERENT WAYS OF JUDGING TRAFFICABILITY

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Abstract:

This article deals with the possibilities of terrain negotiation in extraordinary situations. In these situations the communications, appointed for this kind of movement, are not supposable to use. The use of detours is not always advantageous and facultative. Then it is necessary to judge, whether the vehicles are able to go through the terrain or not. Two of the possible methods, how to find out the trafficability of terrains, are described in this article as well as the trafficability factors.

1. Introduction to the Term Trafficability

Trafficability consists of different types of trafficability – the trafficability of woods, waters, soils, towns, etc. This means that trafficability is a very wide and general problem. Units prefer to go through open terrain because it is usually the simplest way. Together with the fact, that soils cover large part of the land the text is aiming only to the trafficability of the soil. And why is trafficability so important? There is a lot of critical situations in which the army has to overcome the landscape not only on roads and existent ways. They could be damaged by the enemy or by natural disasters. That is why we have to go through terrain. One of the most important thing, how to solve

these situations, is to know the trafficability of soils. The trafficability is the capacity of soils to support vehicles.



Figure 1. An Example of Mire.

Extraordinary situations come about from time to time in our region, as well as in other regions in the world. These situations are usually brought about by different natural influences. Due to these situations some parts of communications become impassable (the bridge damaged by the flood etc.). Then there is a need to get to an unapproachable area in the shortest period of time. The detour is not always possible or is too long. So you have to use the transport through the terrain. The question is, if the terrain is suitable for passing for the given type of vehicles or not. Different types of instruments are used for judging the trafficability of terrain. The comparison of the two of possible methods is described here.

The trafficability of fine-grained soils (silts and clays) and sands, that contain enough fine-grained material to behave like fine-grained soils when wet, is more difficult to assess than the trafficability in coarse-grained soils (clean sands). It does not include problems associated with natural or man-made obstacles (such as forests or ditches). It is connected only with the term trafficability of soils.

2. Trafficability Factors

Trafficability is influenced by a lot of factors. But the most important are soil strength, stickiness, slipperiness, slope, vegetation, organic-soil areas and other obstacles. The goal, of the measurements made in our department, is to judge the trafficability in "normal" conditions. The authors realize that the following factors influence the trafficability and they will work with them in the next research. So after carrying out the measurements in the "normal" conditions, the research will continue and the factors (such as slope etc.) will be covered.



Figure 2. An Example of One Type of Soil (Sandy Clay).

Soil strength. Bearing and traction capacities of soils are functions of their shearing resistance. Shearing resistance is measured by an instrument which is usually jobbed into the soil.

Stickiness. Stickiness may seriously hamper vehicles operating in wet, fine-grained soil. Under extreme conditions, sticky soil can accumulate in a vehicle's running gears, making travel and steering difficult. Normally, stickiness is troublesome only when it occurs in soils of low-bearing capacity. Stickiness occurs in all fine-grained soils when they are wet. The greater the plasticity of the soil, the more severe the effects of

stickiness are. Stickiness adversely affects the speed and control of all vehicles, but will not cause immobilization except for the smallest tracked vehicles.

Slipperiness. Excess water or a layer of soft, plastic soil overlying a firm layer of soil, can produce a slippery surface. Such condition may make steering difficult or may immobilize rubber-tired vehicles. Vegetation, especially when wet and on a slope, may cause immobilization of rubber-tired vehicles. Slipperiness is troublesome, even when associated with soils with high-bearing capacities. Like stickiness, the effects of slipperiness cannot be measured. Soils that are covered with water or a layer of soft, plastic soil are usually slippery and often cause steering difficulties, especially with rubber-tired vehicles.

Slope. The steepest slope or ruling grade, that must be negotiated, should be determined by studying a contour map. For travel over slopes we have to think about the gradient.

Vegetation. The effects of vegetation on trafficability are not within the scope of trafficability of soils, but some points are worth mentioning. Dense grass, especially if wet, may provide slippery conditions. Additionally, soil strength requirements will be greater than normal, if small trees or thick bush must be pushed down by the vehicle.

Organic-soil areas. Some part of the terrain could be blanketed with a layer of organic material composed of roots, mosses, and other vegetation in various stages of decomposition. Usually, high-ground-pressure vehicles can take only a few passes before they break through and become immobilized. Wheeled vehicles usually cannot travel on most of these organic-soil areas.

Other obstacles. A complete assessment of the trafficability of the given area must include the evaluation of obstacles such as forests, rivers, boulder fields, ditches, and hedgerows.

Influence of weather. Trafficability can be estimated if weather conditions, soils, and area topography are generally known. Weather and climatic information is usually available, even for remote areas, from meteorological records, climatology textbooks, or personnel interrogation. Soils and topography data may be obtained from topographic, soils, and geologic maps, aerial photos, or interrogation.

Weather changes produce changes in soil trafficability. Trafficability characteristics measured on a given date cannot be applied later unless full allowance is made for the changes in soil strength caused by weather. Freezing and thawing conditions can cause extreme variations in the trafficability of soils. Several inches of frozen soil may carry a large number of extremely heavy vehicles. However, when this same material is thawing, it may be impassable to nearly all vehicles. Snow cover can have

a significant effect on the depth of freezing. The absence of snow allows frost to penetrate more deeply into the soil.

3. Different Ways of Judging Trafficability

There are more ways how to solve the trafficability of terrains. This article describes two field manuals used for the judging. First is the Czech Field Manual Žen 2-16 "Military Roads and Ways" and the second is the American Field Manual 5-430-00-1 "Planning and Design of Roads, Airfields and Heliports in the Theater of Operations – Road Design".

3.1. First Approach - Military Roads and Ways

In the Czech Republic the trafficability is dealt with in the Field Manual "Military Road and Ways". Due to this manual, it is possible to judge the trafficability by visual observation, but it is not very exact. Another not very reliable method, for trafficability determination, is making a footprint on the soil. If we are able to make full footprint the terrain is supposed to be untrafficable for wheeled vehicles. Then we can use two simple instruments – the engineer crowbar and telescopic penetrometer (PT – 45). These instruments are based on finding out the resistance of soil against leaking of the thorn. Figure 3.

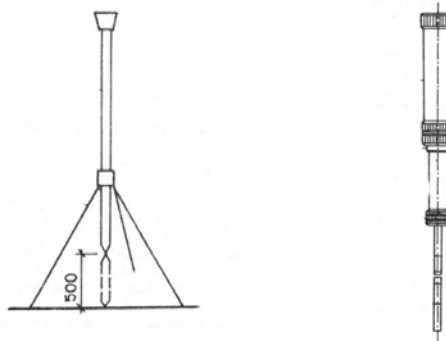


Figure 3. Engineer Crowbar, Telescopic Penetrometer. [4]

The engineer crowbar is used only for casual judgement of the trafficability of terrain. The crowbar is dropped from the high of 0, 5 meter. The depth of bog after one fall is considered to be the depth of wet soil. Then the trafficability is judged due to the chart. The trafficability of the wet terrain is judged on more places. From the measured values we determine the average value.



Figure 4. Measurements with the Telescopic Penetrometer.

The telescopic penetrometer is ended with a thorn; this thorn is pressed to the soil. The instrument has a dial on which we read the pressure needed to press the thorn to different depths. Each measuring is carried out three times in one-meter distance. The number of vehicles, which can negotiate the measured area, is determined due the table.

As a low-supporting terrain we consider the terrain where the engineer crowbar is more than 10 cm deep after one fall, or the telescopic penetrometer measure the value lower than 3 MPa.

3.2. Second Approach - Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations – Road Design

In this field manual we determine the trafficability of the soils by two indexes – rating cone index (RCI) and vehicle cone index (VCI). These two indexes are calculated in a form named Trafficability Test Data Form. As soon as we know the values of this two indexes and compare them, we are able to judge if the soil is trafficable for the given number of vehicles. GO means that the vehicles could go and NOT GO means that they will mire.

$$RCI < VCI \rightarrow GO$$

$$RCI > VCI \rightarrow NOT GO$$

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Rating cone index. [3] RCI is measured with the soil-trafficability test set. This set consists of one canvas carrying case, one cone penetrometer, one soil sampler, remolding equipment and a bag of hand tools. It is shown in Figure 5. RCI is a product of two other indexes - cone index CI and remolding index RI.

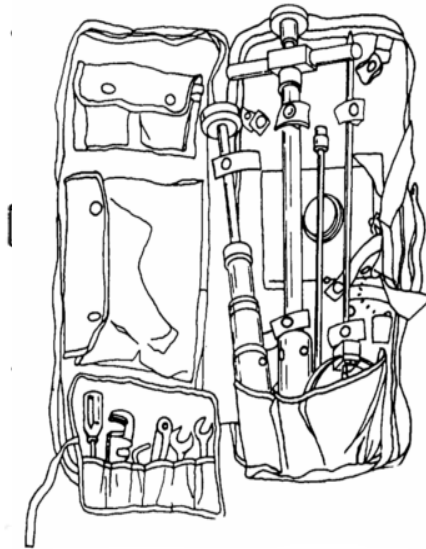


Figure 5. Trafficability Test Set, Cone Penetrometer, Remolding Test Set. [3]

The CI is measured with the cone penetrometer. It is used to determine the shearing strength of low-strength soils. When the cone is forced into the ground, the proving ring is deformed in proportion to the force applied. The amount of force required to move the cone slowly through a given plane is indicated on the dial inside the ring. This force is an index of the soil's shearing resistance and is called the soil's CI in that plane. The cone penetrometer cannot be used to measure gravels. Gravels are considered excellent for 50 passes, and any problems can be determined by visual observation.

The index RI is measured with this set as well. A piston-type soil sampler is used to extract soil samples for remolding tests. The equipment for the remolding test consists of the following: a steel cylinder and an approximately 2,5 pound steel drop hammer sliding, a cone penetrometer.

How to make the measurements? Soldiers should obtain data to determine the number and type of vehicles that can cross the area and the slopes they can climb. Remember that measurements are valid only for the time of the measurement and short periods thereafter, provided no weather changes occur. The number of measurements taken is determined by the time available, the judgment of the range of soil strengths, and the general uniformity of the area. Trafficability-measuring instruments are designed for rapid observations. The accuracy of the average of any series of readings increases with their number taken. Variations in soft soils require that at least 15 readings be taken to establish a true average CI at any spot at a given depth. These 15 readings should be distributed throughout a uniform area. If time is not available to take a large number of measurements, use judgment to reduce the number.



Figure 6. Measurements with the Cone Penetrometer.

Vehicle cone index. [3] For conventional types of vehicles used in some NATO countries, the values of vehicle cone indexes are known and tabulated. On the other hand we have to count the VCI for the vehicles used in the Army of the Czech Republic. First we are able to count the mobility index MI and after that we can find the vehicle cone index from a curve in a chart.

Here is the formula for counting MI [3] :

$$MI = \left[\frac{(CPF) \times (WF)}{(TF) \times (GF)} + (BF) - (CF) \right] \times (EF) \times (TSF),$$

where: *PF* - contact pressure factor,
WF - weight factor,
TF - track factor,
GF - grouser factor,
BF - bogie factor,
CF - clearance factor,
EF - engine factor,
TSF - transmission factor.

4. Measurements on the Local Conditions

The task of the research is to carry out the comparative measurements based on these different methods. The reason why we chose these two methods is that the first one has already been used in the Czech Republic, but the opinion about its accuracy varies. So it was covetable to find another instrument for their comparison. The required instrument should be modern, should be used by other NATO countries as well as to be precise in judging. Whether the second approach really fulfils these demands, we will see after the measurements.



Figure 7. Measurements are pursued in different terrain, in different climatic conditions and with different types of vehicles.

The aim of these measurements is to compare instruments and find out the advantages and disadvantages during their use as well as during the evaluations. Next goal is to define the vehicle indexes for the mostly used vehicles in the Czech Republic, not only in the army. Last but not least, our aim is the assessment of soil indexes in conditions of the Czech Republic and in respect to the Czech system of classification. This depends on the areas where the measurements are made. The experiment runs during the whole year. There is an attempt to make the tests during different climatic conditions, in a different kind of terrain and with different types of vehicles. The results can be used not only in the Army of Czech Republic, but in the civil sphere too.

5. Conclusion

In conclusion it is good to emphasize the importance of knowledge the trafficability of terrain. There are two spheres of utilization – military and civil. In the military sphere the very quick negotiation of the terrain during military actions is necessary. If it is not possible to use the original route the troops tend to choose the shortest way through the terrain. In the civil sector we use this method for judging trafficability of terrain when the normal roads or bridges are damaged due to some natural influences. Then there is need to get to these weatherworn areas to ensure food, material, reconnaissance of harms. And we must not forget one of the most important things, such as the transport of ambulances and other help. If we are able to judge the trafficability of terrain quickly and reliably, we can help in all these cases mentioned above.

There are a lot of possibilities how to determine the trafficability. Here are mentioned two possible systems of methods how to determine it. The first one corresponds with the field manual "Military Roads and Ways". Here we measure with the telescopic penetrometer. After that we can find out how many vehicles can negotiate this terrain. So we measure only the "soil factor". On the other hand there is a method described in the field manual "Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations – Road Design", where it is known the number of vehicles and it is wanted to learn if they can go through the area or not. So in this system we take with account two factors - "soil factor" and "vehicle factor".

The goal of our research is to compare these two instruments and find out their advantages and disadvantages during the use and during the evaluation and to determine which of these methods is better and to state whether the second approach is better. Whether the second approach should replace the existing one or not. Then the next goal is to prepare the conditions for the acceptance of the approach in case that it will be taken over. This acceptance means the determination of the vehicle indexes for the mostly used vehicles in Czech army and the assessment of the soil indexes with respect to the Czech system of classification. And this is the scope of the research. But it is important to know that trafficability is one of the most important things in the decision-making process during any extraordinary situations.

R e f e r e n c e s :

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Introduction of Authors:

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