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MILITARY ROAD INTERPOLATION INTO PUBLIC ROADS NETWORK IN CONDITIONS OF NATURAL DISASTER

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Abstract

The traffic connection of an area is important for the economic development of the country, but it is of decisive importance for defence purposes. Unlike carefully planned public roads, the concept of military road construction must include solutions for "sudden and non-standard" or sudden and unusual circumstances and events, whether military forces participate in war or peacetime (natural disasters) operations. The paper presents the military roads partition and methods of construction in specific terrain. Military engineering units have a key role in the provision of traffic communications. The example shows the construction of a road for evacuation of the population after a natural disaster by bridging the river with a launch bridge with a tank bridge carrier MT-55A with a construction time framework.

Keywords: public roads network, military road, natural disaster, military engineering units

1 Introduction

Today, military forces are not engaged solely for the purpose of state territory protection. Because of the rise of terrorism, as well as natural disasters due to global warming, the role of the military is increasing even in peacetime [1]. The role of each army is to protect and defend the sovereignty of a state, its integrity and territorial integrity. During peacetime, the military has a major role in helping the population when civilian services are not sufficient to assist in times of natural disasters. It possesses material and technical means and the machinery needed to solve such problems. In order to perform successful military and peaceful operations, it is necessary to enable relocation of human recourses and techniques by using public roads and/or construction of new military roads. In doing so, the military road network should be interpolated into the public road network and its use should be coordinated with the companies operating the public highways in accordance with national regulations. Engineering, as part of the military, participates in the planning and construction of military roads having its own structure and command and does not undertake anything without the command of superior commanders.
This paper shows the division of military roads and how they are constructed in special and difficult conditions. It indicates the capability of military engineers to overcome obstacles on the terrain in a limited time and in such circumstances. The method of organizing the work and planning of engineering works for the construction of a temporary military road by observing the general principles of occupational safety and maintenance procedures are described in the paper.

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2 Division of military roads

The military road network consists of: public roads when used by the military units, permanent and temporary military roads.
Public roads are divided [2], [3] by social, traffic and economic features into motorways, state, country and local roads, by type of traffic into motor and mixed roads, by size of motor traffic and by the task of connecting and medium-length of travelling into motorways and five-class and according to terrain configuration to those without restriction (flat terrain), with slight restriction (hilly terrain), considerable restriction (highland terrain), and great restriction (mountain terrain).
Permanent military roads are roads constructed for internal military purposes and are intended for military traffic in peacetime. During the war, they are used together with the existing public roads (for military and civilian traffic). Temporary military roads are roads of limited duration and are built on the routes of the movements of units when existing roads are insufficient or when they are more heavily damaged. These roads are being constructed to bypass sensitive traffic nodes, larger settlements, and contaminated parts of the existing roads, as well as to transport the troops to positions and areas of gathering and similar.
Just as public road regulations prescribe the design of road elements in such a way that motor vehicles can move safely and smoothly, so the design of military roads and their classification and marking depends on [4]: whether there will be wheeled or tracked vehicles, whether it is intended for single row of vehicles (usually 1 to 1.5 lane width of existing public roads) or for two rows of vehicles, depending on axle load, height and width of military vehicles and on space constraints such as curves of small radii, large longitudinal slopes, limited heights and widths (bridges, tunnels, etc.)
The maps of military roads contain the classification of roads depending on the possibility of use in adverse weather conditions and the specific conditions (deep snow, the possibility of floods, etc.) and depending on traffic load [4]. By this classification the roads are divided into: those without restrictions - possible year-round traffic in all conditions and for unlimited loads; with partial restriction - while keeping the potential traffic in almost all weather conditions and with occasional bans, but in difficult conditions it is necessary to limit the traffic load; those whose use is not possible in adverse weather conditions and the potential use would require long-term repairs.

3 Construction in special conditions

In the construction of public roads, the construction in special conditions is not considered, that is, taking into account the principles of tracing, all disadvantages are avoided. Unlike public roads, temporary military roads are usually small in length and the entire section can be built in marshes or in difficult mountainous terrain, and there is a need to build during wintertime when the land is covered with snow.

3.1 Selection of the route

The route of the new military road should be selected in such a way that it is as quickly and easily accessible as possible to the endangered area or to the specified location. The type and slope of the terrain, the length of the route, the narrowest places for overcoming the obstacle, the boundaries of private estates should be determined in order to inflict minimal damage to the land of the inhabitants. The barrier overhang should be suitable for mounting the bridge from the bridge carrier tank. Preferably, the route should be selected in such a way that the route is cleaned with as little mining work as possible and the machinery can be used. In order to optimally select the route of the road, the reconnaissance is carried out on the map and in the field.

3.2 Construction on poorly bearing ground

Coherent soils have poor bearing capacity during the rainfall period, while in the dry season, military vehicles can move outside the designated road. The most difficult are the road sections over the marshy soil, so the survey should determine the optimal conditions for crossing the marsh: the most suitable and shortest route of the road, the conditions for the passability of the marsh, the level of groundwater and surface water. A reconnaissance group is usually formed for routing.
The first variant of the road route is where the marsh is narrowest and closest, with maximum utilization of already existing roads and paths. The wetland may be more passable elsewhere, which determines the crossing point [5]. Passability means the number of vehicles that can pass on one track so that the vehicle (wheels) does not fall into the ground more than the height of the center of the vehicle relative to the ground. The passability can be estimated by starting the vehicle (test load), always having another vehicle to pull out the test or by using a probe or the sonde (thin twig) that is inserted into the marshy soil, and the peat depth is estimated according to the resistance provided by the drive. If trees grow in height over 3 m in height and over 5 cm in thickness, this is usually an indication that the marsh is passable to caterpillars. If a reed and sedge grow on wetland, the soil is moist and impassable. The required bearing capacity of the soil is min. 50 kN/m2. The caterpillars require load capacity of 70-100 kN/m2 and in the event that it has been fulfilled, the traffic can be released after marking the route and removing vegetation at the required crossing width. However, if more vehicles are expected, then it is necessary to improve the carrying capacity of the soil by logs or geotextiles. Up to 600 vehicles should be allowed to pass by improving the load carrying capacity of the soil. If a satisfactory load-bearing cannot be achieved with the described improvements, it is possible to construct an embankment or wooden bridge.
The highest level of surface water is determined by spotting the highest level of flooding by detecting traces on the surrounding land or collecting data from the population. If mixed trees and other vegetation grow on the land, it is a sign that the surface water does not linger for a long time, and if the bush and reeds grow, it is the opposite. Groundwater level is determined by digging bore holes on the routing of reconnaissance. The road level should be above the surface water level.

3.3 Building a road on mountainous terrain

The first step in building a road on mountainous terrain is to determine the route of the road on the map using the existing trails and roads to the maximum extent possible. The lengths of the sections with the maximum longitudinal slope shall not exceed 1 km. Otherwise, the length of 50-100 m with a slope of 2 % should be made after 1 km. This is followed by field reconnaissance and the final route selection. Only after that, the route of the temporary military road is marked.
In the mountainous terrain, large quantities of earthworks are required, the work in the rock material with the use of explosives, the work in confined spaces, construction of large number of facilities, all of which require a lot of care and responsibility to organize the work. To accelerate the progress of work, the method of excavating is applied whereby a wider range of work is opened. Timber (trees that grow in close proximity) is used for the construction of retaining walls on sections where there is a danger of stones falling down or snow avalanches. In the construction of temporary military roads, some solutions not otherwise used in the construction of public roads may be applied: using crossfalls independent of the road geometry (safety), filling in the river or launch bridge crossings, etc. Despite the fact that modern military vehicles can overcome water barriers of greater depths, draft must be managed (remove large stones and level the river bottom, approach the ramps with gentle slopes). If

a bridge is still being built, it is necessary to determine the vertical alignment , considering that the water levels of the mountain rivers can rise sharply and that the water flow is at high speed. Along the dangerous road sections (sharp bends of the precipice and the like), fences are placed on the outside of the pavement in the form of wooden or stone pillars or walls which are painted white on the inside for safer driving at night.
The pavement is made of stone material. In case that the road passes over the rocky soil, the road body is well straightened and the pavement may be avoided. On one-way mountain roads, every 250 m is used for lay-bys of up to 100 m in length. Platforms for shorter vehicle breaks are created in front of long and larger ascents or descents. Along the road, gravel, sand or sand reserves are being prepared to prevent the vehicle from slipping during periods of rain, snow or ice.

3.4 Building military roads in wintertime

Road construction during the winter implies conditions in which the country is covered with snow, temperatures are low and for a long time below 0°C, rivers, lakes and wetlands are frozen. Under these conditions, public roads are not built. However, such conditions do not pose a major problem for the construction of temporary military roads which usually serve traffic only for a short time. These are even easier conditions than periods of heavy rainfall [5]. The frozen soil has good bearing capacity and the movement of vehicles is impeded due to icy conditions which can be mitigated by spreading gravel or dunes. In this case, too, the scouting is required. First, it is necessary to determine the route of the road on the map and then collect information on: thickness and compactness of the snow, air temperatures, thickness, condition and bearing capacity of ice on rivers and lakes, connection of ice with shores, other information about the route (gradients of ascents, falls, etc.), and the site of construction material. After marking the route of the road and clearing the vegetation route, it is necessary to fill the holes at the location of the extracted stumps and clear the route from the snow. Usually it takes the longest time to clear the snow by using different machines and hand tools. On such a road, except for traffic signs, poles 1.2 to 1.6 m high should be installed along the road, or snow pyramids should be constructed to channel traffic and clean up in case of new precipitation. If the section of the road is without major ups and downs, the traffic can be opened immediately after clearing the snow. Passing spaces should be made on one-way roads.

3.5 Maintenance of military roads

Road maintenance work for military purposes includes: removing defects identified by reconnaissance and ongoing maintenance work during use. Maintenance work is no different than that required on public roads.

4 Engineering units

Engineering is an Army branch, equipped and trained for the combat support in all forms of combat. It also has a role in assisting the civilian population in times of natural disasters such as earthquakes, floods, etc. Engineering support is a set of engineering works on overcoming natural and artificial obstacles, eliminating the consequences of attacks, making communication links (roads, airports, heliports, ports, docks) and facilities on them for movement and manoeuvering, delivery and evacuation, landscaping with the aim of protecting the military forces and resources, building artificial and improving natural barriers to prevent the rapid penetration of enemy forces and protecting their own units, finding the required amounts of water and making water available for use, and participating in the disguise of facilities and units in fire positions, command posts, liaison centers, etc.

In accordance with its basic tasks, military engineering has task units which are equipped with the appropriate material resources. Engineering units whose task is the construction of roads, the road units, maintaining and repairing the existing roads and building temporary ones and structures on them, clearing rubble and other obstacles on roads and in populated areas. They are equipped with: dockers, graders, crushers, mixers, rollers, compressors, power drills, chainsaws, cranes, snow cleaners, trucks, launch bridges, loaders, diggers, self-loaders, tool kits, accessories etc.

5 Example of the construction of a temporary military road

A section of a public road that is out of traffic due to the damage, is interpolated by a temporary military road. Overcoming the water barrier on the temporary military road was carried out by the launch bridge, the MT-55A armoured vehicle-launched bridge.

5.1 Organization of engineering works

Depending on the available time, military forces and resources for the construction of a temporary military road should be defined. In order to make the construction faster, on the road alignment which is a linear object, the engineering unit is spread over a relatively long area and works both in groups and individually (humus removal, excavation, mining, etc.), but all are interconnected in the task. It is essential to maximally use the human and material resources of the engineering unit, depending on the work to be performed. In its content, methods of work and means for work, the organization of engineering works is very similar to the organization of work in construction, so these disciplines in scientific and professional sense are mutually developing and complementary. The stages of organization are the planning and preparation of engineering work.
Planning engineering works. The basis for the preparation of the plan of final construction works is the order of the superior commander to perform the engineering tasks and the corresponding technical documentation is made. An engineering work plan must be carried out in all cases, whether the technical solution was given by a task or afterwards. It must be achievable in accordance with the weather, terrain and combat conditions, and should allow for easy monitoring of the progress of works and making the necessary corrections. The development of the plan consists of predicting the external factors that have a positive or negative effect on performing the task, and developing a dynamic plan of activities. The following general principles apply to the planning: gradual engagement of forces and engineering and technical means in the initial phase of work and shutdown in the final phase, simultaneous execution of several work operations for the purpose of faster performing of the task, maximal use of engineering machinery with careful handling and maintenance.
Preparing engineering works. The preparatory work consists of: studying the task, the assessment of the situation, the scouting of the area of the construction works, the arrangement of the work site, preparation of materials, the organization of transport and giving the command.

5.2 The MT-55A armoured vehicle-launched bridge (AVLB) tank

One of the most important engineering machines for overcoming obstacles is the MT-55A armoured vehicle-launched bridge (AVLB) tank (Figure 1). It is modified specially fitted T-55A tank with no turret and weaponry. It is equipped with a bridge and devices that allow the bridge to be laid over an obstacle and placed back on the armored body of the tank [6]. It is tasked for the quick laying of a bridge over antitank barriers (antitank trenches, steep inclines and slopes) on a land that is otherwise passable under normal combat conditions. It

is possible to lay a bridge over water barriers with muddy or soft bottoms, with steep banks without prior engineering arrangements, over deep and impassable parts of riverbeds. The bridge can be used to further strengthen the existing bridges as well as to secure weakly bearing sections of the terrain. The bridge carrier tank has mostly the same equipment found on the T-55A tank as well as modified and new assemblies that are missing from the base tank. Figure 1 shows the launch bridge installation process [7] which is also possible on terrains of various slopes.

Tactical and technical features: MT-55A is a medium tank type with a total weight of 36 t; the crew consist of two members; bridge weight 6 t, load capacity 50 t, width 3300 mm, laying time 3 min. and the time of tank placement 5 to 8 min; the length of MT-55A with folding bridge is 9880 mm and set on the flat surface 27100 mm; the length of the folded bridge is 9600 mm and unfolded is 18000 mm; the width of MT-55A without bridge is 3270 mm and with bridge 3300 mm and the height of MT-55A with folded bridge is 3350 mm.

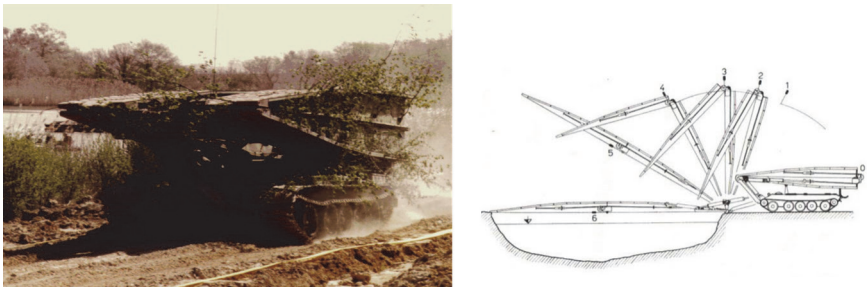

Figure 1 The MT-55A armoured vehicle-launched bridge tank and the assembling process

5.3 Calculation of time and resources required for the given task

The location of the bridge installation on coherent ground, in the example described (Figure 2), was selected at the location of the most favourable slope of the terrain and the least width of the obstacle.

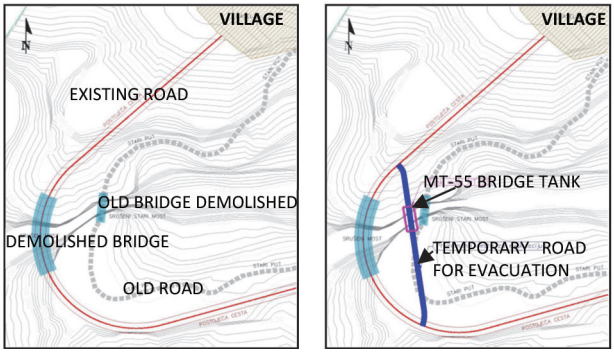

Figure 2 Current state and overview of project draft

Based on the horizontal and vertical alignment and cross sections (Figure 3), the quantities of stone material were calculated for: the road bed (46 m^3) and pavement (16 m^3). For each engineering machine available to this engineering unit, the efficiency was calculated using known empirical terms and taking into account the following influential parameters: soil category on which the works were performed, the coefficient of age of the machine and the competence of the machine operator, the speed of movement of the machine at work, etc.

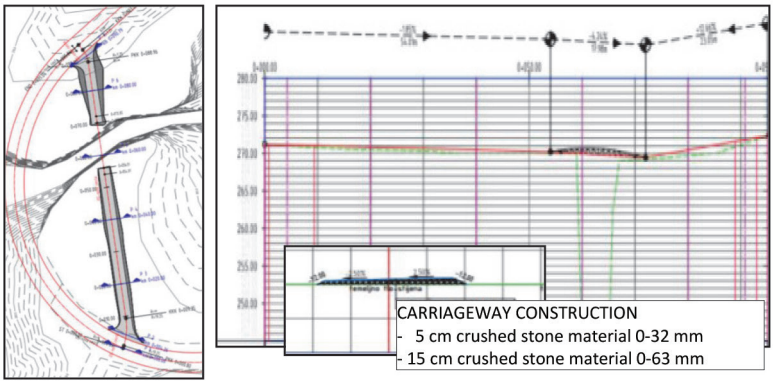

Figure 3 Horizontal and vertical alignment and normal cross sections of temporary military road

Table 1 Overview of works, resources, and time needed to complete

No.	Type of work	People/ means	Quantity	Time needed (min.)
1.	Reconnaissance	Officers	5	20
2.	Stakeout of the first part of road alignment	Soldiers	4	40
3.	Cleaning of the first part of road alignment from vegetation	Soldiers /chain saws	6	30
4.	Mining a rock	Miners	2	35
5.	Levelling by dozer (1st part)	Dozer	1	150
6.	Filling in and levelling of nivelette road (1st part)	Dumper Dozer	5 1	Simultaneously with works under no. 5
7.	Launching of the bridge	TM-55	1	15
8.	Stakeout of the second part of the road alignment	Soldiers	4	15
9.	Cleaning the second part of the road alignment from vegetation	Soldiers /chain saws	6	20
10.	Levelling by dozer (2nd part)	Dozer	1	45
11.	Filling in and levelling of nivelette road (2nd part)	Dumper Dozer	5 1	Simultaneously with works under no. 10
12.	Filling in the road alignment with rough stones	Dumper Dozer	5 1	120
13.	Filling in the road alignment with small stones	Dumper Dozer	5 1	90
14.	Rolling	Road Roller	2	30
15.	Establishing of the traffic	Soldiers	8	20

The following machines were used to perform the task: dozer, loader, excavator, road roller and road grader. Levelling of the ground with a dozer of 14 m^3/h takes approximately 2.5 hrs. It takes 30 minutes to roll the total length of the road. By using 5 dump trucks with a load capacity of 15 m^3, it is possible to transport materials from a quarry 15 km away by monitoring the dynamics of the planned works. The loader is in reserve for spreading excess material. Table 1 shows the type, resources, and dynamics of temporary military road construction done by a military engineer unit. The road was built in 630 minutes (10.5 hours).

6 Conclusion

Military roads differ from civil roads because they are mostly temporary roads and have specific uses (eg. in this case the evacuation of the population and protection of the property). The advantage of engaging the armed forces over civilian services lies in the speed of their work and the ability to currently deploy forces that are more prepared to operate in specific conditions. In its composition, military engineering units have all the necessary material resources and machinery to overcome obstacles and to access more inaccessible terrain, which leads to a faster and more efficient solution of the problem. The example of the construction of a temporary military road shows the organization of work, planning and management of the execution of the task, which is organized hierarchically and is carried out solely according to the commands of the superior ones. The engineering units are capable of finding out quick solutions which is of utmost importance in combat operations but not less important in helping the population during natural disasters. The engagement of the armed forces to remedy the effects of natural disasters shows their humane features and importance during peacetime activities. The armed forces, especially engineering units, will continue to play a major role in recovering and rescuing civilian population during natural disasters, and the best indicators for this are numerous examples from the past when the armed forces made an invaluable contribution in helping the population in exceptional circumstances.

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