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Industrial approbation of temporary road structures for transport-assisted exploitation of forests

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Abstract. The article discusses topical issues for the forest industry of the Russian Federation and the Republic of Belarus in the field of construction of automobile forest roads in difficult soil and hydrological conditions with low bearing capacity of soils and lack of road-building materials. To solve this problem, the authors of the article proposed road structures with the use of geotextile fabric, which could save up to 30% of road-building materials without reducing the strength characteristics of the structure. Recommendations have been developed for the construction of roads using geotectile fabric based on the results of pilot testing in industrial conditions.

1. Introduction

In recent years, in the Russian Federation and the Republic of Belarus there has been an increase in the volume of construction of roads in forested areas. At the same time, the composition of transport networks has been replenished not only with various categories of roads of year-round operation, but also with seasonal and temporary roads. Moreover, constructive solutions for temporary roads should take into account both the regional soil and hydrological conditions of the area where they are planned to be built and the negative impact of weather and climatic factors on the operation of the temporary transport and technological routes. In this case, the construction of temporary forest roads is largely constrained by the type of forest stands, as well as the characteristics of the soil and peat deposits on which they grow. After all, it is precisely these circumstances that mainly determine the bearing capacity of various types of soils in terms of the movement of timber transport vehicles, as well as the operation of vehicles involved in the road construction process (table 1).

Table 1. Types of forest stands, and characteristics of weak foundations and their strength parameters.

Types of forests, tree species, vegetation cover	Characteristics of peat massifs and soil types	Load bearing capacity, MPa
Pine-shrub, pine-sphagnum, ridges with small *Eriophorum vaginatum /Sphagnum spp.* agglomerations (upland), lowland wetland, sedge swamp (lowland).	Bogs. The presence of tree trunks is characteristic, and for floodplain bogs, layers of mineral soil and dense peat. The swamp water level is 0.3 – 0.5 m. The freezing depth is 0.5 – 0.7 m.	0.025–0.055
Ridges with medium *Eriophorum vaginatum /Sphagnum spp.* agglomerations (upland), lowland wetland, sage bog (lowland).	Upland and lowland swamps. Low stability, medium waterlogged. Interlayers and lenses of peat of a fluid consistency and liquid swamp formations are found. The swamp water level is 0.1 - 0.3 m. The freezing depth is 0.4 - 0.8 m.	0.025 –0.01
Ridges with large *Eriophorum vaginatum / Sphagnum spp.* agglomerations, lakeside (upland), sphagnum swamp (upland). Bogs.	Unstable, heavily waterlogged. Lenses of water and liquid wetland formations. Lakes and canals. The swamp water level is 0.1 m. The freezing depth is 0.3 - 1 m.	> 0.01
Pine and spruce forests with *Oxalis spp*, secondary aspen and birch forests. Pine forests with moss, lichen, heather, and lingonberry. Spruce forests with lingonberry, and secondary birch and aspen forests.	Sandy and light loamy. Sandy. Sandy and sandy loam.	0.15 – 0.20
Pine forests with blueberry. Spruce forests with blueberry, and secondary aspen and birch forests. Pine forests with grass.	Sandy loam on top. At a depth of 0.30 – 0.50 m, they are underlain by loam or clay. Ordinary sandy loam, lined at a depth of 0.30 – 0.50 m with loam or clay, less often loamy. Loamy.	0.10 – 0.15
Pine and spruce forests with blueberry and tall mosses, and secondary aspen and birch forests. Spruce stands near streams (in gullies), secondary aspen and birch forests. Pine and spruce forests with grass, sedge and sphagnum, secondary aspen and birch forests.	Loamy. In the upper part, there is a layer of humus up to 0.40 m thick. Loam or clay, on top of a layer of humus with a thickness of up to 0.5 m. Peat, more than 50 cm thick.	0.055 – 0.1

2. Methods and Materials

The data presented in the table indicate that, in order to ensure the passage of forestry vehicles and the movement of road-building equipment across territories characterized by low bearing capacity of soil, it is necessary to develop temporary road structures based on reinforcing layers of geosynthetic fabric, brushwood and local soil. The positive effect of the use of geosynthetic layers is explained by the fact that, when the underlying soil is deformed, they stretch and absorb a part of the load redistributing it to a significantly larger surface area. Moreover, a weak soil base protected by a geosynthetic layer is less loaded than a soil under the pavement without a protective layer [1].

Brushwood lining is a local and widely available material for forest enterprises and therefore is often used for temporary roads. A sealed cushion of wood harvesting residues creates a dense deformable base. At the same time, in the process of arranging a brushwood cushion, the brunches are laid with a large margin in height which depends on soil and hydrological conditions. The use of brushwood allows us to increase the rigidity of the soil base when exposed to and transferring the load, which reduces the specific pressure of vehicles.

To prevent the mixing of materials of structural layers and allow the redistribution of pressure from vehicle movers to a large area of weak underlying soil, alongside with brushwood cushions layers of various types of geosynthetic materials are used, which, in addition to high strength, are wear-resistant, do not decay in the ground, do not reduce the strength gap, and filter water well. They are also an effective solution that allows us to use all the positive properties of local building materials in order to reduce the cost of construction.

For the purposes of road construction, a relatively large number of geosynthetic materials have been used. One of such promising materials is DuPont's Typar, characterized by:

1. High modulus of elasticity, due to which the material can absorb significant loads and perform the function of reinforcing at relatively small deformations.
2. Large elongations at break: depending on the type of material, Typar has elongations under maximum load up to 45%. Thus, local damage does not lead to the destruction of the material and Typar continues to perform its functions.
3. Universal filtering ability, due to the specific structure of the material, which makes it almost impossible to introduce soil particles into the pores and clog them. This allows Typar to maintain consistently good filtering properties under soil pressure and in conditions of strong vibration.
4. High tear and puncture resistance, which is especially valuable when laying out the material.

Other important properties of Typar material are:

1. Easy to install: the material rolls are small and light, which reduces transport and storage costs, as well as labor costs.
2. Easy to handle: Typar rolls can be sawed directly in place with a chain or hand saw.
3. Typar does not absorb water: when used in wet conditions, the weight of the rolls remains unchanged.
4. Typar is resistant to natural acids and alkaloids, as well as to insects, bacteria and mold.
5. Has the same degree of stretching in the longitudinal and latitudinal directions, which allows it to achieve uniform stretching of the geosynthetic layer [2].

3. Results and Discussion

In the industrial conditions, in order to determine which structural and technological solutions can be used on the forest site selected for road construction, visual inspection of the site has to be carried out. A comprehensive study of the territory where road construction works are to be carried out, as a rule, identifies the waterlogged sites and the degree of waterlogging of the terrain (figure 1), as well as the presence of wetlands and peat deposits.

Figure 1. General view of the sites designated for the construction of experimental facilities.

The next stage of a pilot-industrial testing is the selection and development of structural and technological solutions at the experimental facilities of temporary automobile roads. First of all, places are determined where it is possible to use either a layer of local soil or arrange a brushwood cushion made of forest harvesting residues. Then, objects are selected on which structures with layers of brushwood, geosynthetic materials (figure 2) or various types of combined layers (figure 3) will be arranged.

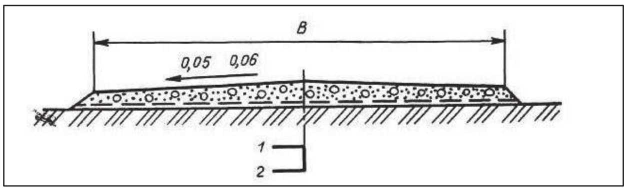

Figure 2. Cross section of the road structure with a layer of synthetic material: 1 - road surface; 2 - geosynthetic fabric, *B* - width.

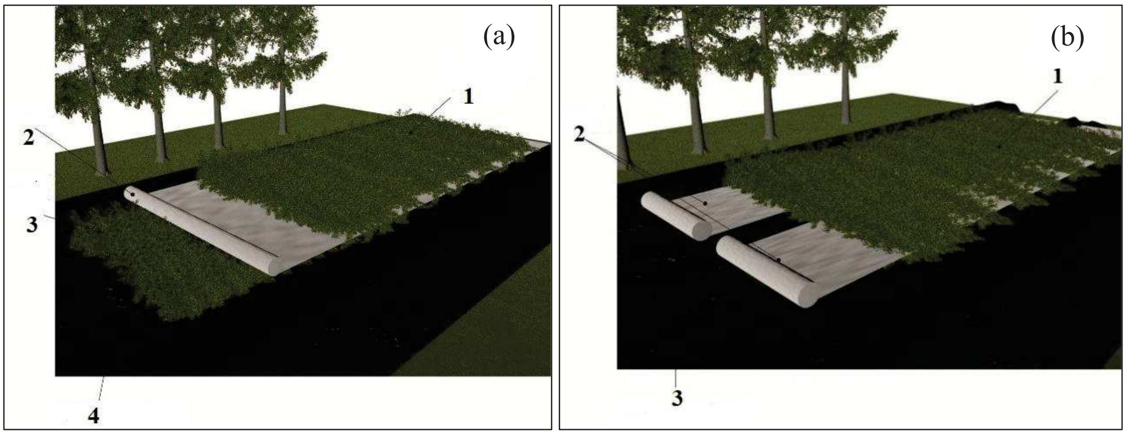

Figure 3. Visualization of the cross sections of temporary roads on weak bases made of a combination of brushwood and layers of geosynthetic material, laid across the entire width of the road surface; (a): 1– upper layer of brushwood; 2 – geosynthetic fabric; 3 – bottom layer of brushwood; 4 – base layer with a low load bearing capacity; and in the wheel drives; (b): 1 – brushwood; 2 – geosynthetic fabric; 3 – base layer with a low load bearing capacity.

As practice shows, the use of interlayers in the construction of temporary roads is the least time-consuming construction approach in which geosynthetic fabric is used on soil bases. In this case, the technological processes are quite simple and are carried out by the road-building equipment available at the road building enterprises. The production technology includes: rolling out the geosynthetic material, filling and leveling the sand coating layer, and its further compaction (figure 4).

Figure 4. Construction of experimental plots with a geosynthetic layer and local soil.

The technology of the construction of a road based on a brushwood lining and geosynthetic material includes leveling, planning and compaction of the base. The process starts with laying out along the entire width of the carriageway forest harvesting residues (figure 5) with their subsequent compaction, then a layer of a non-woven synthetic material is rolled out over the brushwood lining with fastening along the edges of the roadway. Next, on the underlying layer of brushwood lining and interlayers of geosynthetic material, the upper layer of brushwood lining is laid and compacted [3].

Figure 5. Longitudinal tapes and wood harvesting residues.

The design of constructive elements and choice of surface materials for forest transport systems in conditions of excessively moist soils requires the use of effective and at the same time inexpensive materials. As a road-building material, used car tires in combination with local soil can be used. It is the development of new designs of forest transport systems based on used tires that can serve as a fairly rational solution for increasing the carrying capacity of dirt roads on which ruts appear after the movement of timber trains.

In order to more evenly transfer the load from the wheels of moving vehicles along the depth of the road and reduce the specific pressure on a weak base, a road construction based on used tires has been developed. The proposed method for a tire road surface includes the formation of ruts by their preliminary broadening and deepening, as well as the assembly of tires in the form of a tape. Tires are assembled into tapes by first cutting them along the perimeter of the cross section and making two holes symmetrical with respect to the cut line with a subsequent sequential establishment by the method of rotation of each subsequent tire into the holes of the previous one. A distinctive feature of the proposed design is that the tires connected into continuous tapes, to a certain extent, serve as absorbers of pressure from the wheels of vehicles (figure 6).

Figure 6. Use of tires in industrial conditions.

At the end of the processes of pilot construction of road structures, a number of production tests should be carried out in order to assess the operability of a particular technical solution. For these purposes, simplified methods, instruments and equipment should be applied. The operational qualities of temporary roads, in particular the gauge depth after the passage of timber road trains, and the strength of the base should be assessed using a densitometer (figure 7).

Figure 7. Testing the performance of the constructed road surface.

By means of the latter, it has been determined: the indentation resistance of the working tip (E_w, N/cm^2), the modulus of elasticity of the road surface (E_g, MPa), specific adhesion (C_g, MPa), the angle of internal friction (φ_g, deg.), and the working capacity of the experimental section by the number of passes.

Tests carried out at the established experimental facilities in the process of timber transport showed that the developed temporary road structures are quite operational and provide the passage of forestry equipment in difficult terrain conditions.

References

[1] Golyakevich S A and Goronovskii A R 2017 Evaluation of loading dynamics and fatigue life for a forwarder half-frame articulation *Journal of Machinery Manufacture and Reliability* **46** pp 463 – 471

[2] Naskovets M T and Drachilovsky A I 2012 Improvement of road structures to increase the

transport and operational indicators of forest roads [In Russian - Sovershenstvovanie dorozhny`x konstrukcij dlya povy`sheniya transportno-e`kspluatacionny`x pokazatelej lesny`x dorog] *Proceedings of BSTU: Forest and woodworking industry* **2** pp 80–82

[3] Naskovets M T, Korin G S and Drachilovsky A I 2013 Application of Spanbel geotextile material in the construction of pilot objects of forest roads of secondary importance and the results of their tests [In Russian - Primenenie geotekstil`nogo materiala «Spanbel» pri stroitel`stve opy`tny`x ob``ektov lesny`x dorog vtorostepennogo znacheniya i rezul`taty` ix ispy`tanij] *Proceedings of BSTU: Forest and woodworking industry* **2** pp 31–33