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TECHNOLOGICAL MODERNIZATION OF FOREST ROADS CONSTRUCTION IN RUSSIA

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The paper considers the basic problems of construction of wood roads in Russia. Lack of sufficient quantity of roads functioning year round leads to annual isolation of almost 15 million inhabitants of forest settlements in autumn and in spring, absence of rhythm in timber-hauling process, increase in forest products cost. Two organizational methods of forest roads construction, namely, flow-line conveyor and non-flow-line conveyor ones are compared. According to the advanced flow-line conveyor method a complex stream is organized uniting specialized streams equipped with road machines and mechanisms for performing separate works. When the amount of work is small it is recommended to apply a non-flow-line conveyor method, either cyclic or inby.

The experience of constructing a road in a forest, which does not provide any headworks and is carried out by a dredge only, is considered. It allows to lower expenses for construction works.

Owing to the absence of stone road-building materials in the majority of forest regions of Russia a new design of a two-layer road covering from reinforced concrete slabs and the technology of its construction have been developed.

The comparison of the suggested technology of forest roads construction with existing domestic technologies and the Finnish one has shown its efficiency both in terms of money, and from the viewpoint of reduction of the number of necessary machines and equipment.

The technology suggested has passed industrial approbation on running logging enterprises.

Key words: Forest road, Technology, Construction, Reinforced concrete slab

INTRODUCTION

In the strategy of forestry development in the Russian Federation for the period till 2020 much attention is paid to forest roads construction. So, for the period specified it is planned to construct 10 000 km of forest roads and to allocate for this about one billion Euro from the federal budget. It is planned to build trunk-line roads using budget funds and to construct access routes to them using forces and facilities of large forests tenants. Creation of a special state cor-poration for construction of forest roads is considered and discussed in press.

The problem of forest roads construction is complex and many-sided [7-14]. Forest roads are used not only for timber hauling, frequently they provide development of the region as a whole and are important for solving social and other problems. For example, because of the lack of all-weather roads about 15 million of Russians living in forest villages remain literally cut off from the civilization in spring and autumn. Therefore local municipalities should take part in construction, maintenance and repair of trunk-line forest roads as well. It is known, that the better timber-hauling network is developed, the more the payment for forest fund rent conveyed to tenants by the state is. Accordingly, more funding can be allocated for forestry from the budget, including transport infrastructure. Thus, the forest roads system is the wealth bringing constant income and requiring development and maintenance.

Scientific research and global practice show, that forest resources become accessible and forest management successful if road system in a large forest amounts to no less than 10 m/ha of the forest area [1]. It should be noted, that in the majority of forest regions of the Russian Fed-eration the average density of road system makes 0.12 m/ha and is far from the above mentioned parameters [6]. Such state-of-the-art limits the availability of forest resources and possibility of carrying out operations on their reproduction, control and protection. The experience of forest fire fighting in 2010 convincingly testifies that because of impassability of Russia tremendous multi-billion damage was done to large forests, ecological and biological systems and the popu-lation.

DISCUSSION AND METHODS

When constructing forest roads two methods of organization of work are used: flow-line conveyor and non-flow-line conveyor ones [1, 2]. The forest road is an engineering construction designed for movement of vehicles transporting cargoes and passengers. Its basic elements are earth roadbed, road dressing with trackway and road shoulders, engineering constructions (bridges, culverts, water diversion channels, etc.), road furnishing (road signs, marking, etc.). Using a flow-line conveyor method, which is considered to be basic, most progressive and theo-retically developed, a complex conveyor is organized, uniting specialized streams (squads, teams)

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equipped with road machines and mechanisms for performing different kinds of work. Only with small amounts of work, where complex conveyor is impossible to be organized, it is recommended to apply non-flow-line conveyor methods: cyclic or sectional.

To construct a road it is necessary to execute the interconnected complex of preparatory, basic and final works. These works are carried out on easement area. The width of an easement area is adjusted by the Land code of the Russian Federation, 2.05.02-85 SNiP (Construction Standards and Regulations), and makes no less than 30 m for trunk-line roads. Sometimes the clearing width can amount to more than 40 m [1]. It is established, that occupying large territory (4-6 ha/km) forest roads reduce annual wood increment by 16-20 m3 per every kilometer and worsen ecological situation in general [2]. Therefore it is necessary to take measures to reduce the damage from land withdrawal, reducing the width of an easement area.

After cutting a lane and hauling the timber a traffic lane continues to be prepared: stumps are grubbed out or sheared off, a vegetative layer is removed, undergrowth and bushes as well as ground wood and stones are cleaned up, repeatedly laying-out the ground works. Stumps and a vegetative layer are moved to the borders of a clearing. As a result of preparatory works execu-tion the traffic lane represents a closed at all sides site where water can gather and stand. According to the recommendations of the Norms [3] earth trenches or delves for drainage are arranged on its both sides 10-15 days before the beginning of erection of the earth roadbed. Thus, to perform preparatory works apart from harvesting machinery there will be required a set of vehicles consisting of a stumper, a bulldozer and a trench-cutting machine. It is known, that on the average 1-2 culverts are erected within 1 km of a hauling road. For their construction reinforced concrete round rings and prefabricated portal blocks are recommended [3] to be put onto concrete foundation or gravel-macadam foundation pads. Construction of culverts using the existing technology consists of a set of operations: preparatory works connected with the delivery of materials and equipment, preparation of a site where the foundation will further be arranged, installation of blocks of pipes, waterproofing and other works. Such technology is material-intensive, labor-consuming and cost-demanding. Artificial constructions can make from 10 up to 25 per cent of road construction budget cost [2]. It should be noted, that polypropylene pipes has become widespread. Such pipes are made in Russia as well; they possess augmented mechanical stability, reliability within the conditions of temperature fluctuations, have rather small weight, and are produced in diameters up to 1137 mm. These pipes are widely applied on development sites, for example, in reclamation.

Road construction in the forest is complicated with the fact that it is conducted far from the building industry centers in underdeveloped and sparsely populated areas and is concerned with soft and swamp materials, deficiency or full absence of stone ones. According to the Forest Code in force, roads arrangement in large forests is a duty of tenants. However, market relations, competition in the commodity market, aspiration to increase profit make them minimize forest roads construction, maintenance and repair expenses, thus reducing transport component in the production cost.

Cost reduction can be achieved on the basis of foreign experience implementation. The experience of Finland where the greatest approximation to the model of sustainable forest man-agement is realized can be interesting and useful for Russian tenants. Construction of forest roads in Finland is carried out in a lane the width of which is only 12-14 m [15]. After tree felling in a lane and timber hauling no additional preparatory works are executed there and it is this point where significant reduction in cost of road construction is achieved. When timber has been hauled earth roadbed erection begins. The most essential difference of Finnish technologies from Russian ones is in the fact that the works are carried out not by a set of vehicles but by only one machine, the excavator. It excavates the ground and moves it from side ditches to earth roadbed. The ditches depth amounts to approximately 1.0 m, and the height of an earth fill reaches 0.5-0.6 m for waters to go downwards and the road upwards. The cross-section structure of such an earth roadbed is shown in Fig. 1.

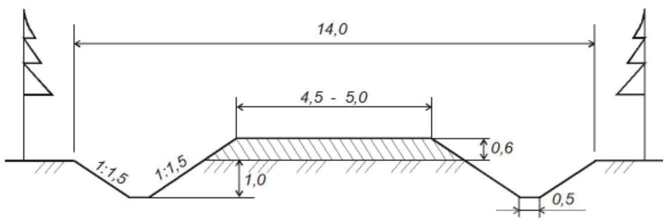

Figure 1: Cross-section structure of an earth fill erected by an excavator from side ditches, m

As the excavator is equipped with a bucket with a continuous cutting edge it also makes rough grading of the earth roadbed top, ditches, slopes of earth fills, as well as preliminary compacting of ground by its own weight of about 15-20 t depending on an excavator type. The same excavator, being a universal machine and having handling accessories (e.g., a set of slings), is also used for installing culverts of all-metal or other pipes. It is necessary to note, that application of an excavator, absence of restrictions on humidity and density of subsoils allow to essentially increase the duration of the road-building season which, using the existing technology, is feasible for only 78-108 working days. It will allow to use building machinery more effectively, to increase annual output and to reduce construction time.

Further, within several years, earth natural stabilization and compaction takes place and the traffic flow is banned there during summer periods. Then a 4.0 m wide and about 0.3 m thick single-layer gravel covering is arranged on the dried roadbed, gravel being taken from local open cast mines without optimizing its structure. Depending on subsurface hydrological conditions of the site, filtering, isolating or other layers can be used.

In the majority of forest regions of Russia natural stone road-building materials (gravel, macadam) are absent or extremely scarce. In our opinion, for such regions it is expedient to use modular reinforced concrete slabs as road covering. They can be produced with high quality at precast concrete factories all the year round and delivered to a place of laying down beforehand (e.g., in winter). More than half a century practice of modular design application has shown that such coverings, in comparison with others, allow quick increase in both the volume of forest road construction, and the volumes of forest exploitation. However, the slabs utilized now and the constructions made from them demonstrate serious drawbacks limiting their application. The main drawbacks are as follows:

- application of expensive (imported) coarse-grained aggregate, i.e. macadam or gravel, considerably increases slab cost;
- imperfection of slab joints in a wheel guide causes the destruction of both the slabs, and the road and results in slabs breakdown, loss of road covering operational quality, additional expenses for repair and maintenance.

A new two-layer construction of modular road covering from slabs made of fine-grain (sandy) reinforced concrete [4-5] without the above mentioned drawbacks is developed and comprehensively investigated at the VSUT (Fig. 2).

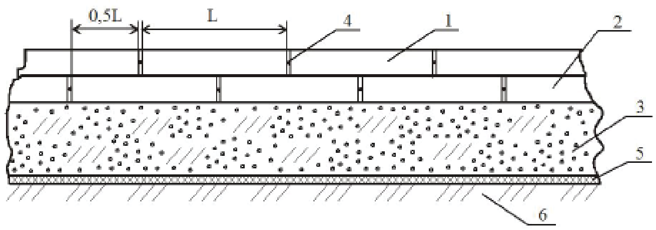

Figure 2: Two-layer road covering from reinforced concrete slabs:
1 – upper layer slabs, 2 – lower layer slabs, 3 – slabs sand base,
4 – butt junctions, 5 – teplonit, 6 – road base, L – slab length

In such a two-layer covering strengthened with welded joints the load from transport wheels is transferred by the top slab at least to two slabs of the bottom layer. As a result contact pressure in the zone of interaction of slabs with the sandy basis considerably decreases, their alignment along the slab length takes place. This excludes occurrence of dangerous plastic deformations in the sandy basis supporting the slabs, and in the underlying ground of the earth roadbed, considerably raising operational reliability of both the covering, and the road in general. Under adverse conditions of the locality (damp, wet places getting waterlogged, etc.) additional strengthening of the road design can be executed by applying a synthetic non-woven material, teplonit, laid down on the earth roadbed. The most used teplonit is 0.006 m thick and is produced as fabric up to 2.2 m wide in rolls up to 40 m long. It has an internal film layer behaving as isolating and connecting interlaminar layer. The film layer also distributes loadings over the surface of the bottom layer, prevents pushing, and increases mechanical durability of the material. One of the drawbacks of common non-woven materials made from synthetic fibers is the fact that they are pervious, which spoils their operational properties. Teplonit has a waterproof film layer which interferes with penetration of moisture. Besides, it consists of polypropylene fibers which are nonhydroscopic, environmentally friendly and light. Heat resistance of teplonit is high, about 1300C. It is convenient in operation and installation, easy to cut out, fastens to the surface, and can be lengthened in width. This material intended for water and heat isolation, is capable to protect the road construction against frosty soil expansion, which is important for operation of roads in conditions of the Russian Federation. Teplonit is proved to be ecologically safe material, it is characterized by high chemical stability, is not subject to rotting, is much lighter and stronger than geotextile materials made from other chemical fibers and their mixes. Teplonit prevents intermixing of sand underlayer with the ground of the earth roadbed, protects the latter against excessive moistening with abundant atmospheric precipitation and spring melting of snow cover.

RESULTS

The comparative analysis of technological distinctions of the works carried out, technical equipment applied in existing and developed technologies of forest road construction is presented in summary Tab. 1.

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Table 1: Summary technological table of the work performed and machinery used under the technologies of wood road construction existing and being designed

	Technological operation	Existing technology and machinery	Technology and machinery being designed
1	2	3	4
I Preparatory works			
1	Tree felling and skidding, limbing, hauling	Clearing width is to no less than 30 m (harvesting machinery)	Forest glade width up to 14 m (two-fold reduction of harvesting machinery volume of work)
2	Stump, float stones, ground wood, undergrowth, etc. removal	Bulldozer, stumper (the work is performed on borrow pits on fill bases up to 0.5 m high)	Backhoe in the places of earth trenches, removed stumps are stacked into the road bed
3	Vegetative layer removal	Bulldozer (he work is performed on borrow pits on fill bases up to 0.5 m high)	Not prefomed
II Earth-moving works			
4	Layer-by-layer development of ground in borrow pits and its moving to an earth-fill	Squad of 2-3 bulldozers	Earth-working is performed by an excavator in side ditches
5	Layer-by-layer earth fill soil spreading	Bulldozer	Not performed
6	Layer-by-layer landfill compacting by manifold roller passage with humidity and specific gravity control	Roller, laboratory	Not performed
7	Earth roadbed top, sideslopes and barrow pits grading	Slop trimming machines, motorized road grader	Excavator
III Water-carrying pipes construction			
8	Site preparation	Bulldozer, diggers	Not performed
9	Pipe base preparation	Bulldozer, diggers	Excavator
10	Gravel-crushed stone subbase installation	Dump truck, bulldozer, diggers	Not performed
11	Pipe mounting	Track-type crane	Excavator with interchangeable equipment (slings) for all-metal or polypropylene pipe laying
12	Pipe waterproofing	Workers	Not performed
IV Road dressing construction			
13	Placing water and heat isolating layer of teplonit	Not performed	Workers, work performance is possible in winter environment
14	Delivery of sand and subbase installation (sub-base)	Dump trucks, motorized road grader, roller	Dump trucks, motorized road grader (winter period is recommended to avoid tracking)
15	Gravel material delivery	Dump trucks	Not performed
16	Slabs delivery		Tractor-trailer trains, truck crane (works are executed in winter), workers
17	Gravel surfacing arangement	Motorized road grader, light roller and super-compactor	Not performed
18	Road covering arrangement	Not performed	Hoist, welder, workers
V Final works			
19	Traffic lane remediation (removed vegetative layer and stubs cleaning off)	Excavator, dump trucks	Not performed
20	Finishing of a road (instalation of signs, crossingpoints provision, striping)	Moto transport vehicles, workers	Moto transport vehicles, workers

CONCLUSION

Analysing the data given in Tab. 1 it is possible to make certain conclusions. The tech-nology of forest road construction under consideration allows tenants to minimize capital investments on purchasing, leasing or renting road-building machines as well as current expenses on their maintenance; it allows to lower substantially the need in experts and workers, to reduce the payroll budget and other payments.

It is necessary to note, that the costeffective technology for forest road construction offered should pass wide approbation in working environment with the aim of bringing in necessary specifications and additions.

We have made and tested experimental batches of road slabs from fine-grain sandy concrete which have successfully passed factory (OAO KPD, Yoshkar-Ola) and industrial check on a working forest hauling highway of Maiski forest industry complex in the Kirov region of the Russian Federation.

In the forest regions of the Russian Federations not rich in natural stone materials it is expedient to use reinforced concrete slabs for road covering. The slabs are made with local sand and are applied in two-layer coverings developed by the authors.

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