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TECHNOLOGY OF REINFORCING SOIL FOREST ROADS BY INTRODUCTION OF SKELETAL AND MINERAL BINDING ADDITIVES

The article points out alternate of technological operations at reinforcing soils of forest roads. It describes a method of mixing and processing of soil by mixture with multi-rotor single-pass soil-mixing machine. This method is more sophisticated and efficient than the use of milling machines, requiring a large number of passes on one track. As skeletal additives, it is offered to use the fractional slag (a waste product of Zhlobin BMP), and as a mineral binder – cement of the grade, which is not below M400. The technical specifications of soil mixing machine D-391, composition of the class to strengthen soils by a leading soil mixing machine D-391 are presented, the sequence of operations to strengthen forest roads using the selected machines is indicated.

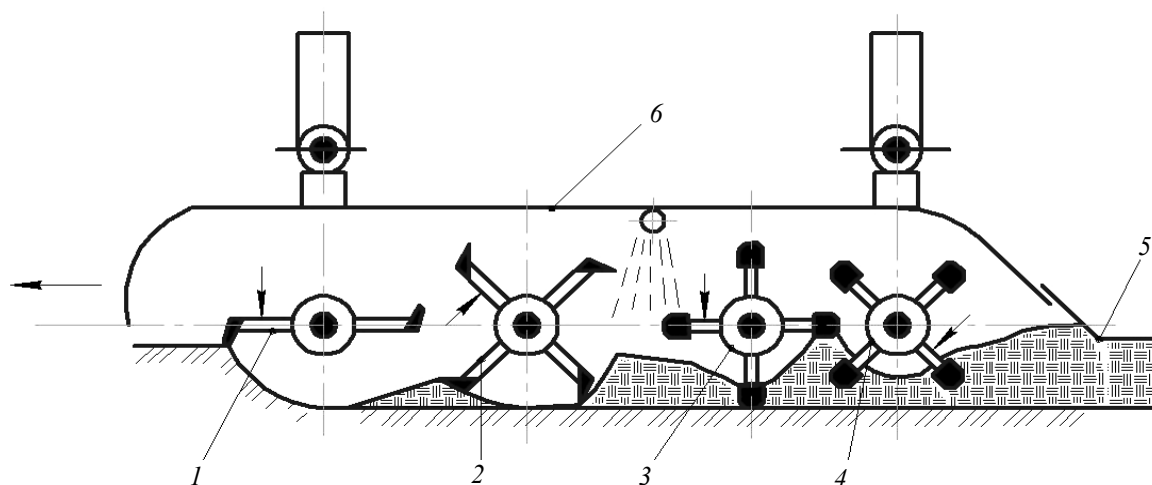
Introduction. Technology of construction of forest roads by reinforcing soils using imported binders has a number of specific features. Great influence on the process have properties of soils and binders, their temperature and humidity, the technical characteristics of leading and supporting machines, construction schemes of layers of the road structure. There are many methods to strengthen soil by binders, but the diversity is confined to technical operations in a definite sequence: 1) pre-grinding and loosening; 2) the exact dosage of materials and obtaining a homogeneous mixture; 3) the distribution of the obtained mixture in accordance with project profile layer; 4) the tightening of the layer (or layers, depending on the technology of the construction), 5) the treatment of the soil, which was subjected to strengthening, as well as creation and maintenance of the required mode of humidity during hardening. [1].

Main part. Single-pass soil-mixing machine and pulverizing mixer are leading machines used for the construction of forest roads with the use of imported materials, such as binders and skeletal mineral additives. Soil-mixing machine is designed to loosen and grind soil, dose and spread binders, as well as mixing of the materials with the soil in a

single pass with pre-compaction [1]. Compounding and processing of soil mixture will be conducted on a forest road by multi-rotor single-pass soil-mixing machine. This method is more efficient and productive than the use of pulverizing mixer, which requires a large number of passes on one track. As skeletal additives it is recommended to use the fractional slag (a waste product of Zhlobin BMP), and as a mineral binder – cement of the grade, which is not below M400. Cement as an inorganic binder can be used to strengthen the forest roads on the basis of all soils. However, in the case of strengthening semi-gravel soils, sandy loam and soil mixture, optimal composition of maximum strength is obtained with minimum percentage of cement in the mixture. [2].

When you create a long-lasting, sustainable and durable pavement structural layers of soils stabilized by skeletal mineral additives and binders (in our case – cement), do not allow overmoisturization road bed soils.

The single -pass soil-mixing machine of D-391 type is chosen as the leading one as a result of analyses. Working body of soil-mixing machine is shown on the Figure.



Working body of a single-pass soil-mixing machine D-391:

1 – Loosening rotor; 2 – grinding rotor; 3, 4 – double-shaft mixer; 5 – back wall; 6 – cover

Main technical characteristics of a single-pass soil-mixing machine D-391 are presented in Table 1.

Table 1
Technical characteristics of soil-mixing machine D-391

Parameter	Value
Type of a machine	Power-driven pneumatic single-pass machine
Engine type	2D12B
Engine capacity, h.p. per minute, (number of rotations per minute)	300/1500
External dimensions, mm:	
Length	11,060
Width	3,078
Height	3,427
Weight, t	22.0
Working movement speeds, km/h:	
1	0.109
2	0.235
3	0.423
4	0.710
Transport speed, km/h	18.5
Processing width, m	2.4
Processing depth, mm	75–250
Dose limits of a binder, l/m ² , (kg/m ²) at speed:	
1st	15–60 (6.2–7.7)
2d	15–60 (2.8–3.6)
3d	15–48 (1.6–20)
4th	15–29 (1.0–12)
Dose precision, %	8–10

Loosening rotor of a soil-mixing machine is similar to the rotor of pulverizing mixer and is designed to loosen the soil, grinding rotor is used to grind the soil and it turns in the opposite direction, i.e. clockwise. Double-shaft mixer is used for final mixing of soil with binding material (from the nozzle enters the liquid binder, skeletal additive comes out of the bunker, located in front of the working bodies). The back wall, which is a regulated one, levels the treated layer of soil according to height.

The machine moves on pneumatic tires, it has four progressive operating speeds – from 0.1 to 0.7 km / h, provides the working width 2.4 m and depth of processing heavy cohesive soils to 0.20 m in the dense body. When using the pre- loosening – up to 0.4 m. The machine is equipped with two dosing devices (for binder and skeletal additives). Dry matter (in this case, the slag fraction 5–10 and 10–20 mm) is dosed in an amount of 15–60 kg/m² when working at first speed and 10–30 kg/m² – at the fourth speed. The water is sup-

plied by dispenser of viscous binding materials. When soil is stabilized by the machine D-391, road bed should be especially carefully planned on working marks to give it the desired cross-section according to the project and uniform compaction of cultivated layer of soil to the maximum density of 0.85–0.90. This activity facilitates greatly grinding of the soil and helps to ensure a desired aggregate composition of the soil. The underlying layer of soil should have a density of at least 0.95 on a standard puddling. Before you process the soil with cement, it is necessary to use soil grader to cut across the width of the carriageway and move it to the road-sides. Then, the road bed is attached to the required cross-section of the project. This method of construction of the road bed provides not only the maximum density, but also protects it from unwanted exposure to water. To increase the strength of the coating on the edges of the base of the skeletal mineral additives and binders it is necessary to hold it wider at 0.50–0.75 m on each side. [3].

Single-pass soil-mixing machine works with the machines, which provide cement and fractional slag: cement trucks, dump trucks, etc. The length of the plot (changeable bay) is chosen taking into consideration the properties of the treated soil, binder dosage, working depth and weather conditions. In heavy soils the length of the plot is an average of 150–200 m, with light sandy soils – 250–300m. Ready mixture of soil, binding material and skeletal additive is distributed evenly and is pressed by the back wall of the chamber, and then it is lightly rolled in by the wheels of the machine .

When the processing of the soil of the first lane to a set depth is finished, the working parts are taken out of the ground and the machine is removed in reverse to the starting position. During the second pass the right side of the road is treated, the third pass – its middle (axial) lane (when there is a large width of the roadway). Adjacent lanes overlap at 0.1–0.2 m. To provide high quality work, using the specified method of strengthening the soil, it is necessary to organize specialized units of machines, where multi-rotor single-pass soil-mixing machine D-391 will be used as a leading one.

To determine the amount of machinery and complete road-building units for strengthening the soils of forest roads, special attention should be paid to the uninterrupted supply of cement, slag material and water, taking into account the quantity of applied material. The number of vehicles is assigned depending on the consumption of materials in a single shift, and productivity of units.

The composition of units to strengthen soil by fractional slag and mineral binder (cement) is presented in Table 2 [3].

Table 2

The composition of units to strengthen soil by a leading soil-mixing machine D-391

Qualification of machines	Machine quantity
Soil-mixing machine D-391	1
Cement truck C-853 (C-571)	3–5
Distributing Tanks DT-20 (DT-10) (for water and water solution of chemical substances)	3–4
Road grader D-598 (D-446)	1
Power driven running roller on pneumatic tires D-627 or D-551 or running roller of trailer type DSK-1 with a tractive vehicle on pneumowheels.	2
Flush coater D-251	1
A removable tank for binder (at distances more than 25km), t	50–75

Conclusion. The use of combined binder let us optimize the process of structure formation, increase the adhesive bonds of a binder and the mineral part of a material. Skeletal additive in conjunc-

tion with the main binder improves its water- and frost-resistance and increases its resistance to water at an early stage of hardening. The use of fractional slag can also reduce the consumption of primary binder with no loss of strengthening properties of reinforced soil. In the near future it is planned to develop technological maps to strengthen soil roads by combined binder and conduct the necessary studies in production.

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