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ECONOMY OF A NON-WASTE ROAD REPAIRING AND COVERING TECHNOLOGY IN DIFFERENT COUNTRIES

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The article questions the economic feasibility of the use of a non-waste repairing and restoration technology for the road surfaces. While writing this article there were conducted several analyses, for example: analysis of consumption volumes of mineral components of asphalt mixtures based on the geography of the commodity market, analysis of changes in cost of materials considering transport conditions. Also defined the conditions and preferential types of asphalt concrete processing in different countries.

Keywords: *non-waste technology; paving; repair; restoration; transportation material; mineral material.*

1. Introduction

Construction, renovation, restoration and maintenance of highways require a significant investment of the Russian Federation budget. Implementation of non-waste technologies of construction, renovation and restoration of asphalt concrete road surfaces is ensured by reuse of mineral materials of damaged layers during processing at workplace or at asphalt concrete plants. According to the CIA total length of roads, paved roads and highways in different countries is shown in Table 1 [10].

Asphalt base layer or coating is a mixture of binder and sorted mineral materials (mineral powder, natural and / or crushed sand, gravel and / or crushed stone) [3]. Composition of the mixture for the base

layer is selected in a way that the storage density and particle size distribution layer could no longer vary under the influence of transportation load. The size of the sorted mineral grains selection depends on the thickness of the layer.

Table 1.

Total length of roads, paved roads and highways in different countries

№	*Country*	*Total length, thousands of km*	*Paved roads, thousands of km*	*Highways, thousands of km*
1	Russia	1283	928	43
2	USA	6587	4306	80
3	China	4116	3454	100
4	Japan	1219	993	84
5	Canada	1042	416	17
6	France	1028	1028	15
7	Germany	645	645	13
8	Sweden	580	135	2
9	Finland	454	50	1
10	Poland	412	281	3
11	Great Britain	395	395	5
12	Turkey	386	353	2
13	Hungary	204	77	2
14	Czech Republic	131	131	1

During the processing on the plant there are taken into account qualitative characteristics of the mineral materials of damaged layers that define the possible share of the use of recycled raw materials for the hot mix asphalt concrete. Samples of the materials that are arriving at the asphalt concrete plant selected according to the rules of acceptance and certification: crushed stone – «GOST 8267-75», crushed gravel – « GOST 10260-74», gravel from metallurgical slag – «GOST 3344-73», gravel – «GOST 8268-74», sand – «GOST 8736-77», bitumen – «GOST 2517-69». The quality of surfactants and activators are checked due to the construction standards («VSN 59-68»).

2. Material volumes

Mineral material (gravel) is the major component of the mixture of various grades of asphalt concrete and is about 90% of the mixture. The development of gravel market is determined by the needs of industries of road and civil construction. Road construction industry is steadily developing, funding for the road industry in 2012 amounted to 392 billion rubles, in 2013 to 452 billion rubles and in 2014 to 477 billion rubles. The plan of commissioning new public roads is displayed on figure 1.

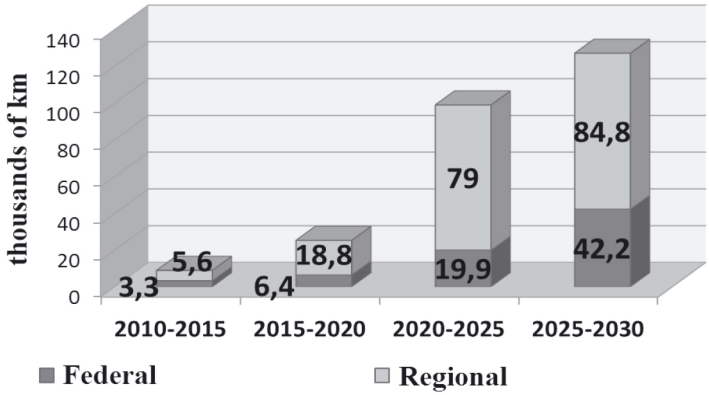

Fig. 1. The plan of commissioning new public roads

According to the Russian Transport Strategy the length of roads in 2030 will reach 1.7 million km. Positive outlook of increasing construction volumes and volumes of road repairing works, restoration and reconstruction leads to incentive growth of demand on mineral material-gravel, sand, mineral powder.

On the North-West, Central and Southern federal districts in each administrative district there are mined deposits of sand and sand and gravel materials which provide the road construction industry. The price of non-metallic building materials including transport costs increases to 30% for crushed stone and gravel and up to 90% on sand as a result ex-

port of extracted materials in other regions of Russia (except for the border regions),becomes uneconomical for suppliers and buyers. The entire volume of products produced on the region territory is implemented in the region or in the border regions of neighboring areas.

The volume of natural sand mining is an indirect indicator of the scale and speed of building complex. The volume of natural sand production in real terms is about 130 millions m^3 per year. The largest volume of sand production among all federal districts is in Central Federal District: in Q3. 2015 there were produced 13.2 million m^3 of natural sand which is 25.9% of the total volume. The second place with a share of 22.9% is the North-Western Federal District, the third place – Ural Federal district with a share of 21.4%. The share of all the other districts combined is only 30.6%.

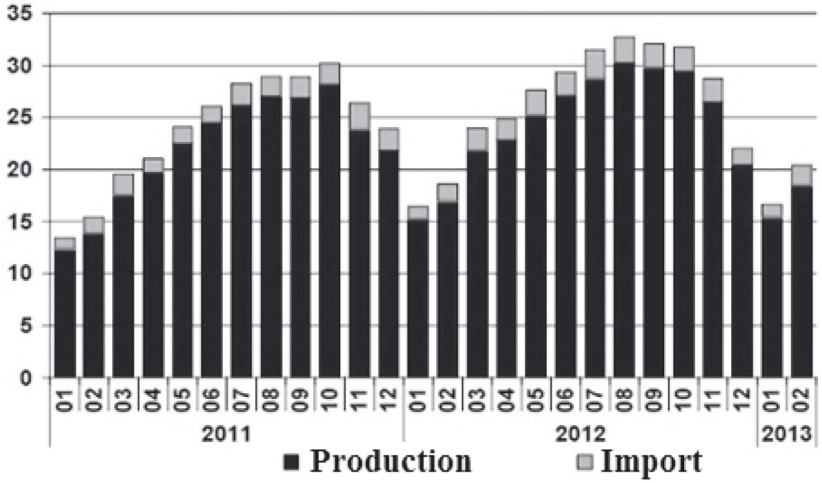

Fig. 2. Dynamics of consumption of pebble, crushed stone and gravel in Russia in 2011–2013

According to «Rosstat» rubble consumption in Russia is increasing by about 7% per year that is approximately 320 millions of tons. Imports are also showing positive trend and increasing by about 10% per

year. Dynamics of consumption of pebble, crushed stone and gravel in Russia are displayed in Figure 2.

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3. Cost of materials with delivery

The average selling price of one ton of rubble is about 600 rubles and stable in regions. In cases of building material shortages in some regions a steady growth in prices appears between 50–70%. Rubble and sand price changing depends on the volume of the purchased consignment. The most expensive kind of rubble is considered to be granite. The highest price purchasing more than 500 m^3 is set at 2000 rubles per 1 m^3 of granite rubble of 5–20 mm fraction. The most expensive type of sand is considered to be quarry sand which price is about 900 rubles per 1m^3. The cost of river sand is almost two times lower than the quarry one and is about 500 rubles per m^3. Average cost of asphalt mixture is 3000 rubles per ton.

Transportation of the material is carried by open wagons, mineral fertilizer hoppers and dump cars, the average rental rate of which is more than 1000 rubles per day. The cost of mineral material including the delivery to the end user increases up to 100% due to the constant growth of railway tariffs, transportation taxes, petrol, diesel and gas fuel prices. In terms of production asphalt mixtures on mobile and stationary plants, increasing prices of mineral materials including delivery lead to the costs increase of the finished mixture and repairing.

4. Technologies

Transportation costs take a significant part of the cost of purchased components of asphalt mixture and sometimes exceed their cost (for

example, delivery of construction sand and bitumen). Economically effective method of repairing and restoration of road surfaces is processing the mineral material of the damaged layer and re-using it by making new asphalt concrete paving using the non-waste technology. Volumes of cold milling granular asphalt and its re-use share in process of reconstruction of damaged road surfaces in the EU are increasing [4]. Local recycling provides cost savings on new building materials and their transportation.

The maximum effect is achieved by using high-performance systems such as "recycler", which for decades produced by leading foreign manufacturers of road machines – Wirtgen Group, Caterpillar, Roadtec, Heijmans. Dynapac, Volvo Construction Equipment, Terex and others [7]. These mechanization provides stabilization of road bases, production of hydraulic binders and new building mixes for base and the surface layers.

Table 2 shows the data of the European Association of asphalt pavements (EAPA) about the use of non-waste restoration coatings technologies in different countries and preferential types of processing asphalt concrete that determine how the implementation of the technology used and the types of mechanization [5, 6].

Table 1.

Use of non-waste restoration coatings technologies in different countries and preferential types of processing asphalt concrete

Country	Asphalt that can be recycled	Types of recycling, %				The use of recycled material for the CEO,%
		Hot recycling	Warm recycling	Cold recycling	Disconnected layers	
Austria	750000	95	0	3	2	-
Belgium	1500000	61	-	-	-	51
Czech Republic	1450000	18	37	25	20	10
Denmark	790000	83	0	0	17	58
Finland	860000	-	-	-	-	20
France	6900000	64	-	-	-	65

End of the Table 1.

Germany	11500000	90	0	0	10	-
Greece	-	-	-	-	-	0,03
Great Britain	4000000-5000000	-	-	10	-	-
Hungary	88000	80	0	10	10	20
Iceland	15000	-	-	-	-	3
Ireland	150000	-	-	-	-	-
Italy	10000000	20	-	-	-	-
Luxembourg	330000	90	0	10	0	50
Holland	4500000	76	-	-	-	70
Norway	686000	21	0	5	74	20
Romania	22000	20	20	20	30	10
Slovakia	26000	90	0	5	5	-
Slovenia	26000	26	0	20	54	5
Spain	205000	85	-	7	8	1,3
Sweden	900000	80	5	5	10	70
Switzerland	1370000	48	17	15	8	27
Turkey	1200000	3	1	1	95	1
Japan	-	-	-	-	-	76
USA	69000000	92	0	0	8	-

Processing is carried using hot, warm and cold technology. Disconnected layers are strengthened by the methods of cold stabilization. Currently there is a tendency of reducing of hot mix production that demonstrate the effective way of using warm asphalt mixes, which are prepared and mixed at a temperature of about 100 to 140°C and preferably cold mixtures that are prepared without heating the mineral material, bitumen emulsion or foamed bitumen. Cold processing is provided by the use of a special bitumen emulsion, which is stabilized by compaction or during mixing and eventually increases the adhesion strength between the particles of the material [4, 8]. Cold mixtures can be made using the innovative self-propelled milling and mixing units and mobile mixing plants, operating modes of which are determined by operating conditions [1, 2, 7].

Conclusion

The geographic boundaries of the commodity market of new mineral materials are determined due to the location producing fields and dislocation of stationary asphalt plants. The full development of the new field of mineral material in the region requires large capital investments. In the case of remoteness of the road construction object from asphalt plants and / or remoteness of plants from mineral deposit it is economically advantageous to use recycling technology. Asphalt concrete is considered to be the most processed material, as it holds the strengths during the whole life cycle of the road surface.

As the main criteria of the efficient reuse of non-metallic building materials (rubble, gravel, sand, etc.), are taken the following factors: the quality of the mineral material of the damaged surface, the presence of explored and developed deposits; the ability to move goods between the territories; consumer safety properties during transportation; the absence of restrictions on importation or exportation of goods; established link between producers and consumers; price policy; transportation costs for the delivery of the components of asphalt mixture to the plant and the delivery of the final mixture to the consumer.

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