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REUSE OF MILLED ASPHALT CHIPS FOR HIGHWAY CONSTRUCTION

Summary

Experimental research of physical and mechanical properties of cold concretes based on milled asphalt concrete has been performed. The influence of compaction load on properties of cold concretes on milled asphalt concrete has been elucidated. The influence of binder type and content on freeze resistance of concrete on milled asphalt concrete has been determined. The influence of binder type and content on bond strength between layers placed by means of cold recycling and layers laid using hot asphalt concrete mixes has been evaluated.

1. Introduction

Asphalt wearing courses are the most commonly used pavement layers of urban streets and highways in Ukraine. Service life of highways asphalt wearing courses does not exceed 14 – 16 years, and it is much shorter for urban streets. Insufficient durability of asphalt wearing courses is caused by many reasons (joint influence of traffic and climatic factors). In recent years the technology of cold recycling of asphalt wearing courses has been spreading when repairing and reconstructing pavements In Ukraine [1-3]. The technology of asphalt wearing courses cold recycling can be implemented in-situ using recyclers or at traditional asphalt plants.

The technique of both hot and cold in-place recycling of pavement layers is known to allow [4-6]: reuse of old materials of existing pavements; provision of wearing course homogeneity by both strength and geometrical parameters; reduction of waste material volumes and materials mining in quarries, providing proper ecological benefits; provision of possibility to renew some traffic lanes of a road with two and more lanes, indicating the most frequent surface course deterioration under traffic loading; reduction of inconvenience caused by operation of technological transport when performing traditional rehabilitation; reduction of deterioration possibility of secondary roads local network taking into account reduction of new materials transportation volumes; reduction of costs for worn wearing courses rehabilitation; avoidance of necessity to elevate shoulders level and decrease opening under overbridges; pavement recycling at simultaneous widening of existing roadway.

In Ukraine some road agencies are experienced in usage of recyclers WR 2500 and WR 4200 (manufactured by WIRTGEN GROUP) for the implementation of technology of cold in-place pavements recycling.

Today road millers for cold milling of wearing courses have found increasing application in many road organizations. When performing rehabilitation of pavement surface courses the technology of cold milling is often applied in order to level the surfaces on sites with plastic deformations, or complete removal of layer with significant amount of accumulated cracks. Cold milling of old asphalt surface courses or rough protective wearing courses, laid by means of surface treatment, results in formation of asphalt chips. Milled asphalt chips are traditionally used as a material for laying of base courses, shoulders pitching and gutting of macadam base courses.

Research performed earlier has shown [7] that simultaneous application of cement and bitumen emulsion at reclamation of old asphalt layers provides improved deformability of the material and its less tendency to shrinkage in comparison with mixes bound with cement only. The structure of asphalt concrete based on these mixes is characterized by two bond types: coagulation and crystallization. The first bond type makes the material similar to asphalt concrete, while the second type promotes formation of rather rigid spatial skeleton in it. Compared to conventional asphalt concrete, the material is characterized by lower temperature susceptibility of strength and improved shear resistance at high service temperatures. However, the influence of compaction load on the parameters of physical and mechanical properties of cold asphalt concretes on milled chips, corrosion resistance of such asphalt concretes and adhesion to layers of hot asphalt mixes, which are laid as protective layers, is less explored.

2. Materials and procedures

Milled asphalt chips obtained by milling of old asphalt wearing courses from fine-aggregate mixes (type B) based on granite aggregates were taken for laboratory research. Portland cement «ПЦ 400» and medium setting cationic road bitumen emulsion with 63 % of bitumen «БНД 90/130» served as binders.

3. Results

Research results obtained indicate the influence of binder content and type on physical and mechanical properties of asphalt concrete based on milled asphalt chips (Table 1). It is apparent that asphalt concretes on cement are characterized by higher compression strength and water resistance coefficients in comparison with asphalt concretes on composite binder. The decrease of parameters of asphalt concretes strength and increase of short-term and long-term water resistance coefficients is observed with the increase of bitumen emulsion content in asphalt concretes.

Table 1 Physical and mechanical properties of asphalt concrete based on milled asphalt chips

Properties parameters	Emulsion content, %											
	0				2				4			
	Cement content, %											
	0	3	5	7	0	3	5	7	0	3	5	7
Water saturation, %	6.7	4.9	4.6	4.3	6.6	4.8	4.5	3.8	6.4	4.7	4.2	3.5
Swelling, %	0.4	0	0	0	0.4	0	0	0	0.3	0	0	0
Compression strength, MPa, at:												
0 °C	6.9	9.6	10.3	10.5	4.7	8.1	8.6	9.8	4.3	5.7	6.9	8.0
20 °C	2.3	4.0	4.7	5.1	1.9	3.6	3.8	4.2	1.5	2.5	3.3	3.6
50 °C	0.2	1.4	1.9	2.0	0.3	1.2	1.4	1.5	0.2	0.7	0.9	1.2
Water resistance coefficient	0.61	0.82	0.83	0.83	0.49	0.81	0.82	0.86	0.46	0.83	0.85	0.85
Long-term water resistance coefficient	0.40	0.80	0.81	0.82	0.34	0.76	0.78	0.81	0.34	0.75	0.77	0.82

The preparation of samples 70 mm in diameter and 70 mm high has been carried out in order to elucidate the influence of compaction load value on physical and mechanical properties of asphalt concretes. The preparation of samples from mixes on organic (bitumen emulsion), hydraulic (cement) and composite (cement + bitumen emulsion) binders has been performed under compaction load of 10, 20 and 30 MPa. The research results of physical and mechanical properties of asphalt concretes under consideration are shown in Table 2. The data analysis indicates that the increase of compaction load results in decrease of water saturation parameter of asphalt concretes, increase of their average density, compression strength, short-term and long-term water resistance coefficients. Asphalt concretes on hydraulic binder (cement) exhibit higher long-term water resistance coefficients as compared to short-term water resistance coefficients. The reason is incomplete cement hydration and its subsequent slow behavior under long-term research.

The results of freeze resistance research has revealed (Table 3) that asphalt concretes with high content of bitumen emulsion show higher resistance to varying freezing and thawing. Asphalt concretes on cement are characterized by more sharp change of freeze resistance coefficient within first 10 to 15 cycles as compared to asphalt concretes on composite binders.

In order to protect pavement laid by means of cold recycling technique hot asphalt mixes are traditionally used. Insufficient bonding strength between pavement layers is one of the basic reasons of premature deterioration of multilayer pavements. The lack of adhesion between layers can cause a 30 % decrease in service life of the structure.

It is recommended to use organic binders when applying tack coat to the wearing course to be repairing. Organic binders, when applied on the surface, have low viscosity and in course of contact formation between layers provide high adhesive and cohesive strength.

For experimental research of interlayer bond the surface of the samples from milled asphalt chips was treated with a layer of tack coat and a layer of hot asphalt mix. Road petroleum bitumen БНД 90/130 and rapid setting road bitumen emulsion were used as adhesives. The binder content for tack coat varied from 0 to 0.6 kg/m² converted to bitumen. The parameter of shearing strength, evaluated by means of tensile-testing machine, was accepted as criterion of interlayer bond. Deformation rate of the samples comprised 3 mm/min.

Table 2 The influence of compaction load on physical and mechanical properties of asphalt concrete

Properties parameters	Binder type and content								
	4 % emulsion			5 % cement			4 % emulsion + 5 % cement		
	Compaction load, MPa								
	10	20	30	10	20	30	10	20	30
Average density, kg/m ³	2131	2149	2152	2156	2213	2251	2143	2182	2205
Water saturation, %	8.6	8.3	7.8	11.3	8.9	7.3	8.1	6.0	5.1
Swelling, %	0.3	0.3	0.3	0	0	0	0	0	0
Compression strength, MPa, at:									
0 °C	6.0	6.2	6.5	8.2	10.4	10.5	7.7	8.2	8.3
20 °C	2.1	2.4	2.4	4.0	5.0	4.9	3.2	3.4	3.6
50 °C	0.2	0.3	0.3	1.5	1.8	1.8	1.0	1.1	1.2
Short-term water resistance coefficient	0.49	0.50	0.51	0.75	0.78	0.86	0.76	0.80	0.82
Long-term water resistance coefficient	0.36	0.41	0.42	0.85	0.86	0.90	0.83	0.86	0.89

Table 3 Freeze resistance coefficient of asphalt concrete based on milled asphalt chips

Binder type and content	Number of freeze and thaw cycles				
	5	10	20	30	50
5 % cement	0.89	0.83	0.79	0.77	0.74
5 % cement + 2 % bitumen emulsion	0.90	0.85	0.78	0.74	0.67
5 % cement + 4 % bitumen emulsion	0.96	0.92	0.87	0.83	0.77

The research of the effect of different binders content on parameter of interlayer bond has revealed (Fig. 1 and 2) that content dependences of interlayer bond between conventional asphalt concrete and asphalt concrete from cold mixes on milled chips pass through a maximum. The maximum value of interlayer bond is typical for asphalt concrete on cement. The increase of cationic bitumen emulsion content in composite binder results in decrease of

interlayer bond, and maximum of the dependence shifts to the side of lower content of organic binder applied for tack coat. The regularity specified is peculiar to both bitumen and bitumen emulsions used for tack coat. The highest values of interlayer bonding strength are observed at 0.2 – 0.4 kg/m² of road petroleum bitumen and 0.35 – 0.7 kg/m² (0.2-0.4 kg/m² converted to bitumen) of cationic bitumen emulsion. Bonding strength of the samples bonded with bitumen emulsion averages about 12 % higher than that of samples bonded with bitumen. It can be explained by better surface wetting with emulsion.

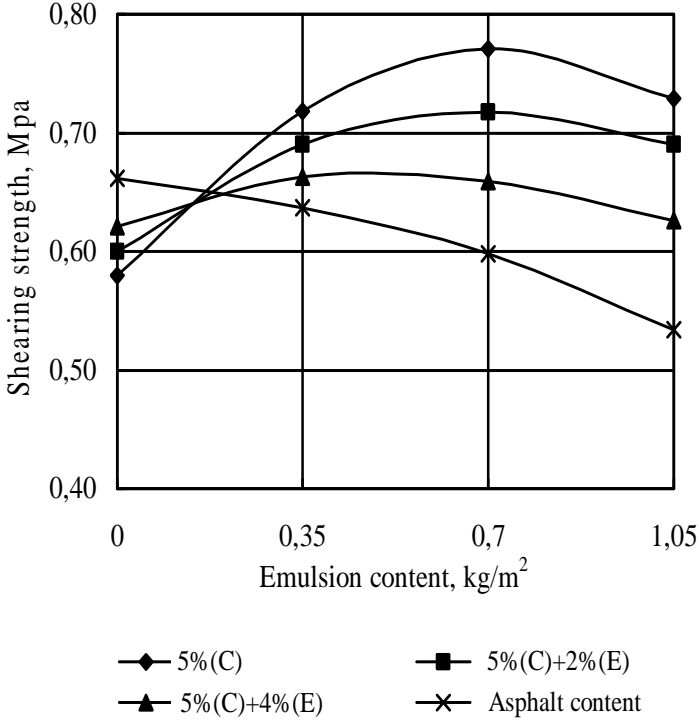


Fig. 1 Relationship between interlayer bonding strength and cationic bitumen emulsion content

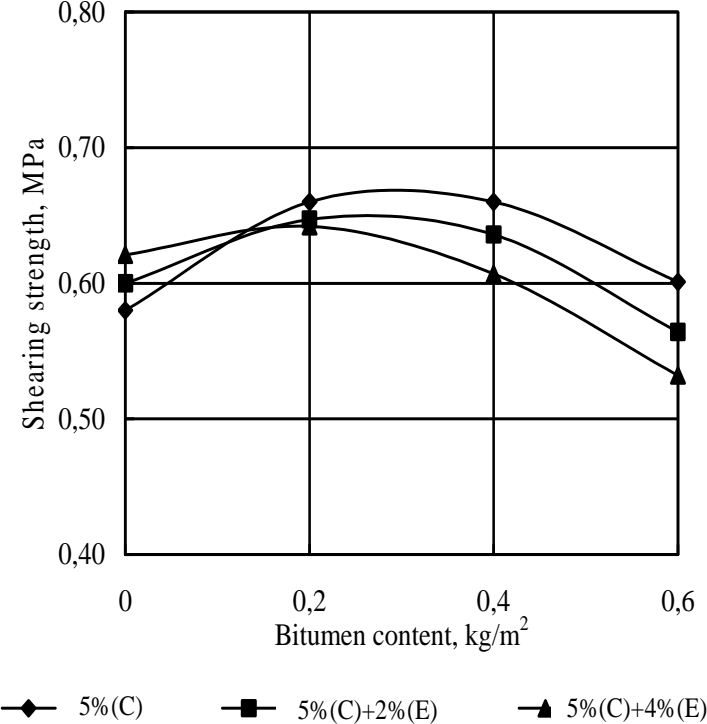


Fig. 2 Relationship between interlayer bonding strength and bitumen content

The outcome of the research carried out in 2003 – 2004 resulted in production of cold mixes based on milled asphalt concrete, mineral and composite binder at asphalt plants, and construction of experimental sites in Ternopil and Kharkiv region (Fig. 3-4). The experience obtained makes it possible to recommend the specified material for use in road construction in base courses and lower wearing courses on highways of all categories.



Fig. 3 General view of surface course from cold mixes based on milled asphalt concrete after compaction (left image – composite binder, right image – cement)



Fig. 4 General view of surface course from cold mixes based on milled asphalt concrete on composite binder after 8 months of service

4. Conclusions

Construction, reconstruction and rehabilitation of highway pavements takes much costs for purchase of road-building materials and their delivery. In Ukraine granite aggregates fall into the category of the most used materials. Taking into account the fact that some regions of Ukraine lack natural resources of durable aggregates the implementation of alternative technologies in road construction is promising for them. Scaling of asphalt wearing courses and plastic deformations as ruts and buildups as well as cracks and other damages and failures points to the fact that application of alternative technology of pavements cold recycling is perspective. When implementing the technology of cold recycling of asphalt wearing courses with distinctive plastic deformations it is efficient to use cement or composite binder with low content of cationic bitumen emulsion as a binder. The technology of pavements cold recycling can be implemented directly on site or at stationary and

transportable asphalt plants. It is recommended to lay rough protective layer by means of surface treatment, slurry-seal mixes or hot asphalt mixes in order to increase corrosion resistance of courses from such asphalt concrete. The level of durability of the whole pavement structure is determined, first of all, by interlayer bond strength. Experimental research has determined content of petroleum bitumen and cationic rapid setting bitumen emulsion as binders for tack coat of pavement layers from cold reclaimed mixes before their coverage with fine-aggregate hot asphalt mixes.

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