International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 24 (2015) pp 45345-45349

The Analysis Of Structure Bituminous Knitting, Modified By A Rubber Crumb

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Abstract-Poor quality ofroad asphalt(insufficientfor the Russian conditionsfracture toughness, elasticity, adhesion) -is one ofthe main causes ofpremature failureof asphaltroadsurfaces.Polymers, which allowchanging oneorseveralproperties suchas sensitivityto temperature change, cohesion, elasticity are introducedinto asphalt cementcompositionto modifyit. For the purpose of upgrading of bitumens polymers modifiers which physical and chemically interact with bitumen components are entered into them, allowing to reach high operational rates of a roadbed. The main shortcoming modified knitting is high cost. Use of comminuted rubber from waste automobile tires allows to reduce considerably cost without loss of service performance of material. Laboratory researches were made on the basis of the theory of scheduling of experiment in the certified road-building laboratory. Process of modification of bitumen is reasonable with use of the theory of pastes. The area of the rational structure modified knitting which application can increase considerably longevity of both career roads, and public roads is certain. Introduction of this material at construction will allow to organize a sales market for producers of comminuted rubber from the processed tires of heavy-load career motor transport.

Keywords: coal tar, comminuted rubber, the modified

1. INTRODUCTION

In recent years, the Russian Federation activelyinvests in road building. In 2015 the state corporation Avtodor, plans to construct over 12 thousand kilometers in Russiamore than 12thousand kilometers ofnew high-speedroads,the quality of whichshould be as closeto European standards[1]. The quality question, is actual and for career roads.

The structure-formingcomponent of theasphalt concrete mixisasphalt cement, whichlargely determines theperformance propertiesof the final product-asphalt concrete. Cement should be chosendepending on theheating temperature ofthe coatingin the mosthot(summer) seasonand thetemperatureof the coldest days-0.92or0.98.ForKuzbass they are+61°C and-42°C, e.g. the binderplasticityintervalshouldbemore than 100°C[2].

In most cases the heavy roadpetroleum bitumen withan intervalof plasticity,usuallynot exceeding70°C [3] in accordance with the State Standard22245-90 [4] is used a cement.

Polymers, which allowchanging oneorseveralproperties suchas sensitivityto temperature change, cohesion, elasticity are introducedinto asphalt cementcompositionto modifyit[5]. Polymer modified asphalt cement have higherplasticityrange in comparison withconventional asphalt, which allows to maintainperformance characteristicsat lowandat hightemperatures.From 2009to 2012the consumption ofpolymer modified asphalt cementin Russia increasedby 5.6 times, but stillitis much lower thanin other countries.Applyingpolymer modified asphalt cementprovides increasedoverhaul life of roadcoatingsfrom 3-4 to7-10 years, significantly increasing itsfracture toughness, heat resistance, shearresistance, water resistanceand frostresistancethatallows to fullyrecoup the construction costsover several yearsof operation[6].

In world practice,the following groups ofpolymer modified asphalt cement are used[7]:

1)asphalt plusstyrene-butadiene-styrene;
2)rubber modified road asphalt cement;
3)asphalt plusethylenevinylacetate;
4)asphalt pluslatex;
5)asphalt pluspolyolefin (synthetic rubber);
6)asphalt plussulfur;
7)asphalt pluscoal tar/epoxyresin.

In this work modification of bitumens with use of comminuted rubber as it is more perspective for the following reasons was investigated: 1) the problem of utilization of waste automobile tires which is already solved in the majority the developed countries of the world is in Russia only at an early stage of development.[8]; 2) the cost of the rubber asphalt, made with recovery of the rubber industry, below than when using other modified bituminous knitting.

Preparation ofasphalt concrete mixturesusingrubbercrumb can be carried outin two ways:dry and wet[9]. The drymethod involvesthe addition ofcrumb rubber inthe mixingtank; the wet one is based on the preliminary introduction of crumbsinto the asphaltand preparationof rubber modified asphalt cement[10].The experience of usingrubbercrumb abroadindicatesthat the performanceproperties of coatings which arelaidusing"dry"methodshowedunsatisfactory results in most cases. The coatings,tripledfromasphalt concrete mixtures, in whichthe rubbermodifier isintroduced by the"wet" method, were moreresistant toruttingand had longer life. In this regard,in the United Statesin 1994,the introductionof rubber crumb inasphalt mix by "dry" method was abandoned[11].The use of the "wet"methodforms a bondbetween therubbercrumb and the asphalt forminga heterogeneousspatial structure,at the expenseofthat the materialhave thedegree of elasticity that is sufficientfor the mostoperational purposes[12]. Such structurecan retaina largenumberof finefillerswithout significantsegregation [13].

The main disadvantage ofproducingrubber modified asphalt cement is the complexity ofits rational composition choice selectionandthe development of its effectivepreparation technology.

The rationalratio of the componentsof rubber modified asphalt cement as well as temperature-timemodesof its preparationwillvary considerably dependingon the type ofthe asphalt used, the chemical structureand the rubberfraction[14].For these reasons,a simplelearning fromforeign colleaguesand using their rubber modified asphalt cement "recipes"is not possible.

2. MATERIALS AND METHODS

As partof the study the technology for rubber modified asphalt cement preparationleading toeffective rubbercrumb interactionwithasphalt has been developed. The heavy roadpetroleum bitumen and the crumb rubberfromused automobile tiresmanufactured in Russia were usedas the raw materials.

Reliability of the drawn conclusions is confirmed by results of an assessment of the RBV physical and chemical properties.

In table 1 and drawing 1 reduced ring-and-ball softening temperature, in table 2 and figure 2 – depth of needle penetration at 25°C .

Tab. (1). - The table showing the changes of ring-and-ballsofteningtemperature related to theplasticizer and rubber crumb content

Rubbercrumbcontent, %	Plasticizercontent, %			
	0	5	10	15
0	43	40	37	34
5	45	43	41	39
10	46	46	45	43
15	47	48	50	46
20	45	48	53	42
25	38	41	41	37

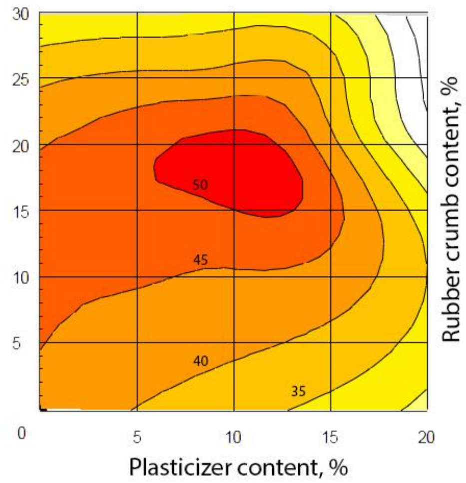

Fig. (1). - The graph showing the changes of ring-and-ballsofteningtemperature related to theplasticizer and rubber crumb content

Tab. (2). - The table showing the changes of the depth ofneedle penetrationat 25°C related to theplasticizer and rubber crumb content

Rubbercrumbcontent, %	Plasticizercontent, %			
	0	5	10	15
0	90	145	177	230
5	110	110	150	216
10	120	113	138	182
15	130	115	140	168

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20	175	157	172	198
25	220	220	230	240

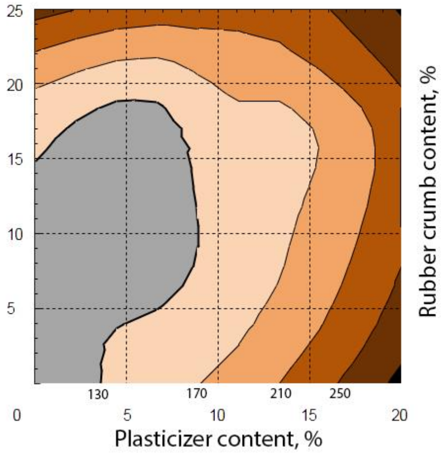

Fig. (2). - The graph showing the changes of the depth ofneedle penetrationat 25°C related to theplasticizer and rubber crumb content

3. RESULTS

The analysis of the presented data shows (fig. 3) that softening point on a ring-and-ball has a maximum at the content of softener in the range of 10 +/-5% and the content of comminuted rubber 20 +/-5 of %. Thus the increase in a penetration of in comparison with initial bitumen on 25-190 shares of mm is observed.

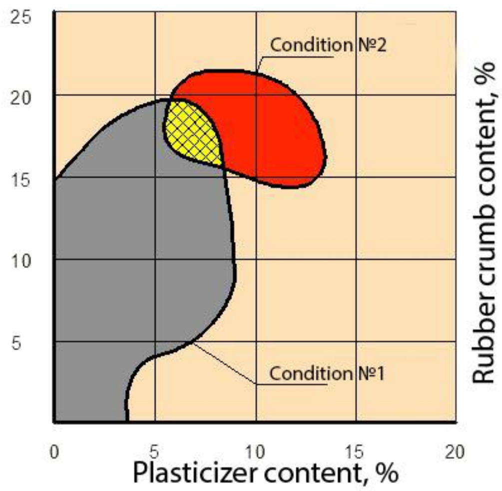

Fig. (3). - Discovery of the region fulfilling conditions 1 и 2

High performance of rubber modifiedasphalt cement isobtained through theuseof the "wet"method - thestructuringof the system "rubber crumb-plasticizer-asphalt" [15]. The developed technologyallows obtaininga stablepaste.It is known thata paste – is highly concentratedsuspensionhaving the structure. The structure ofpastes- is aspatial netformed by theparticlesof the dispersed phase(rubber crumb), in the loop of which there is thedispersion medium(oil asphalt). We can say that a pasteoccupies an intermediate positionbetween a powderand a dilute suspension[16].Since a paste is a structuredsystem, its structural andmechanical properties, whichare characterizedby parameters suchas viscosity, elasticity, plasticity are its determinants.Pasteshavea coagulationstructure, sotheirtechnological propertiesare mainly determined bythe mechanical propertiesof interparticleliquid layers[17, 18]. Attractive forcesbetween the particles, dependingon the distancebetween them (the thickness of the layers) and conditioned byVanderWaalsandhydrogen bonds are acted through theselayers.Moreover, the strength of the contactcan be reduced therepulsive forcesbetween the particles, providingaggregatestability of the suspension; that’s why thestructures in theaggregatestabile suspensionsare notformedor, ifformed, are very fragile.

The oil asphalt absorptionoccurs on the surface ofthe rubbercrumb,therefore the plasticizermay react only withthe free centers of the rubber crump surface [19]. Inthis case, theinteraction between the moleculesof the plasticizerwith the rubber surface is hinderedto some extentby the asphalt adsorption.Consequently, the binding ofthe plasticizerto the crumbsurface in the presence ofthe asphalt is reduced. It follows thatin the course of the asphalt -the paste in fact - preparation, the incompletestabilization of thedispersesystems by theplasticizer occurs.

If the disperse systemstabilization is incompletethedoubleelectric layer and the solvation shell of particles is broken only partially; the aggregation of particles occursin certainareas, in the regions of the surface withoutstability factor, i.e. in places where the oil asphalt is adsorbed[20].The spatialnet is formed, in the loops of which the dispersion medium(oil asphalt) is stored. The formedliquidlayer between theparticles, although decreasing the structure strength, givesit a certainflexibility andelasticity.The fine particlesof rubbercrumb are completelystabilized. This is due tothe denserlayersof the plasticizeron the small particlesthatcauses theirrepulsionand preventsaggregation[21, 22].

Thisassumption is supported bythe photo of the asphalt cement dropbordershown inFigure 4.

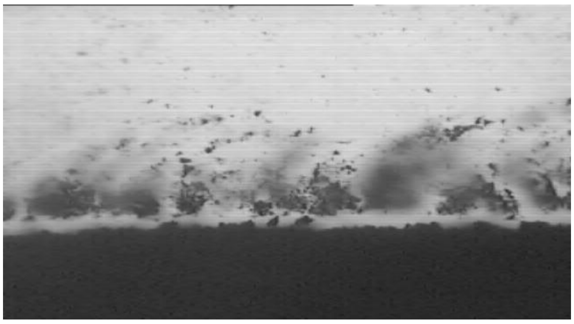

Fig. (4). - The asphalt cement dropborder*(enlargement in 42 times)*

The photographshows thatthe larger rubbercrumb particlesare in the "aggregated interconnection" between them along the surface areaswhich have no stability factor after the stabilization, forming the micro loopscontaining the dispersion mediuminside-asphalt[23]. The smallest rubbercrumb particlesare not aggregatedandpresentboth insidethe micro loopsandin a free stateand occupythe most"profitable" position. Consequently, we can assume that therubber modifiedasphalt cement has the gel-likestructure [24].

Therefore, the model of the spatial network of the asphalt cement can be presented as follows (Fig. 5).

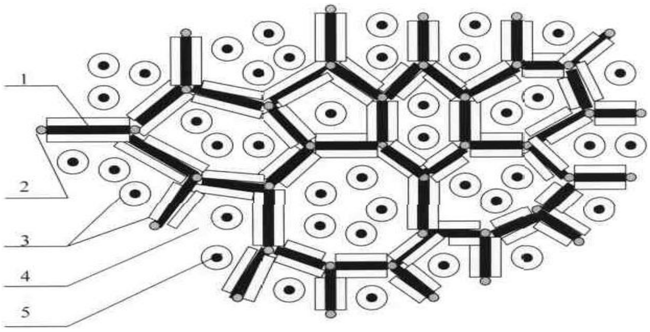

Fig. (5). - The model of the spatial network of the asphalt cement (flat projection):1 – large rubber crump particles; 2 – surface areas of the particles with no stability factor; 3 – surface areas of the particles with stability factor; 4 – structure loops filled with the dispersion medium; 5 – small coal particles

4. EXCLUSION

Coagulationstructures differinthe distinct dependence oftheir structural andmechanical properties onthe intensity of themechanical interactions. Nomass transferprocesses in thestructured systemscan be startedwithout destroying thepreviousstructuretherein. Destruction ofspatial structuresin the pastes-a complex processcharacterized bythe factthat as thedegree of destructionchanges considerablyandthe mechanism ofthe structure collapse(e.g.paste overheating - the beginning ofthe crumb rubber pyrolysis, etc.).

5. CONCLUSION

Thus, thetechnological properties of therubber modifiedasphalt cementare caused: by molecularcohesionof the dispersed*medium* particles with each otherat points of their contact, wherethe thickness of thedispersion mediumlayersbetween them is minimum(lacking stabilityfactor). In the limitingcase thecompletephasecontactis possible. Coagulationinteraction of particlescauses the formation of the structureswith the significantreversibleelastic properties; the presence ofa thin filmat the contact pointsbetween the particles[25].

CONFLICT OF INTERESTS

The author have no conflicts of interest to declare

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