

Research of Asphalt Concrete Rutting Resistance with Application of Forta FI Fibers

Nguyen Van Long¹, Podolsky V.I.P.² Mordovtseva T.V.³

¹*Ho Chi Minh University of Transport, Ho Shi Mihn Vietnam.*

¹*PhD of Tech. Sc. head of Moto road department, e-mail: long_gtvt@mail.ru*

^{2,3}*Voronezh State Technical University, Voronezh, Russian Federation.*

²*Dr of Tech. Sc. head of the department of road construction and operation*

³*Senior lecturer of road construction and operation department, e-mail: tatvikt@mail.ru*

Abstract

Rutting formation reduces highways durability, traffic safety and comfort, decreases the cost of road transport and economic costs for repairs. Application of asphalt concrete reinforced with fibres to construct road pavement top course is one of the applied method for this problem solution.

There is given the researches results of the main physical-mechanical properties and rutting resistance of solid fine – grained asphalt concrete BTN C12,5 with different fibres Forta FI content. The results show that asphalt concrete with reinforced fibres Forta FI deformability is better than it is with traditional content.

Positive effect from application of reinforcing fibres Forta FI with the amount of 0.05% by mixture weight for improvement asphalt concrete rutting resistance is determined. There is suggested asphalt concrete BTN C12,5 reinforced with fibers Forta FI in amount of 0,05 % by mixture weight application of asphalt concrete, reinforced with Forte FI fibres for construction of road pavement upper course.

Keywords: dispersed reinforcement, Forta FI fibers, deformability resistance, heat resistance coefficient rut resistance, rut formation

INTRODUCTION

The enhancement of asphalt concrete surfaces deformability strength is the main target in road construction [1 - 13, 19]. Material workability to resist against plastic flow under vehicles effect at high temperatures is evaluated by compressive strength. Road structure resistance against plastic flow mostly depends on its strength properties [3]. Surface evenness is characterized by its rebound deflection upon traffic loads determining shear and tensile stress in pavement courses [4].

In the previous works the authors mentioned that the temperature on motor roads asphalt concrete surface in Vietnam in summer time reaches 70°C and more which exceeds the values provided in normative documents. Ratio of compressive strength of asphalt concrete heated up to 20 °C and strength at t 50 °C is called coefficient of heat resistance. This coefficient characterizes black mixes and asphalt concrete heat resistance at high temperatures. According to the analysis of existing methods of rut resistance evaluation it

was determined that in modern climatic conditions in Vietnam used coefficient of heat resistance R20/R50 does not provide asphalt concrete pavement evenness and structural properties under traffic loads affect at higher temperature [6].

The more so nowadays multiaxes heavy vehicles move along Vietnamese highways and their axes load significantly exceeds values specified in normative 22 TCN 211-06.

Because of the above mentioned causes longitudinal ruts are formed in the road base (fig.1) Rut formation on asphalt concrete road surfaces reduces traffic comfort and safety and harms country economy. It is because of the cost of road transport increase caused by low level of consumer characteristics and also leads to the necessity to repair road more often than it is needed according to normative [8, 11].



Fig. 1. Longitudinal ruts on asphalt concrete road pavement in Vietnam

As it is mentioned in [11], at high summer temperatures one of the main directions of achievement of road pavement deformability is injection of reinforced fibers into asphalt concrete mixture. This method was investigated and successfully applied in road construction in such countries as Russia, China, Japan, USA and other European countries [1, 2, 14, 15, 16, 17, 18]. Introduced in asphalt concrete mixture reinforcing fibers affect positively in the following ways:

- during mixtures transportation and distribution fibres injection promotes thickness enlargement of cementing agents on mineral grains film without following risk of ruts formation;
- during pavement operation they supply strength of organic cementing agents and form three-dimensional structure in mixture which promotes asphalt concrete

pavement resistance against shearing deformations.

One of such fibres is Forta FI (fig. 2). Forta FI is a patent mixture of two synthetic fibres which work together improving asphalt concrete performance criteria. Fibers Forta FI consist of unique twisted bundles polypropylene and high-strength high-temperature aramid fibres [20]. Polypropylene fibres promote asphalt concrete mixture and distribution. High-strength, high-temperature aramid fibres reinforce and improve asphalt concrete physical- mechanic and operated characteristics. That is why their application significantly brings down ruts and reflected cracking formation and also decreases course thickness without stability loss.

Main technical characteristics of Forta FI fibres are given in table 1. [20].



Fig.2 Polymeric fibres Forta FI

Table 1: Main technical characteristic of polymeric fibres Forta FI

Materials	Polypropylene and aramid
Feature	Twisted fibrillated fibre and fibre without monothreads
Length	19 mm и 38 mm
Colour	Yellow-brown
Unite weight	0,91 g/cm ³ and 1,44 g/cm ³
Resistance against acidity/ alkalize	Inert
Tension strength	Up to 4921,7 kg/cm ² и 28124 kg/cm ²
Melting temperature	166°C and 427 °C

The results of testing received at the university of Arizona (USA) and Europe show that fibres Forta FI application improves asphalt concrete resistance against rut and cracking formation. Results of testing of asphalt concrete of type B received by Ltd «АБ3-1» (asphalt concrete plant in St. Petersburg) witness that with Forta FI application velocity of rut formation and its depth decreases in two times

In order to develop the technology of application of dispersed reinforced asphalt concrete in road construction in Vietnam the authors investigated main physical – mechanical and operation characteristics of asphalt concrete of BTN C12,5 reinforced with Forta FI fibres [11, 20].

1. Research of fibres Forta FI affect on physical-mechanical asphalt concrete characteristics. To estimate fibres Forta FI influence on main physical- mechanical and operation characteristics of asphalt concrete dispersed reinforced asphalt concrete of type BTN C12,5 on cement agent Petrolimex 60/70 was tested in laboratory of center of tested results quality supply3 (QUATEST 3) and in laboratory of company BMT (city of Ho Shi Min)

Following materials were used while tesing:

- Stone from career Tang Dong Hiep, Binjiang Province compliance with requirements TCVN 8819-2011;
- bitumen Petrolimex 60/70 satisfies the requirements of TCVN 7493-2005 and characterized by penetration at 25 °C – 63,3×0,1mm, softening temperature of 48 °C, tensility at 25 °C – >120 cm;
- mineral powder Holcim according to requirements TCVN 8819-2011;
- fibres Forta FI (USA) delivered by BMT company (city of Ho Shi Min). According to producer recommendations there were used fibres Forta FI with different composition 0,0 %, 0,03 %, 0,05 % and 0,07 % by weight of asphalt concrete mix.

Compositions of dense asphalt concrete BTN C12,5 were determined according to the requirements TCVN 8820-2011 и 858/QĐ-BGTVT. Granulometric composition of asphalt concrete BTN C12,5 is given in fig.3.

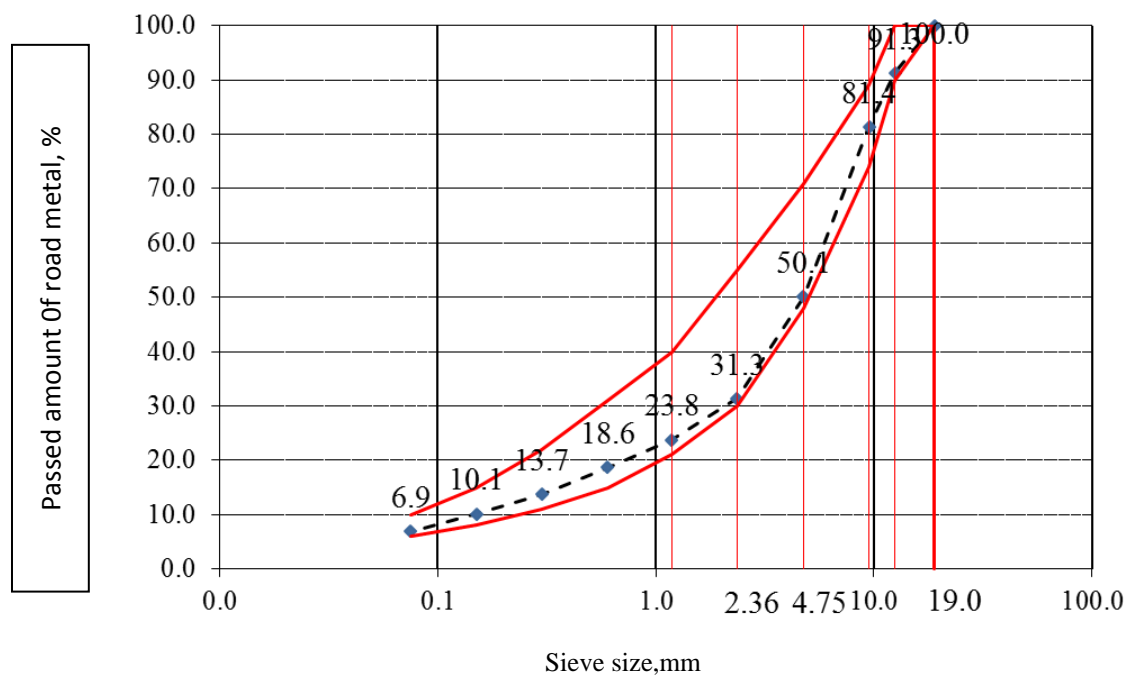


Fig. 3. Fig.3 Granulometric composition of dense fine-grained asphalt concrete BTNC 12,5

Three cylindrical samples were prepared and tested in the laboratory according to Marshall’s method. Preparation of the mixtures were done in the following way: the mixture of stone material without mineral powder was heated up to the 180±185 °C; at this temperature it was placed into mixer where mineral powder and fibres Forta FI was added and mixed during 2 minutes. Bitumen heated up to 160 °C, was added least and them “wet” mixing was being done during 2 minutes.

After that asphalt concrete samples were cured in air not less than 12 hours. Then the samples were placed into water for 40-50 minutes at designed temperature 60±1 °C for temperature control. While testing the samples of asphalt concrete were put between clams and loaded with deformation velocity of 50mm/min, when the load achieving its maximum began to go down. Maximal load value which samples can perceive before destruction is taken as asphalt concrete resistance by Marshall’s method.

Simultaneously top clam vertical displacement relative to lowest one was measured. It is asphalt concrete plasticity by Marshall. The test should take not less than 60 sec from the moment of sample is taken out from water bath up to the moment of maximal load achievement [10].

The results of experimental investigations of physical-mechanical properties of asphalt - concrete BTN C12,5 on bitumen Petrolimex 60/70 with different compositions of fibres Forta FI are given in table 2.

Table 2: Main physical- mechanical characteristics of asphalt concrete BTN C12,5 with different composition of Forta FI fibres

Characteristics	Composition of fibres Forta FI, %				Values according to TCVN 8819-2011 и 858/QĐ-BGTVT
	0,0	0,03	0,05	0,07	
Optimum composition of bitumen, %	5,0	5,01	5,07	5,17	5÷6
Average density, g/cm ³	2,401	2,398	2,395	2,381	-
Real density, g/cm ³	2,503	2,501	2,500	2,496	-
Residual porosity, %	4,1	4,1	4,1	4,6	3÷6
Resistance at 60 °C, kN	13,5	13,7	14,2	12,6	≥ 8
Plasticity at 60 °C, mm	3,0	2,8	3,1	3,5	2÷4
Residual resistance, %	93,33	94,16	94,37	92,86	≥ 75

Data of table 2 show that:

- Physical-mechanical properties of asphalt concrete BTN C12,5 with different composition of fibres Forta FI meet requirements of 858/QĐ-BGTVT and TCVN 8820-2011 regulations.
- optimal composition of bitumen increases with increasing of fibres Forta FI composition. This result is explained by the following way: more bitumen is needed while injecting fibres in order to cover the fibres surface for better absorption.
- asphalt –concrete density decreases with increasing of fibres Forta FI. It is because fibres Forta FI have less specific weight than mineral agglomeration. The more so asphalt concrete mixture becomes more elastic with increasing of fibres composition due to its natural elasticity. That is why at the same consolidation and increasing of fibres asphalt concrete density decreases.
- Asphalt concrete stability increases primary and then decreases with increasing of fibres Forta FI composition and achieves maximal value (14,2 kN) at fibres composition of 0,05 %. It is explained by the following fact: fibres originate special net for asphalt concrete mixture strength increasing. The more so aramid fibres relax tension appeared in asphalt concrete leading to

asphalt concrete strength. But this mixture is heterogeneous and polyphase composite material consisting of conglomerates and adhesive bitumen. Fibres FortaFI cannot distribute evenly in asphalt concrete mixture and its coagulation promotes weak places formation inside the mixture.

2. Fibres Forta FI influence on rut resistance.

Experimental investigations for rut resistance were done with the help of Hamburg means for estimation of rut formation – HWTD (fig 1) by the method of A 1617/QĐ-BGTVT. Samples -slabs of 320x260x50mm size were tested at the temperature of 50 °C. Samples-slabs were prepared according to appendix C of regulation 1617/QĐ-BGTVT. Rut depth in tested slabs was registered in 15000 loading cycles.



Fig.4. Hamburg means of rut formation estimation HWTD

The results of experimental investigations are given in table 3.

Table 3. Results of determination of rut depth of asphalt concrete BTN C12,5 with different fibres Forta FI composition

Characteristics		Composition of Forta FI, %			
		0,0	0,03	0,05	0,07 ^(*)
Rut depth, mm	Left track	13,1	12,7	7,5	15,0
	Right track	9,5	8,1	4,7	11,7
	Average	11,3	10,4	6,1	13,3
	Appendix A QĐ 1617/QĐ-BGTVT, not more	12,5			
Velocity of rut formation, mm/1000 of load cycles	Left track	1,01	1,19	0,45	1,77
	Right track	0,77	0,78	0,35	1,36
	Average	0,89	0,98	0,40	1,57

^(*) Rut depth is registered at 12000 passes of loading

The data of the table shows that:

- rut of asphalt concrete BTN C12,5 reinforced with fibres of 0,07 % by mixture weight is deeper than

others and increases maximum permissible value given in QĐ 1617/QĐ-BGTVT though it was registered at 12000 passes of loading;

- at composition of 0,0 %, 0,03 % and 0,05 % of fibres Forta FI by mixture weight, asphalt concrete BTN C12,5 rut depth at 15000 passes of loadings is less than maximum permissible values given in QĐ 1617/QĐ-BGTVT;
- rut depths of asphalt concrete BTN C12,5 with 0,03 % and 0,05 % of Forta FI fibres by mixture weight at 15000 passes of loading is 10,4 mm and 6,1 mm decreases in accordance with control sample;
- speed formation of rut of asphalt concrete BTN C12,5 with 0,03 % and 0,07 % of Forta FI fibres by mixture weight is more than control one but at composition of Forta FI fibres 0,05% by mixture weight this rate decreases by 55,06 % in comparison with control sample;

Based on this investigation it is recommended to apply asphalt concrete BTN C12,5 reinforced with 0,05% Forta FI fibres by mixture weight for arrangement of upper course of pavement of motor ways of high categories.

CONCLUSION

1. Introduction of reinforcing fibres Forta FI is one of the main direction of improving asphalt concrete strength characteristics and rut resistance.
2. It is established that introduction of 0,03 % and 0,05 % Forta FI fibres from mixture weight enhances Marshall stability and decreases rut depth of asphalt concrete which leads to increase of deformation stability of asphalt concrete pavements.
3. The analysis of received data allows to recommend the application of asphalt concrete BTN C12,5 reinforced with Forta FI fibres in amount of 0,05% by mixture weight for construction of surface upper course of high categories roads.
4. The tests were conducted only in laboratory conditions that is why it is necessary to investigate Forta FI fibres influence on deformation stability of asphalt concrete to find reliable base for dispersed reinforced asphalt concrete application in upper courses of non-rigid pavement.

But it is necessary to mention that introduction of dispersed reinforced asphalt concrete in Vietnam is restrained by the absence of normative documents and needs their execution and approval.

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