Studying on the Polymer-Modified Concrete of Pavement Performance

Yiqin Shen[1,a], Xiao Chen[2,b], Hongjun Guo[3,c],YuanhuiXiang[1,d],Qinghai Liu[4,e]

[1]EXi Expressway Administration of Hubei Department of Transportation

[2]Wuhan University of Technology

[3]Hubei Safety & Environment Technology Institute Co., Ltd.

[4]Hubei Chang Jiang Rord& Bridge

[a]email:228548632@qq.com,[b]email: chenxiao1981@whut.edu.cn,
[c]email:412805409@qq.com,[d]email:171657742@qq.com, [e]email:18597096@qq.com

Keywords: Polymer, Cement concrete, Pavement performance

Abstract. On account of cement concrete has many disadvantages,including pavement poor toughne ss, high brittleness, easy cracking and other fatal flaws, the concrete reinforced by polymer-modified fiber is recommended as a new building material. This paper focuses on studying the polymer-modi fied concrete of pavement performance. It contains flexural toughness, shrinkage resistance, wear-r esisting property,anti-cracking ability.

Introduction

In many Chinese parts , cement concrete has been widely used as pavement material.It has many advantages ,such as a long service life, small maintained workload and less energy consumption.But cement concrete has many disadvantages,including pavement poor toughness, high brittleness, easy cracking and other fatal flaws[1].

Cresson has made natural rubber latex as filler putting in pavement construction materials since 1923. Polymer-modified concrete has over 90 years of history[2]. Thereafter fiber modified cement-based materials is gradually turned up , but most of the fiber is pulled from the concrete matrix after being destroyed , showing its effect has not been a real play.

Today, concrete rein forced by polymer-modified fiber rises in response to the proper time and conditions.According to relevant documentation. It has many research about mechanical properties [4], but its road performance about flexural toughness, shrinkage resistance, wear-resisting property,anti-cracking ability is not much, not enough depth, and relevant reports are also relatively small[5].

Raw Materials and Test Method

Raw materials

PO 42.5 cement using ordinary portland cement, meeting the relevant standards;PC-3301C water reducing agent; Shanghai styrene-butadiene latex (DB) produced by BASF.Aggregate particle size:1#：0-2.36mm, 2#：2.36mm-4.75mm, 3#:4.75-9.5mm .needle like: 8.2 percent.

Test Method

(1) Flexural toughness test

Using UTM25 tests the polymer modified mortar of flexural toughness,recording specimen load and deflection data. .

(2) Shrinkage resistance test

Shrinkage resistance test uses "falling weight method"recommended by American Concrete Institute (ACI) 544 Commission.

(3) Wear-resisting property test

According to the special requirements about abrasion resistance on pavement material, molding 150mm×150mm×50mm specimens,conducting wear-resisting property test according to "Highway Engineering Cement Concrete Test Rules" (JTJ053-94) .

Experiments and Results

Research on road performance of polymer modified cement concrete materials

As the paving material, polymer modified cement concrete must have excellent road performance. The material of the road performance is mainly manifested in resistance to bending toughness, impact, wear, early shrinkage crack and other aspects. Therefore, this section focuses on the systematic study of the above aspects of polymer modified cement concrete materials.In Experimental, Concrete proportion of mixture: cement 335kg/m³;aggregate gradation 1#(0-2.36mm): 2#(2.36-4.75mm): 3#(4.75-9.5mm) = 4:1:5;water-cement ratio 0.35; fiber content 0.14%.

Research on flexural toughness of polymer modified cement concrete materials

The influence of the amount of emulsion on concrete flexural toughness is shown in Table 1. It can be seen that when mixed with polymer latex, the maximum deflection and the flexural toughness of the sample increases with the amount of the emulsion rises. The sample DB-100 can increase the maximum deflection at 74.7% and increase the flexural toughness at 108.4%, as compared to the sample DB-0.

Table 1 The influence of the amount of fiber and latex on concrete flexural toughness

Number	Ultimate pressure/KN	Maximum deflection/mm	Flexural toughness/J
DB-0	18.305	0.376	3.305
DB-70	20.87	0.521	5.286
DB-80	21.264	0.584	5.605
DB-90	22.315	0.634	6.219
DB-100	23.706	0.657	6.887

Research on the impact resistance of polymer modified cement concrete materials

The influence of the amount of emulsion on concrete impact resistance is shown in Table 2. It can be found that when mixed with latex, the impact resistance increases with the increasing of the amount of the emulsion. And the impact performance of the sample DB-100 improved 4.2 times when compares to the sample DB-0. The failure patterns of the sample DB-0 and the sample DB-90 after the completion of the impact test are shown in Fig.1. The failure pattern of the sample DB-90, compared with the sample DB-0, the number of cracks increase, the emergence and development of cracks are shown as radial, and cross section is not flat, which indicates that the polymer have crack resistance action on concrete.

Table2 Influence of polymer content on the impact resistance of PCC

Number	Impact times of first crack/N1	Impact times of destroy/Nc	$\Delta N=N_1-Nc$	Impact energy $W/10^3 N\bullet m$
DB-0	291	293	2	5.91
DB-70	787	792	5	15.96
DB-80	1172	1180	8	23.78
DB-90	1399	1408	9	28.38
DB-100	1511	1524	13	30.75

(a) Ordinary concrete 0-DB-00 (b)Polymer concrete 90-DB-00

Fig.1 Sample morphology after the impact test

Research on the wear resistance of polymer modified cement concrete materials

The influence of the polymer on the wear resistance of the polymer modified cement concrete material is shown in Table 3. It shows that its wear resistance of the sample gradually improved with the increasing of the amount of polymer. The sample DB-100 can reduce the amount of wear at 13.1% when compared with the sample DB-70. Whereas compared to the sample DB-0, it can reduce the wear at 42.9%.

Table 3 Effect of polymer on the wear resistance of PCC

Number	Unit amount of wear/(kg/m^2)	Number	Unit amount of wear/(kg/m^2)
DB-0	4.89	0-DB-12	3.11
DB-70	3.21	0-DB-14	3.01
DB-80	3.08	90-DB-10	2.77
DB-90	2.92	90-DB-12	2.21
DB-100	2.79	90-DB-14	2.23

Study on anti-cracking ability of polymer-modified cement concrete materials

For anti-cracking ability of polymer emulsion modified cement-based materials, the test concrete pr oportion of mixture and the test results are shown in Table 4.

Overall opinion: The sample A-0 earliest cracks and crack the most serious; and compared with t he sample A-0, It shows that with the adding of the amount of polymer , the cracking time can be p rolonged , the cracks can be reducing, and it can better improve its anti-cracking ability. With the in creasing of the amount of polymer , cracking time gradually increased, when emulsion adds in an a mount of 164g, the cracking time can be prolonged at 101.9%.

Table 4 the test of concrete proportion of mixture and results

serial number	cement mortar ratio						initial cracking time	Fracture character description
	cement /(g)	River sand/ (g)	DB/ (g)	fiber volume percent /(%)	water/ (g)	water reducer /(g)		
A-0	600	1200	0	0	240	3	58.4	longest, widest
A-1	600	1200	127	0	180	3	88.1	Longer, wider
A-2	600	1200	164	0	120	3	117.9	narrow, short,

Conclusions

(1) When concrete is mixed with polymer latex, the maximum deflection and the flexural toughness of the sample increases with the amount of the emulsion rises. The sample DB-100 increase the flexural toughness at 108.4%, as compared to the sample DB-0.
(2) When concrete is mixed with polymer latex, the impact resistance increases with the increasing of the amount of the emulsion.the impact performance of the sample DB-100 improved 4.2 times when compares to the sample DB-0.
(3)When concrete is mixed with polymer latex, the wear resistance of the sample gradually improved with the increasing of the amount of polymer. The sample DB-100 can reduce the amount of wear at 42.9% when compares to the sample DB-0.
(4)With the increasing of the amount of polymer , cracking time gradually increased, when emulsio n adds in an amount of 164g, the cracking time can be prolonged at 101.9%.
In summary, through the research of DB latex effect on the cement concrete materials, it can been found that DB latex can better improve the pavement performance.

Acknowledgements

This work was financially supported by the National Natural Science Fund (51402226) and Hubei province transportation science and technology project (20130113).

References

[1] Davidovits J. Geopolymer chemistry and application [M]. Geopolymer Institute, SaintQuentin, France, 2008:3-15

[2] Wang Qing, Ding Zhao Yang, Zhang J,Qui L G,Sui Zhi Tong. Study on slag-based geopolymer hydration process[J]. Key Engineering Materials (2011)477:67-71

[3] J.C.Swanepoel, C.A.Strydom.Utilisation of fly ash in a geopolymeric material[J]. Applied Geochemistry, 2002, 17(8):1143-1148.

[4] Van Jarsveld J G S, Van Deventer J S J, Lukey G C. The effect of composition and temperature on the properties of fly ash and kaolinite-based geopolymers[J]. Chemical Engineering Journa,l 2002, 89:63~73.

[5] Beeldens A,Van Gemert D,Schorn H, et al. From microstructure to macrostructure: an integrated models of structure formation in polymer-modified concrete[J].Materials and structures ,(2005).