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PROPERTIES OF ASPHALT PAVING MATERIALS WITH RECYCLED FRP

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The authors tried to find the feasibility of the application of waste FRP for pavement materials expecting improvement of properties by remain fiber. Asphalt binders and mixtures mixed with crushed FRP and with fiber picked out from FRP were tested. Though the results of the tests of crushed FRP did not indicate good improvement, the results of the tests using fiber picked out from FRP indicated improvement of rutting resistance performance. From these results, it was suggested that waste FRP could be used as reinforcement materials of asphalt pavement by processing adequately.

1. Introduction

Fiber Reinforced Plastic (FRP) is utilized widely for from bathtub to automobile parts, but waste FRP occurs simultaneously, too. Therefore recycling of FRP is attracting attention. There are three methods for FRP recycling; combustion method, heat resolution method and crush method. The authors tried to find the feasibility of the application of waste FRP recycled by crush method for asphalt pavement materials.

Asphalt pavement is affected by heat in summer, and it causes rutting (plastic deformation) in the upper asphalt pavement. Asphalt pavement is also affected by cold environment in winter, and it causes cracking in the asphalt pavement. As one of these countermeasures, fiber reinforcement for asphalt pavement has been adopted using vinylon, methyl cellulose, etc.

Reinforcement of asphalt pavement using glass fiber contained in waste FRP were considered. Asphalt mixtures mixed with simply crushed FRP, that contains approximately 30 % of glass fiber, were tested. FRP that removed resin and filler ingredient and contains more than 85 % fiber ingredient were also tested.

2. Experimental

2.1 Materials

Table-1 shows recycled materials used in this study. Two types of simply crushed FRP were selected in this study. One is 20μm and the other is 5mm of maximum fiber length. These materials were used only for mixture test. Three types of recycled glass fibers from FRP removing resin and filler were also used in this study.The content of recycled glass fibers from FRP was more than 80%, where that of crushed FRP were approximately 30%. Recycled glass fibers from FRP were used for both binder and mixture tests varying its maximumfiber length from 0.8 to 3.2mm. All of FRP were originally from scraps made in faculties. Asphalt used in both binder and mixture tests was straight asphalt (60/80), and aggregate for mixture test was prepared as dense-graded asphalt concrete (maximum particle size 13mm) from crushed stone and coarse sand.

Table-1 Recycled Materials used for the tests

Name of recycled materials	Outlines	Test item
Recycled glass fiber from FRP Maximum length: 0.8mm	Glass fiber picked out from FRP Maximum length: 0.8mm, glass content: 87.8%	Binder and mixture test
Recycled glass fiber from FRP Maximum length: 1.6mm	Glass fiber picked out from FRP Maximum length: 1.6mm, glass content: 84.3%	Binder and mixture test
Recycled glass fiber from FRP Maximum length: 3.2mm	Glass fiber picked out from FRP Maximum length: 3.2mm, glass content: 87.5%	Binder and mixture test
Powdered FRP	Powdered FRP Maximum length: 20μm, glass content: applx. 30%	Mixture test
Crushed FRP	Crushed FRP, SMC molding FRP, containing filler Maximum length: 5mm, glass content: applx. 30%	Mixture test

2.2 Binder tests

Recycled glass fibers from FRP were added a little by little to heated asphalt at 170°C stirring constantly, and the asphalts stirred 3 hours after adding stated amount were used as samples. Samples were evaluated in major items as properties of paving asphalt; penetration, softening point, viscosity at 60°C, Fraas breaking point, toughness and tenacity.

2.3 Mixture tests

Asphalt mixture specimens were made from asphalt, aggregate and recycled FRP, and evaluated in wheel tracking test and bending test. Wheel tracking test was used for the evaluation of rutting resistance, and bending test was used for the evaluation of low-temperature cracking resistance.

3. Results

3.1 Binder tests

For each samples, fiber dispersion in asphalt were observed using a microscope, and they showed almost good dispersion in asphalt binder. The results of binder tests were shown in Figure-1.

Penetration decreased and softening point increased as adding recycled glass fiber from FRP. The longer recycled glass fiber from FRP, the more penetration and softening point changed. These results show the length of fiber affect the properties of asphalt binder. The result of viscosity at 60°C changed with length of fiber remarkably. Though Fraas breaking point of 0.8mm sample came higher, that of 3.2mm sample did not changed. Basically, Fraas breaking point will become higher when insoluble thing, like glass fiber, is added. It is considered that longer fiber can reinforce asphalt binder more effectively, and it was the reason that no change was observed in Fraas breaking point in the case of 3.2mm fiber.

In conclusion of binder tests, the results showed properties of asphalt binder are affected by mixing recycled glass fiber from FRP. With mixing the fiber, improvement of high temperature properties is expected without changing low temperature properties.

3.2 Mixture tests

The results of mixture tests are shown in Table-2. Amount of asphalt was selected at Optimum Asphal t Content (OAC) that decided by conventional mixture design method. Dynamic stability (DS) of recycled glass fiber from FRP were more than twice of standard, and it means

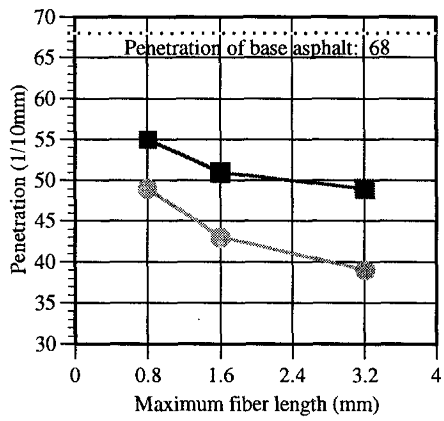


Figure-1(a) Result of penetration

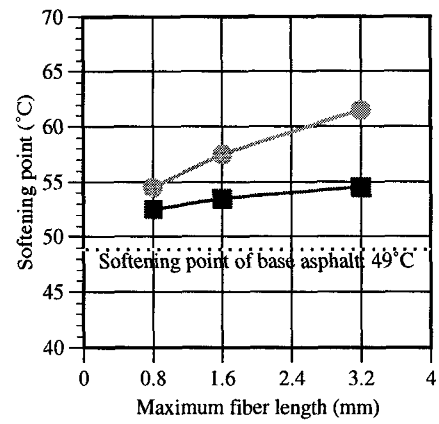


Figure-1(b) Result of softening point

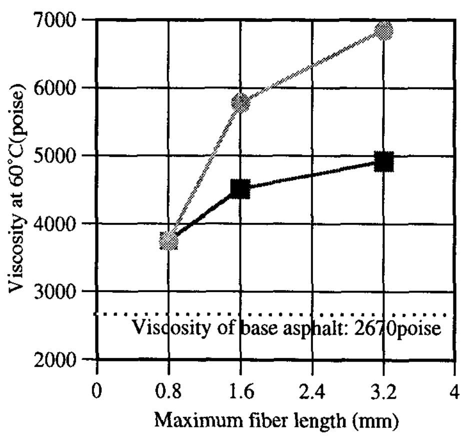


Figure-1(c) Result of viscosity at 60°C

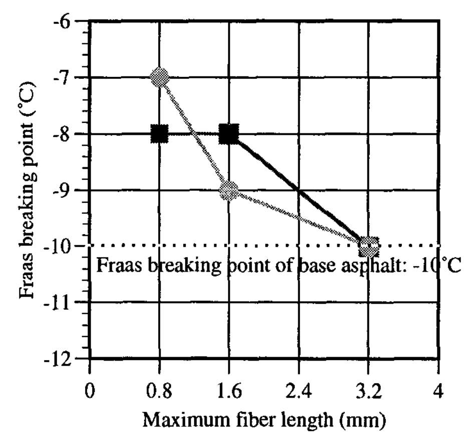


Figure-1(d) Result of Fraas breaking point

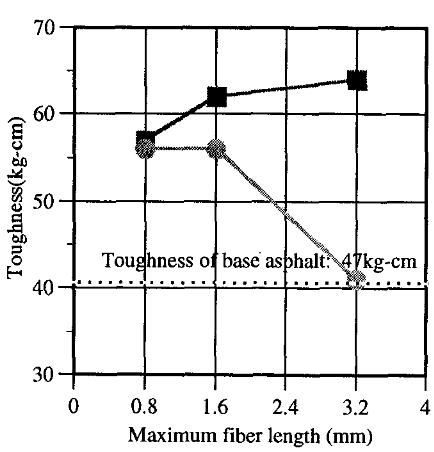


Figure-1(e) Result of toughness

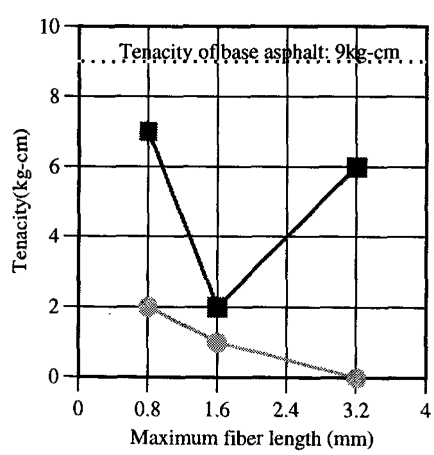
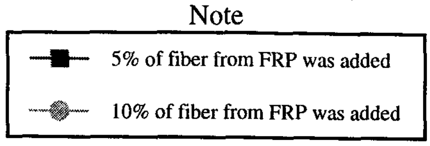


Figure-1(f) Result of tenacity

Note



rutting resistance was improved. The effect of fiber length to dynamic stability was not clear.

Dynamic stability of crushed FRP increased 1.15 times of standard, however DS of powdered FRP which maximum length is 20μm decreased 0.82 of standard.

The result of bending test shows that bending strength and strain of fiber added mixtures steadily change.

In conclusion of mixture test, the results of mixture test shown same tendency as binder test. Improvement of high temperature properties is expected without changing low temperature properties with mixing the fiber.

Table-2 Results of mixture tests

Recycled materials	Condition and amount of added materials	Wheel tracking test		Bending test	
		Improvement ratio of dynamic stability (DS)	Increasing ratio of initial deformation (d_0)	Bending strength (kgf/cm^2)	Strain ($x10^3$)
Straight asphalt (Standard) (No recycled materials)	Asphalt: 6.6% Recycled materials: 0%	1	1	87.8	3.2
Recycled glass fiber from FRP Maximum length: 0.8mm	Asphalt: 6.6% Recycled materials: 0.66%	2.22	1.13	87.5	3.3
Recycled glass fiber from FRP Maximum length: 3.2mm	Asphalt: 6.6% Recycled materials: 0.66%	2.22	1.39	94.0	3.1
Powdered FRP Maximum length: 20μm	Asphalt: 6.0% Recycled materials: 0.6%	0.82	1.10	80.8	2.6
Crushed FRP Maximum length: 5mm	Asphalt: 6.0% Recycled materials: 10%	1.15	1.97	73.1	3.6

4. Conclusion

In this paper, feasibility of the application of waste FRP for pavement materials was studied expecting improvement of properties by remain fiber. And as the result, it was suggested that waste FRP could be used as reinforcement materials of asphalt pavement by processing adequately.

Farther research subjects which would be solved are as follow.

1) Establishment of effective application method
2) Improvement of adhesive property between fiber and asphalt
3) Execution method
4) Long term durability
5) Re-recycling use

References

1) Nishizaki, I. and Sakamoto, H.:Tests of asphalts and mixtures mixed with recycled plastics and rubbers, 50th Annual Conference of Japan Society of Civil Engineering (1995)