The General Performance of Newly Developed Rejuvenator And Its Application

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ABSTRACT:

Recent years, the manufacturing ratio of recycled pavement in Japan has been up to 70wt% and more, and the demand for the rejuvenator will rise more and more in the foreseeable future. New rejuvenator was developed which recovers the performances of recycled bitumen in mixture not only in physical properties but also in chemical compositions which have been changed during service period. The new rejuvenator gives us safety handling at asphalt mixing plants with high flash point above 300°C like a conventional straight run bitumen. Additionally, the rejuvenator makes uniform recycled asphalt mixture with excellent properties by introducing relative high volume in the mixture compare with that of general mineral oil additives.

KEY WORDS: rejuvenator, RAP, PAHs.

1. INTRODUCTION

In Japan, the reuse of the asphalt pavement waste material is carried out flourishingly, and approximately 99wt% of asphalt pavement waste material is being reused as recycled asphalt pavement (RAP). The production of RAP begins to be increased remarkably from early 1990's and reached 40 million tons in 2000, and is approximately constant afterwards. The production content of asphalt mixture was 50 million tons, and the 73wt% of asphalt mixtures contains asphalt pavement waste materials in 2008. Therefore, high-performance rejuvenator for RAP is required. There is the viscosity range of used conventional rejuvenators from an oil type to an asphalt type widely. However, the recovery of deteriorated bitumen in the asphalt pavement waste material by the addition of these types of rejuvenators is not clear.

In this paper, the performance and recovery mechanism of the developed rejuvenator for deteriorated bitumen in the asphalt pavement waste material are described.

2. REJUVENATOR PROPERTIES

The properties of developed rejuvenator which passes a standard of Japan Road Association are shown in Table1. The developed rejuvenator has a good handling in asphalt mixture plants because the flash point of developed rejuvenator is higher in 70°C or more than that of conventional oil-type rejuvenator. On the other hand, the polycyclic-aromatics hydrocarbons (PAHs) specified in the European parliament and the council of the European union is shown in Table 2. The measured values of eight regulated substances of developed rejuvenator are considerably lower than those of the specified PAH value, and the developed rejuvenator clear the European union regulation (76/769/EEC, 2005/69/EC).

Table 1 Typical properties of developed rejuvenator

	Unit	Specification	Conventional rejuvenator	Developed rejuvenator
Dynamic viscosity @ 60°C	mm^2/s	80~1000	160	600
Flash point(COC)	°C	over 230	260	330
Mass change after TFOT	%	-3 ~ +3	-0.02	-0.01
Density @ 15°C	g/cm^3	report	0.901	0.962

Table 2 PAH contents of developed rejuvenator

Substance (mg/kg)	Specification	Developed rejuvenator
Benzo(a)pyrene	Below 1mg/kg	0.1
Benzo(e)pyrene	Below 10mg/kg	0.1
Benzo(a)anthracene		ND
Benzo(b)fluoranthene		ND
Benzo(j)fluoranthene		ND
Benzo(k)fluoranthene		ND
Chrysene		0.1

3. TEST RESULTS AND DISCUSSION

3.1 Preparation of dense graded Asphalt Mixtures (Dense mixture,13mm top)

Test specimens were prepared by the mixing of 50wt% of brand-new materials of bitumen and aggregates and 50wt% of the asphalt pavement waste material with additional 0.4wt% of developed rejuvenator at 160°C. The penetration of recovered bitumen in recycled asphalt

mixture achieved 70 (1/10mm) by the addition of developed rejuvenator. In this mix design, 5.7wt% of bitumen content was fixed and straight-run bitumen with a penetration of 60/80 (1/10mm) was used as new bitumen.

3.2 Asphalt Mixtures Tests

According to the specified test methods of Japan Road Association, rutting resistance (Dynamic stability @60°C) and retained Marshall stability for evaluating water resistance of test specimens with developed and conventional rejuvenator were measured , and their bending test at low temperature (-10°C) was also carried out. These test results are shown in Table 3.

Table 3 Mixture properties with developed rejuvenator

	Unit	Conventional rejuvenator	Developed rejuvenator
Dynamic stability @ 60°C	Pass/mm	1000	1800
Retained Marshall Stability	%	82.1	92.1
Bending stiffness @ -10°C	MPa	1700	1400

The retained Marshall stability of recycled asphalt mixtures with developed and conventional rejuvenators are 92.1% and 82.1% respectively, and it is cleared that the addition of developed rejuvenator to the asphalt pavement waste material for RAP production gives good influence to water resistance.

The rutting resistance of recycled asphalt mixture with developed rejuvenator is 1800(pass/mm), and this value is 1.8 times higher of that of asphalt mixture with conventional one.

The bending stiffness of recycled asphalt mixture with developed rejuvenator is somewhat lower than that of recycled asphalt mixture with conventional rejuvenator. This may be due to the fact that developed rejuvenator improved the flexibility of deteriorated bitumen in the asphalt pavement waste material. From these test results, it is cleared that RAP with developed rejuvenator has a good physical properties.

4. Evaluation of Chemical Composition

Figure 1 illustrates the chemical compositions of new 60/80 bitumen (A), extracted bitumen from asphalt pavement waste material after 5-year service period (B), recycled bitumen with developed rejuvenator (C) and recycled bitumen with conventional oil-type rejuvenators (D).

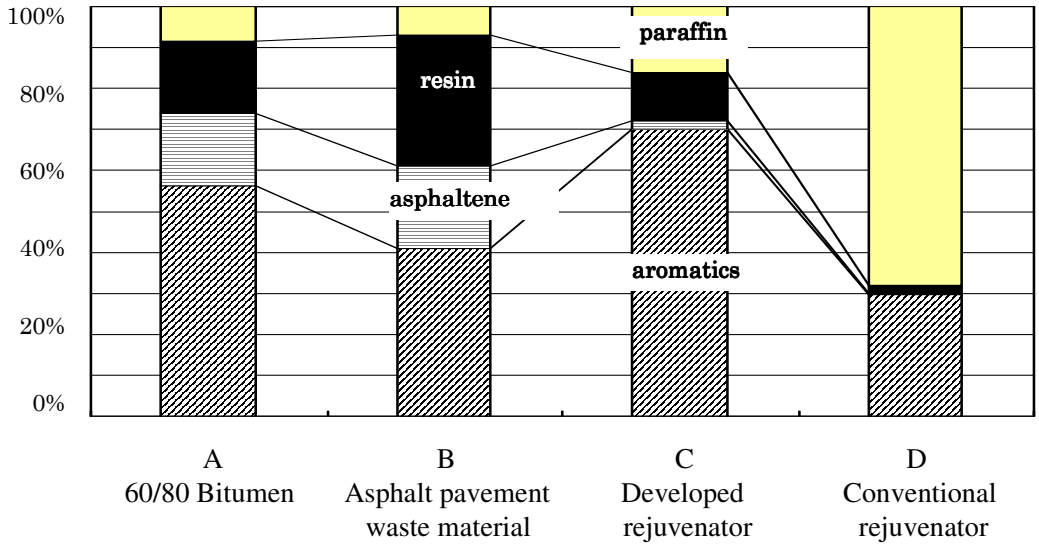

Figure 1 The chemical compositions of extracted bitumen

These chemical compositions were measured by thin-layer chromatography with FID detector (TLC/FID) method) . In this study, the used asphalt pavement waste material has exposed for 5years as pavement.

The ratio of chemical composition of asphalt pavement waste material is different from that of new 60/80 bitumen. Particularly, aromatics and resins of asphalt pavement waste material considerably changed compare to those of new 60/80 bitumen. Aromatics decrease about 20% and resins increase about 200% after 5years exposure respectively. Hereon, the role of the rejuvenator to get good performances of RAP not only in physical properties but also in chemical compositions, is to introduce sufficient amount of aromatics in the RAP.

From this test result, it is found that the developed rejuvenator with appreciable amounts of aromatics is very effective to recover the bitumen properties in the RAP. On the other hand , it is difficult for conventional oil-type rejuvenator with less amounts of aromatics to recover the bitumen properties in the RAP. Furthermore, it is assumed that developed rejuvenator is dispersed uniformly in RAP to relatively in comparison with oil type one by adding much quantity.

Generally bitumen components in the asphalt pavement waste material is deteriorated and hardened after the service period, a sufficient penetration and elongation can not be secured. Therefore there has been arised a major problem in the RAP some cracks have been generated in a short period which reuses the asphalt pavement waste material. Besides, it is known that due to such deterioration of the pavement, an aromatic content in the bitumen is decreased [1), 2)]. Particularly, the high aromatic type rejuvenator can bring the bitumen

component in the asphalt pavement waste material thus deteriorated close to a composition of the bitumen which does not use the asphalt pavement waste material, namely new bitumen by adding it thereto improves the flexibility of regenerated pavement and is effective in securing performance in service life.

5. CONCLUSION

The developed rejuvenator is very effective for improvement in RAP properties because it can recover the chemical composition of deteriorated bitumen, and RAP with developed rejuvenator has good physical performance. Accordingly, the improvement in service life of RAP also can expected by the addition of the developed rejuvenator.

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