

Experimental study on the preparation of BRA waterproof coating

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Abstract. General petroleum asphalt is a common inexpensive impermeability of waterproof material, but its some performance limits its development. In order to make up for the defect and reduce the cost, we discussed the preparation of waterproof coating made of petroleum asphalt which is modified by BRA in this paper. We use the process of modification before emulsification to check the influences of dosage of BRA and bentonite, fluorocarbon emulsion on the properties of waterproof coating. The results prove that, this kind of waterproof coating has more excellent high temperature stability, elasticity, etc. The addition of bentonite can improve the plasticity, cohesiveness of waterproof coating. Fluorocarbon emulsion has a great influence on the low temperature properties of the waterproof coating.

Introduction

Petroleum asphalt, as the most widely used waterproof material in the waterproof anti-seepage engineering in domestic and international currently, is used for waterproof project with the advantages of the raw materials easy to get and low price^[1].

Kyminas et al.^[2] have made a relatively strong and durable roofing asphalt waterproof coating which is mainly used in roof waterproof eroded by the wind and rain in the long term. Roberts, etc^[3] have developed the asphalt waterproof coating used in the basement metope waterproof, which had a good weather resistance, chemical corrosion resistance, high tensile strength and high elongation. Construction science research institute of Shanxi province has developed environment-friendly water-based asphalt polyurethane waterproof coating^[4]. They combined the oil asphalt and solid colored polyurethane waterproof coating, which kept the good performance of waterproof coating and also reduced the cost. Jilin architecture and civil engineering institut^[5] studied the asphalt waterproof coating emulsified by bentonite, which was modified by fluorocarbon emulsion. It was found that the properties of crack resistance and low temperature flexibility of waterproof coating were improved.

However, some properties of petroleum asphalt, such as heat flow and cold brittleness, weather resistance and other problems, which hinders its application and development in the field of waterproof material. And the emergence of modified asphalt waterproof coating will overcome the problems of petroleum asphalt. Meanwhile, due to the enhancement of people's environmental consciousness, the research of modified asphalt has become a hot topic.

Buton rock asphalt (referred to as BRA) is a kind of natural asphalt produced on the Indonesian island of Buton^[6]. Because of its perennial coexisting with environment and withstanding the long-term harsh test of environment in nature, its properties are particularly stable and have a strong weather resistance and "semi polymerization". It contains more impurities of clay and sand. Its asphalt content is about 20% ~ 30% and the rest is limestone mineral^[7]. BRA, a kind of rarely cheaper and easier to get modified material than petroleum asphalt, has a rich reserves and its mining is relatively simple.

Currently, our country applies BRA mainly to the construction of public transportation and road, but its application in research of waterproof coating has not been reported. Therefore, in this paper, it used BRA to modify asphalt and made bentonite and fluorocarbon emulsion as modification agent to prepare waterproof coating, after which we would evaluate its performance.

Experimental

Raw materials. The A-90 asphalt(Liao river),Buton rock asphalt(Indonesian island of Buton),Fluorocarbon resin emulsion(Changshu run Lin fluorine and silicone material Co., Ltd,solid content, $\geq 45\%$),Bentonite(Shenzhen Haiyang Powder Technology Co., Ltd,containings of montmorillonite, $\geq 85\%$),Styrene butadiene latex(Jiangsu dongtai citizens kay chemical co., Ltd,solid content, $\geq 20\%$),Chloroprene latex(Shanghai chemical technology Co., Ltd,solid content, $\geq 48\%$).

Experimental Procedure. 1)According to take adequate amount of the matrix asphalt, heated to 160-200 °C.Then add dosage of 20% BRA and stir for 30 min in 180 °C. The samples will be put in oven 20 min, a quick modified asphalt gotten. 2) According to take a certain amount of the organobentonite,adding appropriate 70°C hot water. After mixing evenly, put it into the oven for 8h.Then the bentonite paste is made. 3)The modified asphalt was heated to 160-200°C. Add 12% content of organobentonite and stir 30 min in 180 °C. Then the emulsified asphalt is prepared. 4)It is cooled to 50 °C, adding 10% content of fluorocarbon emulsion. Make it mixed with emulsified asphalt evenly.Then cooling to 40 °C,BRA modified asphalt waterproof coating is made.

Performance test. Test method for specified performance of BRA modified asphalt waterproof coating was according to JC/T408-2005 *emulsion waterproof coating* .

Results and analysis

The influence of dosage of BRA. In the case of constant temperature and stirring rate,study its effect on the basic properties of the matrix asphalt by changing the content of BRA.The experimental results are shown in Table 1.

Table 1 Effect of the content of BRA on matrix asphalt

Serial number	BRA content(%)	Needle penetration	Softening point(°C)	Ductility(cm)
1	0	92.4	45.9	168.9
2	5	86	46.7	166.7
3	15	80.9	50.2	164.2
4	20	75	53.4	160.3
5	25	72.8	59.1	155.6
6	30	70	61.8	147.4
7	35	68	68.6	144.8
8	40	67.2	75.5	140.3

Notes: The penetration (25 °C 100g, 5S, 0.1mm), ductility (15 C, 5cm/min).

From Table 1,it can be concluded that asphalt penetration decreases along with the addition of BRA.When dosage of bra is in more than 20%, penetration do not significantly change.Asphalt asphalt penetration show soft and hard degree and consistency and the resistance to shear failure,which reflect the index of relative viscosity of asphalt in certain condition.It suggests that the addition of BRA improves the structure of asphalt for increasing the hardness and reducing consistency.The addition of BRA will also change the softening point of asphalt. Along with the augment of BRA, softening point increases,while the BRA content continues to grow to 25%, the softening point changes rarely.And with the augment of BRA, asphalt ductility decreases, but not so much.Asphalt softening point and ductility respectively reflect the thermal stability and low temperature extension of asphalt.Hence,the datas in Table 1 suggests that BRA effectively improves the high temperature property of matrix asphalt,and at the same time, reduces the low temperature performance,but only to a small extent.Therefore,through comprehensive analysis, the effect of modified asphalt is better when BRA content is 20%.

Make microanalysis of 20% content of the BRA and the minerals in BRA with the S-4800 ice emission scanning electron microscope and test results is shown in Figure 1, 2.

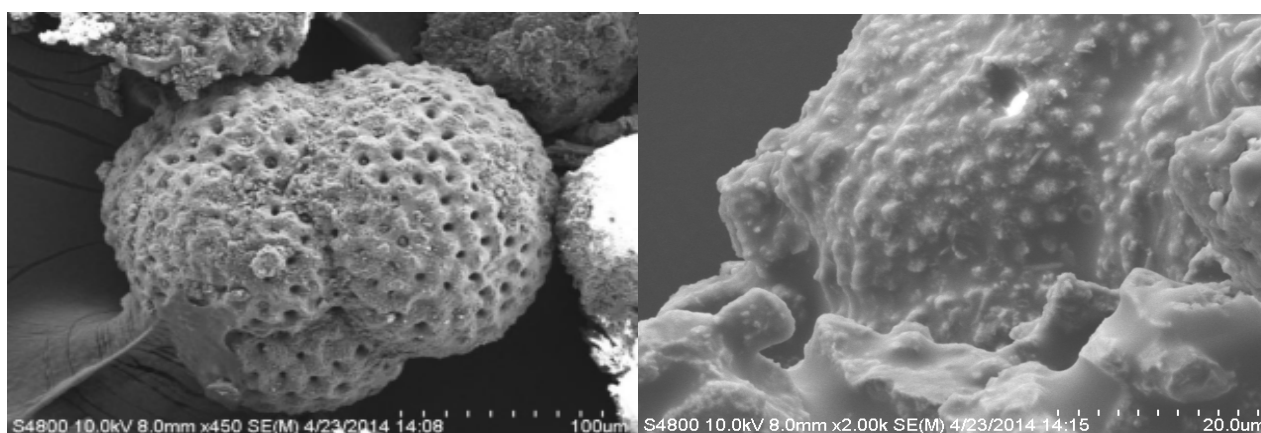


Figure 1 the diagram of powders of BRA in SEM (left),**figure 2** the diagram of 20% BRA in SEM (right)

Figure 1 shows that BRA has developed pores in the mineral powder, some of which deep into the interior of the mineral. Mineral surface is rough, uneven and higher crystallization degree. This shows that the properties of BRA are stable and it has strong adhesion. Through the Figure 2, it is observed that BRA and asphalt are mutually inclusive and particle surface coats with asphalt that permeates in the slag particles in the asphalt mixture, which forming a kind of continuous overlapping two-phase structure^[8]. This structure shape makes modified asphalt by BRA good heat storage stability and rheological property. Therefore, thermal stability, elasticity and film-forming property of BRA modified asphalt waterproof coating will be improved greatly.

BRA modification is just a simple physical mixing processes through the Figure 1 and Figure 2 and the "half aggregation effect" of BRA forms many active areas which can combine with the matrix asphalt quickly to form a continuous overlapping two-phase structure. This formation makes softening point rise rapidly, reduces the hardness of asphalt, increases its creep performance and lowers its properties of cracking tensile in the low temperature. It illustrates that BRA can improve the high temperature performance of matrix asphalt greatly with reducing its performance at low temperature. And fluorocarbon emulsion can modify the low temperature performance of waterproof coating, which makes up for the deficiency. The combination of both improves high temperature stability, low temperature flexibility and frost resistance of waterproof coating effectively.

The influence of the emulsifier. Select of bentonite, styrene butadiene latex and chloroprene latex as emulsifier. Make comparison experiment and record the effect of modification. The results are shown in Table 2.

Table 2 Effect of emulsifier on modified asphalt by BRA

Emulsifier	Heat resistance	Impervious property	Surface drying time(h)	Low temperature flexibility	Apparent state
No modifier agent	drippage	seepage	2	preferably	black, solid at room temperature
Bentonite	no flow	non seepage	6	preferably	puce, pasty at room temperature
Styrene butadiene latex	flowing without dripping	non seepage	8	preferably	black, pasty at room temperature
Neoprene latex	flowing without dripping	non seepage	8	poor	brown, pasty at room temperature

Notes: impervious property (200mm water static pressure for 7D), low temperature flexibility (-15°C)

It can be drawn by Table 2 that bentonite, styrene butadiene latex and chloroprene latex all have good effects to emulsify the modified asphalt by BRA. After the addition of emulsifier, modified

asphalt by BRA looks like a paste or liquid at room temperature with a good heat resistance and waterproof impermeability. But the emulsifications of styrene butadiene latex or chloroprene latex decrease its heat resistance with waterproof coating flowing under the standard test condition. Especially the low temperature property of chloroprene latex is also very poor, it can be observed obvious cracks with the naked eye in testing standards.

Bentonite crystal structure unit is composed of two layers of SiO_4 tetrahedron and a layer of $\text{AlO}_2(\text{OH})_4$ octahedron among them^[9]. Its cations in the interlayer are easy to be exchanged, which makes it a great deal of ion exchange capacity. The isomorphism exchange in this structure causes the unit cell remaining negative charge, which becomes the root cause of emerging interlayer water in structure. And c axis also expands with increase of the amount of water, which renders bentonite a good expansibility, adsorption and cation exchange to provide a favorable condition of composite or insertion reaction for the object matter. And modified sodium base bentonite has more superior physical and chemical properties, such as greater bibulous rate, higher expansion ratio and bigger cation exchange capacity and its colloidal suspension possesses good thixotropy, viscosity, lubricity, thermal stability, plasticity and cohesiveness^[10]. Consequently, it can widely improve various performance indexes of the waterproof coating and lower cost by choosing sodium base bentonite as emulsifier.

The effect of fluorocarbon emulsion. Choose fluorocarbon emulsion as a modifier for experiment and record its modification effects. The results are shown in Table 3.

Table 3 Comparison of the performance of the modified waterproof coating by fluorocarbon emulsion

Project	Before modification	After modification
Flexibility($\Phi 10\text{mm}$)	$(-12\pm 1)^\circ\text{C}$ no crack, fracture	$(-19\pm 1)^\circ\text{C}$ no crack, fracture
Heat resistance	120°C no flow, foaming and sliding	180°C no flow, foaming and sliding
Elongation at break(%)	1.20	1.50
Water impermeability(0.1 MPa, 30min)	non seepage	non seepage
Freezing resistance	no cracking of fifteen times	no cracking of twenty times
Artificial accelerated aging(h)	200	1600
Anti-permeability (MPa)	0.25(film thickness of 2.3mm)	0.3(film thickness of 1.0mm)

According to the results of the Table 3, it shows that the properties of waterproof coating, such as waterproofness, artificial aging resistance, elongation at break and flexibility, are improved significantly after using fluorocarbon emulsion. And this is because the fluorocarbon polymer molecules exist the C - F key, greater than C - H key and the shielding effect of electron clouds of the fluorine atoms to C - C key is stronger than H atoms. Therefore, fluorine atoms can protect it from UV and chemical substances, which improves the artificial aging resistance of waterproof coating to a great extent. Also because of its unique polarity, F atoms form electrostatic protective layer in the molecule periphery, excluding other polar molecules, which shows the special surface properties of fluorocarbon coating, such as contamination resistance, self-cleaning, low frictional, repelling water and oil and electrical insulation and greatly improves its compatibility with other substances^[11]. This experiment adopts the average particle size of fluorocarbon emulsion at about 200 nm for the good compatibility with bentonite emulsified asphalt, which not only improves the stability of emulsified asphalt, but also ensures to form a dense protective film between the emulsion particles and emulsion asphalt. It can effectively prevent erosion of the film and also improve the impermeability of waterproof coating, so that waterproof coating will have more excellent mechanical properties.

The addition of fluorocarbon emulsion can improve the performances of waterproof coating and the amount of that has different influences on its performance. The polymer can not be formed stable and elastic protective layer inside of coating, if too little. As well, if in excess, coating internal system is

easy to occur phase transformation, the discontinuous phase polymer becoming continuous phase and the asphalt turned into the continuous phase. Moreover, it can increase the cost if fluorocarbon emulsion dosage is too high. So the content of that is controlled at about 10%. And choose the good low-temperature film-forming fluorocarbon emulsion (which has good elongation at break and elongation rate of springback), to improve low temperature flexibility, elongation and elasticity of the emulsified asphalt effectively.

Conclusions

1. BRA, as a modifier of matrix asphalt, improves the softening point, needle penetration and ductility obviously and also advances the thermal stability, elasticity and film-forming properties of waterproof coating greatly. It's determined experimentally that 20% mixing amount of BRA has better modification.
2. Bentonite as emulsifier can improve the thermal stability of the waterproof coating better.
3. Fluorocarbon emulsion and BRA can make up for the deficiency of each other, which improves the properties of waterproof coating, such as anti-permeability, film-formation, low temperature flexibility and durability obviously. It's determined experimentally that 10% mixing amount of fluorocarbon emulsion has better modification.
4. BRA is more cheap and easy to get than asphalt and the substitution amount of BRA is up to 20% in the experiment, which greatly saves the cost, in favour of mass production, popularization and application.

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