Research on Mechanical Property of High Elasticity Stress-absorbing Band

Zhisheng Liu  
*Key Laboratory of Highway Construction & Maintenance Technique in Less Region, Taiyuan, Shanxi, China*

Runcheng Li  
*Shanxi Transportation Research Institute, Taiyuan, Shanxi, China*

ABSTRACT: Authors of papers to research mechanical property of high elasticity stress-absorbing band for crack reflection of asphalt overlay on old cement pavement. Tensile ductility property of high elasticity rubber mastics and stress-absorbing band were tested and compared with crack stick on the market to analyze the mechanism of crack resistance. The result showed that high elasticity stress-absorbing band appeared elastic-stretching, strengthen stage, yield and necking stage during stretching process, which same with standard elastic materials. Setting fiberglass mesh in the middle of band was better for mechanical property of high elasticity rubber mastics. Compared with crack stick, high elasticity stress-absorbing band was better for crack resistance.

1 INSTRUCTIONS

Nowadays, asphalt pavement had become the main form of high-grade highways in our country. However, cement concrete pavement still occupied certain proportion in heavy-duty traffic area, especially. A large scale of asphalt overlay on old cement pavement had been finished organized by road management department in order to improve driving conditions, operational efficiency and service level. Reflection cracks often appear in the asphalt overlay near corresponding cracks of old cement pavement, which caused by combined action of load and temperature changes\(^1\). Water penetrates into subbase and roadbed along reflection cracks easily, which will cause erosion and soften roadbed, reduce the meaning of the cement pavement maintenance\(^2 - 4\). Therefore, crack-resistance layer between overlays and old cement pavement was necessary in order to enhance pavement service life\(^5 - 7\). Crack-reflection preventing layer has been widely applied, but there are many types of material and obvious difference on anti-cracking effect. This paper focus on mechanical property and construction feature of high elasticity stress-absorbing band developed by key lab of highway construction and maintenance technology in loess region ministry of transport in china, which will lay a foundation for application of high elasticity stress-absorbing band.

2 MATERIALS

2.1 Base asphalt

The base asphalt in paper was SK70# from construction site of “Ji-Da” highway in Shanxi China. Performance index of base asphalt were tested according to “Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering (JTGE20-2011)” as show in table 1.

<table>
<thead>
<tr>
<th>Index</th>
<th>Test value</th>
<th>Code value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needle penetration ( (0.1\text{mm,} 25\text{°C}) )</td>
<td>71</td>
<td>60-80</td>
</tr>
<tr>
<td>Softening point /(^\circ\text{C})</td>
<td>46.2</td>
<td>&gt;45</td>
</tr>
<tr>
<td>Ductility/cm ( (10\text{°C}) )</td>
<td>27.2</td>
<td>&gt;25</td>
</tr>
<tr>
<td>TFOT Residual penetration ratio( (5\text{°C}) )</td>
<td>69%</td>
<td>&gt;=61%</td>
</tr>
<tr>
<td>TFOT Residual ductility ratio( (10\text{°C}) )</td>
<td>8.4</td>
<td>&gt;=6</td>
</tr>
</tbody>
</table>

The table 1 told us that all index of base asphalt meet the code value.

2.2 Modifiers

(1) Ductility modifier

High ductility SBS-1301 was selected as ductility modifier, to overcome the shortcomings of asphalt that brittle in the winter and soft in the summer. It had been used in road construction widely. Index of SBS as show in table2.

(2) Elastic modifier

Waste rubber powder was selected as elastic modifier in order to improve the stress dispersion of...
base asphalt. Waste rubber powder had been used in playground, waterproof coiled material. The fineness of rubber powder in test was 30 meshes.

(3) Stabilizer

One of stabilizer is a kind of amorphous copolymer with low molecular weight, polymerized by propylene and ethylene.

The other one of stabilizer is a kind of polymer gel used in footwear, bags, auto parts, PP and PE materials, cohering plank and thin film. The proportion of two stabilizers was 1:1 in experiments.

<table>
<thead>
<tr>
<th>Type</th>
<th>SBS-1301</th>
<th>Ratio of S/B</th>
<th>30/70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength of elongation (300%,MPa)</td>
<td>2.34</td>
<td>tensile strength (MPa)</td>
<td>18.4</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>760</td>
<td>melt flow rate (g/10min)</td>
<td>1.8</td>
</tr>
</tbody>
</table>

2.3 Mineral filler

High quality lime powder as mineral filler to increase the high temperature stability of asphalt materials.

3 TEST METHODS

3.1 Sample shaping

Preparation technology of high elasticity stress-absorbing band was simple, but mixing time and heating temperature must be strictly controlled. Specific steps are as follows:

(1) Dehydration of asphalt lasted for an hour at the condition of 105℃.

(2) Heating asphalt to 140±5℃, adding SBS, vigorous stirring is the continued for 30~40min.

(3) Heating asphalt to 170±5℃, adding rubber powder, stirring in low-speed still blend well, not engage with asphalt.

(4) Heating asphalt to 190±5℃, adding lime powder, stirring in low-speed still blend well, and then adding stabilizer to avoid deposition of lime powder. At the moment, asphalt mixture named high elasticity rubber mastics.

(5) High elasticity rubber mastics was poured into crack of old cement pavement, and covered by fiberglass mesh in place, and poured rubber mastics twice, which formed high elasticity stress-absorbing band, as shown in Figure 1.

Table 2. Index of SBS.

<table>
<thead>
<tr>
<th>Type</th>
<th>SBS-1301</th>
<th>Ratio of S/B</th>
<th>30/70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength of elongation (300%,MPa)</td>
<td>2.34</td>
<td>tensile strength (MPa)</td>
<td>18.4</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>760</td>
<td>melt flow rate (g/10min)</td>
<td>1.8</td>
</tr>
</tbody>
</table>

2.3 Mineral filler

High quality lime powder as mineral filler to increase the high temperature stability of asphalt materials.

3 TEST METHODS

3.1 Sample shaping

Preparation technology of high elasticity stress-absorbing band was simple, but mixing time and heating temperature must be strictly controlled. Specific steps are as follows:

(1) Dehydration of asphalt lasted for an hour at the condition of 105℃.

(2) Heating asphalt to 140±5℃, adding SBS, vigorous stirring is the continued for 30~40min.

(3) Heating asphalt to 170±5℃, adding rubber powder, stirring in low-speed still blend well, not engage with asphalt.

(4) Heating asphalt to 190±5℃, adding lime powder, stirring in low-speed still blend well, and then adding stabilizer to avoid deposition of lime powder. At the moment, asphalt mixture named high elasticity rubber mastics.

(5) High elasticity rubber mastics was poured into crack of old cement pavement, and covered by fiberglass mesh in place, and poured rubber mastics twice, which formed high elasticity stress-absorbing band, as shown in Figure 1.

Table 2. Index of SBS.

<table>
<thead>
<tr>
<th>Type</th>
<th>SBS-1301</th>
<th>Ratio of S/B</th>
<th>30/70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength of elongation (300%,MPa)</td>
<td>2.34</td>
<td>tensile strength (MPa)</td>
<td>18.4</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>760</td>
<td>melt flow rate (g/10min)</td>
<td>1.8</td>
</tr>
</tbody>
</table>

During construction, traffic must be controlled still temperature of high elasticity rubber mastics falls below 60℃ to make sure completeness of high elasticity stress-absorbing band.

3.2 Tensile ductility property

Tensile ductility property were tested by universal testing-machines, specimen shape were 20×12cm², test temperature was at 25℃, test method followed “Geosynthetics and Plastic geogrids (GB/T 14800-2010)”, the stretching velocity was 20mm/min.

4 TEST RESULT

4.1 Tensile ductility property of high elasticity rubber mastics

Tensile ductility property result of high elasticity rubber mastics was showed in Figure 2. Tensile strength values increased with the stretching of specimens, but no snap or tension decreases. So strength values of high elasticity rubber mastics at elongation 500% was identified as breaking force.

![Figure 2. Relationship of elongation and breaking force.](image)

As showed in figure 2, tensile strength values appeared the trend “growth- decrease- growth-decrease” behind elongation of 120mm over and over again, which stated that high elasticity rubber mastics resisted external force constantly. All the tests collected in table 3.

Table 3. Tensile ductility of high elasticity rubber mastics.

<table>
<thead>
<tr>
<th>thickness of the specimen(mm)</th>
<th>breaking force(N)</th>
<th>breaking strength(MPa)</th>
<th>breaking work(J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>90.21</td>
<td>0.78</td>
<td>22834</td>
</tr>
<tr>
<td>5</td>
<td>75.14</td>
<td>0.64</td>
<td>19243</td>
</tr>
<tr>
<td>4</td>
<td>55.02</td>
<td>0.44</td>
<td>13678</td>
</tr>
</tbody>
</table>

From table 3, breaking force of high elasticity rubber mastics increased with thickness adding, and same phenomenon showed in breaking strength and work of breaking.
In real engineering, fiberglass mesh in high elasticity stress-absorbing band can increase tensile and crack resistance of asphalt pavement, reduce heat transfer from heat asphalt mixture to high elasticity rubber mastics, and aggrandize the bond performance between layers. So, the pull force and deformation recovery performance of high elasticity stress-absorbing band were tested at room temperature (25 °C).

4.2 Tensile ductility property high elasticity stress-absorbing band

Tensile ductility property result of high elasticity stress-absorbing band in Figure 3. The breaking force of specimen increased with deforming length, and fell sharply at elongation of 3mm. At this time, material damage occurred along fiberglass mesh and get worse. Breaking force of specimen kept at the values of high elasticity rubber mastics.

As showed in figure 3, relationship of elongation and breaking force for high elasticity stress-absorbing band appeared the same phenomenon with standard elastic materials which has elastic deformation, strengthen stage, yield and necking stage. In the result analysis, 80% of the peak value was identified as strength of stress-absorbing band.

This paper researched mechanical property of high elasticity stress-absorbing band (A, B), and crack stick (C) as comparative case for breaking force, breaking strength and work of breaking. During the elongation, polymer on surface of crack stick damaged first and separated with geotextile. Therefore, strength of crack stick mainly undertaken by internal geotextile, polymer on surface connected the structure layer. The main problem of crack stick was solve the deformation coordination of geotextile and polymer, high elasticity stress-absorbing band did not exist this problem obviously. The mechanical properties of three kinds of materials is shown in figure 4~7.
As showed in fig.4~7, two kinds of high elasticity stress-absorbing band (A, B) had different Breaking force, breaking strength and breaking work, because fiberglass mesh of A was on the surface not in the middle of band which showed in Fig1. Which predicated that put fiberglass mesh in the middle of band would contribute to mechanical property of high elasticity stress-absorbing band. Analyzes its basic reason, high elasticity rubber mastics was elastic buffer and fiberglass mesh played the role of limiting deformation of rubber mastics, rubber mastics and fiberglass mesh would be separated when they deformed large if fiberglass mesh did not in the middle of band like specimen A. In the process of forming for specimen B, rubber mastics on either side of fiberglass mesh merged together, rubber mastics can be deformation with fiberglass mesh in the process of stretching, and then mechanical property were very good.

Breaking force and breaking strength of high elasticity stress-absorbing band (B) and crack stick (C) didn't appear to be much different. Thickness of geotextile in crack stick (C) is greater than which of fiberglass mesh, if polymer separated with geotextile during the elongation, the asphalt pavement would crack although geotextile still bear the tensile stress. On the contrary, high elasticity rubber mastics bore the tensile stress even if fiberglass mesh destroyed, and have certain waterproof function.

5 CONCLUSION

High elasticity stress-absorbing band appeared the same tensile stress growth curve with standard elastic materials, which has elastic deformation, strengthen stage, yield and necking stage. Setting fiberglass mesh in the middle of band can contribute to mechanical property of high elasticity stress-absorbing band. Compared with crack stick, high elasticity rubber mastics bore the tensile stress even if fiberglass mesh destroyed, and still have certain waterproof function.

REFERENCES