Research on Application of MMA Super-solid Seal in Preventive Maintenance of Bridge Deck

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Abstract: In order to solve the problems of minor cracks, insufficient slip resistance, and lightening of the asphalt concrete bridge deck, the self-developed MMA super-solid seal is used to preventive maintenance of Yulong River Bridge and Baisha Viaduct of G65 Yangshuo to Pingle and G65 Guilin to Yangshuo expressways. The road performance of the MMA super-solid seal was evaluated. Engineering application results show MMA super-solid seal has a good preventive maintenance effect. The various road performance indicators (water permeability coefficient, bonding strength, sliding resistance, structural depth, etc.) meet the design requirements. MMA super-solid seal has a short maintenance time and excellent road performance, which is conducive to the sustainable development of road engineering. It can not only guarantee the service quality of the bridge deck, but also prolong the life of the bridge deck.

1. Introduction
With the rapid development of road construction cause in China in recent years, fruitful research results have been obtained. The construction scale of bridges which are an important part in road construction and serve as a bond linking China with the whole world, is on the progressive increase year by year, so their importance is self-evident. However, due to the ever-increasing traffic volume, load capacity and paving materials, continuously elevated construction technology level and increasingly hostile environmental factors, many bridge deck pavements experience minor diseases like cracking, aggregate loosening, color fading and pit slot before reaching the design life limit. Under this circumstance, the service quality and even service life of the bridges will be seriously impacted if the preventive maintenance of bridge deck is not timely done. Preventive maintenance of bridge deck refers to proactive protective works aiming to slow down the performance degradation of pavement layer and lengthen the service life of the bridge deck pavement, which is of favorable overall performance with minor diseases, while not affecting the structural load-carrying capacity. Preventive maintenance technologies, such as modified asphalt synchronous chip seal, fog sealing layer, ultrathin wearing course, thin overlay and sand fog seal, have been successfully applied to the preventive maintenance works of bridge decks [1-3]. Nevertheless, for highway bridges featured by large traffic volume, strong traffic continuity and high requirement for smooth traffic flow, the existing preventive maintenance technologies are stuck in various problems like too long maintenance time and poor surface wear resistance of seal coat [4,5].
Directing at the deficiencies faced by the existing preventive maintenance technologies of bridge deck, the author was occupied in the engineering practice using the self-developed MMA ultra-solid seal coat technology. As a new-type preventive pavement maintenance technology, MMA ultra-solid seal coat is characterized by fast solidification process of seal coat material and short maintenance time. The cementing material is coated on the base surface via a dedicated coating equipment, and the wear-resisting carborundum is spread, thus forming a seal coat that can improve the skid resistance of the pavement, recover its color and luster and enhance the water tightness [6].

Yulonghe Bridge and Baisha Overpass on Yangshuo-to-Pingle segment and Guilin-to-Yangshuo segment of G65 Baotou-Maoming Highway are two-way four-lane bituminous concrete highways, with the design running speed of 120 km/h. Now minor pavement diseases like cracking, aggregate loosening and color fading appear on the decks of the two bridges, and hereby the MMA ultra-solid seal coat-based preventive maintenance plan will be adopted to realize the preventive maintenance of the bridge decks in consideration of their design traverse loading, large traffic volume, strong traffic continuity, etc.

2. Raw Materials

2.1 Cementing material

The MMA ultra-solid seal coat was formed by blending component A and component B of MMA material, catalyst, filler and color paste, etc. With a certain fluidity, the cementing material could permeate into the minor cracks on the pavement. The basic technical requirements for the physical and mechanical properties of cured MMA material as well as the viscosity and content of cementing material, and aggregate content are listed in Table 1.

| Test items                  | Technical requirements | Test methods          |
|-----------------------------|------------------------|-----------------------|
| tensile strength (25℃) /MPa | ≥5                     | GB/T 1040.1-2006     |
| elongation at break (25℃) /%| ≥100                   | GB/T 1040.1-2006     |
| viscosity (25℃) / (Pa·s)   | ≤3                     | GB/T 2794-2013       |
| hardening time (25℃) /h    | ≤1.0                   | GB/T 16777-2008      |

2.2 Aggregate

The aggregate used for the MMA ultra-solid seal coat was wear-resisting carborundum with antiskid and wear-resisting functions, and its technical indexes are seen in Table 2.
Table 2. Technical requirements of the aggregate.

| Test items            | Technical requirements | Test methods          |
|-----------------------|------------------------|-----------------------|
| Partial size (mm)     | 0.18–0.25              | JTG E42-2005 T0327   |
| apparent density (g/cm³) | ≥2.50                | JTG E42-2005 T0328   |
| moisture content (%)  | ≤1.0                   | JTG E42-2005 T0332   |
| mud content (%)       | ≤0.5                   | JTG E42-2005 T0333   |

3. Construction

3.1 Preparations before the construction

The road surface temperature should be over 5°C during the construction using the MMA ultra-solid seal coat technology, in order to achieve a favorable maintenance effect. Moreover, preparatory works like repair of pavement diseases, base surface treatment, protection of ancillary facilities and protection of construction safety, and the concrete repair and treatment methods are presented as follows:

1) Repair of pavement diseases: The holes and cracks (larger than 3 mm) on the pavement and irregular joints on the original pavement, which may affect the construction quality of MMA ultra-solid seal coat, must be disposed in accordance with Technical Specifications for Maintenance of Highway Asphalt Pavement (JTG 5142-2019).

2) Base surface treatment: In order to ensure the construction quality of MMA ultra-solid seal coat, sand blasting treatment of the base surface should be carried out to clear away aging asphalt membrane, loose building stones, cement blocks, dust and sundries, etc., and the pavement should be swept with a dryer to guarantee a clean tidy and dry pavement.

![Figure 2: Sand blasting treatment of base surface](image)

3) Protection of construction safety: The construction of MMA ultra-solid seal coat is generally conducted under semi-closed status of pavement, during which the “safety first” principle should be strictly abided by. Before the construction, the safety control, traffic control, and safety protection of constructors should be done well.

4) Protection of ancillary facilities: The road markings should be protected using plastic adhesive tapes or PVC pipes to prevent the material from being sprayed on the markings. The adhesive tapes can be uncovered or PVC pipes can be removed after the maintenance is completed. For the road segment where road markings should be redrawn, the protection of original markings may be omitted.
3.2 Spray coating construction
A bi-component coating machine (Figure 4) was used to spray the cementing material for the MMA ultra-solid seal coat. In the spray coating process, the components A and B in the cementing material well blended and accurately measured were poured into the hoppers A and B of the bi-component coating machine, respectively. The pressures of lifting pumps for components A and B were kept equal, the spray coating operation was conducted by professional constructors, and the concrete construction process is shown as below:

3.3 Aggregate spreading
The aggregates should be spread immediately 2 min after the coating construction of the cementing
material for the MMA ultra-solid seal coat, and the spreading operation should be implemented by professional spreading personnel. The spreading process should be as uniform as possible to ensure good aggregate embedding effect and appearance of seal coat, and the concrete aggregate spreading process is shown in Figure 6.

![Figure 6. Aggregate spreading](image)

3.4 Floating sand sweeping and opening to traffic

After the construction was completed, the construction area was maintained for 1 h, and the road could be opened to traffic only after the material was completely solidified and the floating sands on the surface were swept and recycled. As the cementing material for the MMA ultra-solid seal coat belonged to a fast-curing reaction-type high polymer material, the material could be cured and formed rapidly (1 h maintenance at room temperature) due to the chain polymerization reaction triggered by free radicals, thus accelerating the opening to traffic. Therefore, the MMA ultra-solid seal coat is applicable to preventive maintenance projects for road segments that require rapid opening to traffic with large traffic volumes.

![Figure 7. Floating sand sweeping](image)

![Figure 8. Opening to traffic](image)
4. Detection of Pavement Performance

The pavement performance was detected for the MMA ultra-solid seal coat after the maintenance of the construction area, mainly aiming to investigate the following pavement performances: bonding strength between MMA ultra-solid seal coat and base surface, pendulum-type friction coefficient, water permeability coefficient, texture depth, etc.

4.1 Detection of strength detection

In accordance with *Test Methods for Building Waterproofing Coatings*, a drawing instrument was used to test the bonding strength of the post-maintenance pavement as shown in Figure 9, and the concrete testing results are seen in Table 3. It could be known that the bonding surface between MMA ultra-solid seal coat and drawing head was completely fractured, and all testing results were higher than 1 MPa, which was completely higher than the required value in the design, indicating the superior bonding strength between MMA ultra-solid seal coat and base surface.

![Figure 9. Field detection of bonding strength](image)

| Number | Test Value/MPa | Technical Requirement/MPa | Test Method               |
|--------|----------------|---------------------------|---------------------------|
| 1      | 4.08           | ≥1                        | GB/T 16777-2008 (A method) |
| 2      | 4.34           |                           |                           |
| 3      | 3.40           |                           |                           |

4.2 Detection of texture depth

According to *Field Test Methods of Subgrade and Pavement for Highway Engineering*, the texture depth of the post-maintenance pavement was completed using the sand spreading method, and the detection process and results are shown in Figure 10. It could be known from Table 4 that the bonding surface between MMA ultra-solid seal coat and drawing head was completely fractured, and all detection results were greater than 1 MPa, which was completely higher than the required value in the design, indicating the superior bonding strength between MMA ultra-solid seal coat and base surface.

![Figure 10. Field detection of texture depth](image)
### Table 4. Detection results of texture depth.

| Number | Test value /BPN | Technical requirement /mm | Test method       |
|--------|-----------------|---------------------------|------------------|
| 1      | 0.80            |                           |                  |
| 2      | 0.81            |                           |                  |
| 3      | 0.80            | ≥0.55                     | JTG E60-2008 T0961 |
| 4      | 0.83            |                           |                  |
| 5      | 0.81            |                           |                  |

#### 4.3 Detection of pendulum-type friction coefficient

The skid resistance is one of important indexes indicating the road traffic safety. The wear-resisting carborundum embedded on the surface of MMA ultra-solid seal coat can provide the seal coat with favorable skid resistance and further improve the traffic safety. According to the testing method specified in *Field Test Methods of Subgrade and Pavement for Highway Engineering*, the pendulum-type friction coefficient tester was used to test the skid resistance of the post-maintenance pavement, the test process is shown in Figure 11, and the concrete testing results are seen in Table 5. It could be seen from Table 5 that the pendulum-type friction coefficient of MMA ultra-solid seal coat was always greater than 50, which was completely higher than the required value and pendulum value of the original pavement, manifesting the satisfactory antiskid performance of seal coat.

![Pendulum value (39) of original pavement; Pendulum value (94) of MMA ultra-solid seal coat; Pendulum value (92) of MMA ultra-solid seal coat](image)

**Figure 11. Field detection of pendulum-type friction coefficient**

#### Table 5. Detection results of pendulum-type friction coefficient.

| Number | Test value /BPN | Technical requirement /BPN | Test method       |
|--------|-----------------|---------------------------|------------------|
| 1      | 94              |                           |                  |
| 2      | 92              |                           |                  |
| 3      | 92              | ≥50                       | JTG E60-2008 T0964 |
| 4      | 96              |                           |                  |
| 5      | 94              |                           |                  |

#### 4.4 Detection of water permeability coefficient

Besides improving the antiskid performance of the pavement, the MMA ultra-solid seal coat can solidify the discrete aggregate and improve the water tightness of the pavement. The water permeability coefficient of the post-maintenance pavement was detected via a pavement water permeability tester in accordance with *Field Test Methods of Subgrade and Pavement for Highway Engineering*, and the
detection process is shown in Figure 12. The results showed that the water permeability coefficient of the MMA ultra-solid seal coat was 0, so the pavement was not stuck in water seepage, with excellent water tightness.

Through the pavement performance test like bonding strength, texture depth, pendulum-type friction coefficient and water permeability coefficient of MMA ultra-solid seal coat, it was proved that the pavement performance of this MMA ultra-solid seal coat could meet the design requirements. Furthermore, the pavement performance would be gradually degraded with its service time, so its pavement performance indexes would be tracked and monitored during the service period of bridge deck, and the grain falling and wear phenomena on the surface of seal coat would be observed, in order to explore the service time-dependent degradation of pavement performance of the seal coat.

5. Conclusions
The MMA ultra-solid seal coat, a new-type preventive maintenance technology, has apparent advantages over the traditional seal coat technology and can realize excellent maintenance effect when applied to the preventive maintenance of bridge deck. The actual engineering application indicates that:
1) The MMA ultra-solid seal coat can greatly strengthen the traffic safety by virtue of superior skid resistance.
2) The seal coat material is featured by high curing speed, short maintenance time and fast opening to traffic.
3) The bonding strength with the base surface is higher than the value specified in the relevant code requirement currently in force, and moreover, it can effectively solidify the discrete aggregate.
4) With outstanding water tightness, this seal coat is capable of sealing the minor cracks on the pavement well and exerting a good water sealing effect.

As the pavement preventive maintenance market is continuously developing, new-type preventive maintenance technologies have emerged endlessly, among which the MMA ultra-solid seal coat can effectively solve problems (long maintenance time, slow opening to traffic and insufficient skid resistance) faced by the traditional seal coat technologies, along with apparent engineering practice
effect and extensive application prospect.

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References
[1] Ping, S.J., Guo, S., Bo Z.S., Cui, K.R. (2014) Bridge deck asphalt paving sand fog seal preventive maintenance technology of engineering practice. Journal of Highway and Transportation Research and Development, 31: 177-181.
[2] Duan, D.J., Wang, G.A. (2010) SBS modified bitumen synchronous chip seal in baoshu highway application of huang river large bridge. Journal of Highway and Transportation Research and Development, 27: 45-48.
[3] Mao, Y.R. (2014) Application of modified asphalt macadam seal coat in bridge deck maintenance. Construction, 4: 2479-2479.
[4] Zeng, D.L. (2015) Application of waterborne epoxy modified emulsified asphalt in maintenance of fog sealing layer. Highway, 60: 212-215.
[5] Deng, Y.X, Xie Q. (2019) Study on sealing performance of waterborne epoxy emulsified asphalt rushed stone. Journal of China & Foreign Highway, 39: 260-264.
[6] Li, P.L., Wang, J., Xu, J.H. (2020) Research on construction technology of MMA preventative maintenance materials. Technology of Highway and Transport, 36: 47-62.