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Effect of the stabilizer on bubble stability and homogeneity of cement emulsified asphalt mortar in slab ballastless track

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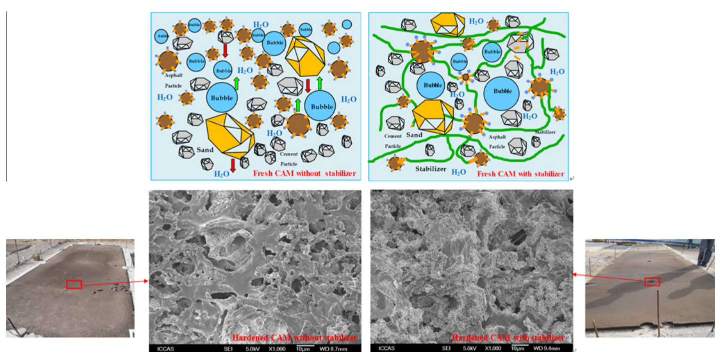
HIGHLIGHTS

- Stabilizer increases consistency of fresh CAM.
- Stabilizer improves bubble stability and homogeneity of CAM effectively.
- Stabilizer reduces the segregation of CAM obviously.
- Stabilizer increases interfacial bonding strength of hardened CAM.
- Stabilizer improves construction quality of field CAM.

GRAPHICAL ABSTRACT

Stabilizing effect model, typical interfacial surface morphology and construction quality of the cement emulsified asphalt mortar (CAM) with the stabilizer.



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ABSTRACT

Cement emulsified asphalt mortar (CAM) is a critical and complex engineering material for slab ballastless track. Since the bubble stability of fresh CAM is a crucial and potential property to determine the construction quality of hardened CAM on site, to improve the bubble stability of CAM, the effect of the stabilizer on bubble stability was studied and evaluated by the property indexes of the workability, fluidity, time-dependent loss of air content under simulating disturbance condition and segregation of CAM in lab and on site. Moreover, to research the actual engineering application effect of the stabilizer, the bonding strength and construction quality of CAM with and without the stabilizer were tested respectively by lifting the full-scale track slab above the CAM at the age of 14 days on site along with the microstructure analysis on the interfacial morphology with SEM. Results showed that the stabilizer can enhance the consistency and improve the bubble stability of fresh CAM; reduce the segregation and improve the homogeneity of hardened CAM effectively. Moreover, the stabilizer can increase the interfacial bonding strength between the hardened CAM and the concrete bottom of track slab with fewer asphalt particles or bubbles of CAM floating up to the interfacial surface; improve the construction quality of CAM on site. Good agreements for the effect of the stabilizer have also been found between the simulating experiment result in laboratory and that on site. The effect of the stabilizer on bubble stability of CAM may be due to the three-dimensional network formed by long cellulose ether and associative

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polyurethane molecular chains of the stabilizer. Related model was briefly supposed. These findings show promising field applications of the stabilizer and also provide a valuable reference for the preparation and construction quality control of CAM with high workability.

1. Introduction

The slab ballastless track is an advanced track structure with many high performance properties, such as low maintenance requirement, a long service life and the reduction of the structure height, etc. [1,2]. It has been widely used in many high speed passenger dedicated lines such as the Beijing–Tianjin intercity railway, Beijing–Shanghai high-speed railway and Hangzhou–Changsha high-speed railway and so on. The slab ballastless track typically consists of rail, fastening system, track slab, cement emulsified asphalt mortar (hereinafter referred to as CAM) layer, and concrete bottom slab [3,4]. CAM is a kind of organic-inorganic complex composite material with excellent fluidity and self-compacted ability and one of the most important engineering materials with low elastic modulus and damping capacity for slab ballastless track [5,6]. It is made by stirring the raw materials including emulsified asphalt, dry materials (mainly produced by cement, expansive agent, sand, etc.), water, superplasticizer and defoamer in a special mixing device according to the established mixing procedures [7,8]. The construction process is grouting the fresh CAM without vibrating through grouting holes of track slab into the interspace with the dimension of length in 645 cm, width in 255 cm and height in 2–4 cm between track slab and bottom slab [9,10]. CAM layer, as the filling layer between track slab and concrete bottom slab, is to fill, support, bond, bear and transfer force as well as to provide appropriate flexibility and toughness as buffer action [11]. Therefore, the properties of CAM are very important for the safety, stability and comfortable degree of the non-ballast slab track [12], the performance of CAM will directly impact the durability of track structure and the difficulty of maintenance of railway lines [13,14].

With the rapid development of Chinese high speed railway, CAM as a critical important engineering material has attracted great investigative efforts. Pioneering investigations were mainly performed on the preparation, rheological behavior, strength mechanism, process of setting and hardening and the relationship between the component and the physical properties of hardened mortar as well as the construction technology [6,15,11,16–22]. However, there was little concern and research on the property of bubble stability of fresh CAM and homogeneity of hardened CAM. Bubble stability is the ability to keep the gas content of fresh CAM stable during the unavoidable external disturbance construction process such as slow stirring, transporting, transferring and grouting on site [19]. It is a critical property to determine the construction quality of CAM filling layer. Since if the bubble stability of CAM is poor, even if the properties of workability, mechanical strength and durability of CAM can generally meet the technical requirements of the specification [23] in laboratory test free from real disturbance, however, on construction site with real disturbance, small bubbles in fresh CAM will combine with each other to form into big bubbles and then float and emerge from the internal to the surface of CAM under disturbance condition. For example, as shown in Fig. 1, the air content of fresh CAM with poor bubble stability in mixing device decreased fiercely from 8% to less than 4% just in 10 min after high speed mixing finished. If this kind of CAM was grouted into the interspace between track slab and bottom slab on construction site, after CAM hardened, a lot of small bubbles would appear on the surface of CAM and furthermore there would be a foam layer and surface peeling between the track slab and hardened CAM as shown in Figs. 2 and 3, respectively. The size of bubbles on cross section of hardened CAM were larger and the bubbles distributed unevenly as shown in Fig. 4, meanwhile, the hardened CAM matrix became more porous and generated segregation and delamination as shown in Fig. 5. Therefore, the poor bubble stability of fresh CAM would adversely influence the homogeneity, mechanical strength and durability of CAM filling layer and reduce the interfacial bonding strength between CAM and track slab and thereby affect the integrality and stability of slab ballastless track seriously [24,25]. However, until now, the bubbly stability of fresh CAM with high workability and high air content is still difficult to control effectively, especially on construction site.

Consequently, the working objective of this study was to improve the bubble stability and homogeneity of CAM, the effect

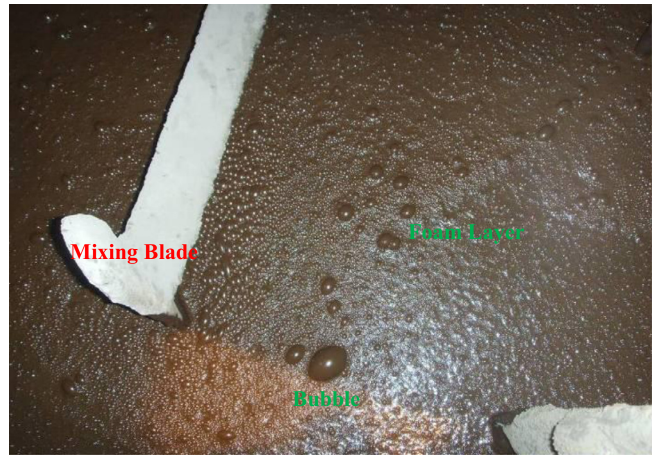

Fig. 1. Small bubbles in fresh CAM with poor bubble stability combine with each other to form into big bubbles and then emerge from the internal to the surface of CAM in mixing device resulting in the formation of bubble foam layer on the surface.

Fig. 2. After lifting the track slab above, foam layer on the surface of hardened CAM was seen. Foam layer would decrease the bonding strength between CAM filling layer and track slab seriously.