The application of warm mix asphalt technology in China: a review

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Abstract. Increasing emission of greenhouse gases is an environmental issue, and it is a great concern to curb this problem from further harm to the environment. With increasing interest in the use of warm mix asphalt (WMA) in the paving industry, more studies in this field for improvement of WMA properties seem to be necessary. WMA technology, recently developed in Europe, is gaining strong interest in the China. WMA has various benefits such as, reduction of asphalt binder temperature, reduction in energy consumption and less air pollution. It reduces short-term aging, compacting effort and decreases temperature drop during transportation. This paper reviews that the warm-mix asphalt have the potential of improving pavement performance, efficiency and environmental stewardship. Overall, warm-mix asphalt provides substantial sustainability benefits similar to or, in some cases, better than conventional hot-mix asphalt.
Keywords: WMA, pavement sustainability, asphalt additives, reduced emissions.

1 Introduction

Global concerns over the increasing damage to the environment from greenhouse gas emissions has created greater awareness, within the past two decades, for sustainable development practices in all spheres of human endeavor including the road construction industry [1]. Production of the mix at high temperatures is a source of concern as it requires high energy use, results in binder aging in the hot-mix plant and the generation of greenhouse gases. To address these concerns, the asphalt industry has developed warm-mix asphalt technologies that enable the production of asphalt mixes at temperatures that are 20˚C - 40˚C lower than conventional HMA production temperatures.

WMA technologies were pioneered in Europe [2]. Many countries are adopting WMA technologies due to their advantages in sustainability. The growing acceptance of WMA is based on

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confirmation of its economic, environmental and performance benefits relative to conventional HMA, and it is anticipated that WMA will soon become the standard practice within the industry [3-5].

The motivation for WMA development was derived from the Kyoto Protocol which emphasized a worldwide concerted effort to reduce greenhouse gas emissions into the atmosphere. More recently, though, additional impetus has come from the United Nations Climate Summit held on September 23, 2014 in New York, at which world leaders and several organizations announced strong commitments to cut greenhouse gas emissions [6]. This paper presents a review of literature on the technologies, applications and social benefits with warm mix asphalt in the asphalt pavement.

2 Review of warm mix asphalt technology

In 1995, Shell and Kolo-veidekke jointly developed a warm mix asphalt technology, and the following year conducted a field test using this technology [7-8]. In the development and use of early, Shell and Kolo-veidekke use soft asphalt and emulsified asphalt to produce warm mix asphalt, this WMA can be the same as the hot mix asphalt mixture in performance, but the cost of production is higher than the HMA by 20%. In order to reduce the cost of production and improve the performance of WMA, shell and Kolo-veidekke use foamed asphalt and soft asphalt to produce WMA in 1998. And then the WMA of field tests were conducted. And the comparison of field experiment between WMA and HMA was made. After a long period of observation, it found that the road performance of WMA is good. In 2000, the concept of WMA was put forward for the first time by Harrison and Christodulaki at the 1st International World of Asphalt Pavements Conference. In the same year, the WMA was large-scale introduced at the 2nd Eurasphalt & Eurobitume Congress [8]. Subsequently, WMA have been a large number of applications in Japan and Europe and other places. At present, the usage of WMA is increasing year by year, and WMA has become a hot research topic in the international research of asphalt pavement [9-15].

In 2002, the WMA technology was adopted by the United States. And the first warm asphalt pavement was constructed in 2004. The Warm Mix Asphalt Technical Working Group was set up to systematically evaluate and guide warm mix technology, and to promote the application and popularization of warm mix technology in 2005. In order to formulate the design of mix proportion and pavement performance test specifications for warm mix asphalt, the project of NCHRP 09-43 was conducted [16]. In order to provide a guide for the construction of warm mix asphalt mixture, NCHRP 09-47 project had been completed [17]. Warm mix asphalt material has been widely studied and applied in the United States, there are hundreds of warm mix asphalt mixture construction or pilot projects in the United States.

In China, WMA technology was started in 2005. In 2005, the Evotherm warm mix technology was used to build the first warm asphalt pavement in China. In 2006, the Evotherm warm mix technology was used to build the world's first SMA pavement with modified asphalt. In 2008, the world's first rubber warm mix asphalt pavement was built with Evotherm warm mix technology. Since 2006, the Evotherm warm mix asphalt technology has been widely spread in China, especially in Beijing and Shanghai successfully implemented nearly 20 projects. Also, Sasobit warm mix technology has been widely used, in China. At present, dozens of projects constructed with WMA technology have been the successful implementation, including Shanghai Donghai Avenue, Chongqing lijiatuo bridge, Shanghai Lupu Bridge, and Shandong Yellow River Bridge and so on.

3 Advantages of WMA

There are numerous benefits of WMA identified by several researchers. According to the development of warm mix technology[18-22], the advantage of WMA is mainly reflected in the following aspects:

- significantly lower production and placement temperatures, which can save more than 30% of the energy consumption.

- decreased the harmful gases and dust emissions from mixing plant and during placement. improved working conditions for plant/paving crew; less aging of binder during plant mixing and placement, thus improving longevity of
  pavement service life;
- extended paving season (i.e., paving during cooler weather);
- significantly improve tunnel construction, and improve construction of visibility.

4 Engineering application

Studies [23-25] have shown that WMA performs equally or possibly better than HMA and that both materials have similar versatility. WMA has been 1) used in dense-graded, stone matrix, mastic, and open-graded friction-course mixes; 2) used with polymer-modified binders; 3) placed in pavements with traffic expected to exceed 30 million 18-kip-equivalent single-axle loads and in a range of layer thicknesses; and 4) paved at bus stops, on airfields, and on port facilities [26]. In all these applications, WMA exhibited similar or better performance, including improved compaction, similar stiffness and rutting resistance, improved resistance to fatigue and thermal cracking, similar or less moisture damage and greater durability compared with HMA [26].

5 Conclusion

Warm-mix asphalt is a new asphalt technology, which saves energy and cost. WMA reduces the temperature of asphalt binder during mixing and laying stages and has the benefits of economic, environmental, performance and social. So, WMA as a sustainable pavement is good for environment with a drop of global warming and decreasing emissions of greenhouse gases in the atmosphere.

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