Asphalt Concrete Used to Combat Climate Change

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INTRODUCTION

According to the Intergovernmental Panel on Climate Change (IPCC), the earth's annual temperature has increased by approximately 1.3^{o}F over the 20th century. The National Science and Technology Center reports an average 0.58^{o}F increase in temperature per decade within the past few decades in the US. Along with the increase in temperature, many regions (particularly the eastern United States) have seen an increase in the total average annual precipitation. Warming has also contributed to glacier mass loss and ocean thermal expansion, increasing sea levels and increasing the risk of road erosion from storm surges and waves further inland. [1]

Since most roadways in the United States are designed to withstand local weather and climate, the unpredictability of weather conditions due to climate change make pavement design a bit more challenging. Projected increases in frequency and intensity of extreme weather conditions bring an increase of potential problems for roadways. High temperatures may result in softening and expansion of pavements leading to increased rutting and potholes, while heavy rains can weaken or wash out the subsoil and shorten the life expectancy of the asphalt. Increased asphalt degradation not only increases replacement cycles, but also leads to limited access, congestion, and higher costs. [2]

Despite the potential effects of extreme weather on asphalt pavements, asphalt concrete (specifically hot mix asphalt) is still the most common paving material used in the United States. Some of the many advantages contributing to asphalt concretes high popularity are its low initial and low maintenance costs, its flexibility and speed of construction, and its ability to handle heavy loads. Asphalt pavements also reduce noise and improve ride quality. [3] By altering the mix design, asphalt pavements can be designed to withstand most all weather conditions. Several mix types, including open graded friction course and stone matrix asphalt, exist to combat the effects of extreme weather on a pavement's performance and life expectancy.

ASPHALT CEMENTS USE IN EXTREME WEATHER CONDITIONS

Hot mix asphalt (HMA), the most frequently used surfacing material in the US, accounts for 96% of America's roads and can be designed to meet most any specifications and construction uses. [4] Hot mix asphalt surfaces such as stone matrix asphalt (SMA), designed using the Superpave method, and open graded friction courses (OGFG) work well in many climates. Stone Matrix Asphalt's high coarse aggregate content, high asphalt content and high filler content result in a mix with excellent stone-on-stone content that is very resistant to rutting. Open graded HMA designed with a layer having a large volume of air voids, helps improve drainage, increase skid resistance and reduce splash and spray. [4] Although SMA and OGFC pavements exhibit many advantages, there may be higher costs associated with the binder and asphalt content along with additional time and effort to produce the mix. Furthermore, open graded mixtures typically require additional de-icing applications in cold regions and SMA mixtures require extra cooling time to prevent early flushing of the binder. [5]

Porous Asphalt

Porous asphalt incorporates the use of OGFC placed over a filter course on top of a reservoir of large single sized aggregate. It is designed to reduce runoff from roads and parking lots that would otherwise drain back into creeks and rivers. Porous asphalt became increasingly accepted in the United States in 2012 after west central Oregon experienced a major winter storm which caused millions of dollars of flood damage to the area, with the exception of one community. Pringle Creek in Salem, Oregon had a storm water control scheme consisting of roads and parking lots made with porous asphalt. As a result, Pringle creek only experienced a few puddles. [6]

That summer dozens of porous asphalt projects were installed around the country. In New York, Lake George's Beach Road became the heaviest traveled road in the state to incorporate porous asphalt and solved a huge environmental problem for the lake, where storm water was the number one contributor of contaminants. Downstate, porous asphalt was used to solve flooding problems in the city borough of Queens. [6]

Along with its ability to improve drainage, porous asphalt also has the ability to reduce the urban heat island effect and also requires less salt for snow and ice removal than conventional pavements. Because of its ability to clog, a filter fabric is typically placed at the bottom to prevent fines from migrating to the top. Sand should be avoided for snow and ice removal; however, the pavement can be vacuumed, jet washed or flushed to maintain its porosity.

Asphalt Rubber

Another mix that has proven successful in a variety of climates is asphalt rubber (AR). In Arizona's climatically diverse regions, rubberized asphalt has been used for over 25 years to resurface highway and city streets. Two types of AR used by the Arizona Department of Transportation (ADOT) are Asphalt-Rubber, Asphalt Concrete Friction Course (AR-ACFC), also known as an open graded friction course, and Asphalt-Rubber, Asphalt Concrete (AR-AC) which is a gap graded mix. Both types have been used over Portland cement concrete pavements (PCCP) and asphalt concrete (AC) pavements. Over 3000 miles of asphalt rubber overlays, most commonly consisting of 80% hot paving grade asphalt and 20% ground tire rubber, have been constructed by ADOT since 1988. [7]

In 2002, a series of projects were evaluated throughout the state. Each project consisted of an AR-ACFC placed over existing PCCP constructed between 1988 and 1995. The locations varied from the desert regions of Tucson and Phoenix, where temperatures range from 20^{o}F to 120^{o}F, to the alpine region of Flagstaff, where temperatures range from -30^{o}F to 90^{o}F. After evaluation, all the pavements, differing in age from 7 to 14 years, showed considerable resistance to aging. The Flagstaff pavement, although still serving well, was nearing the end of its life. [7]

Other states such as California, Florida, and Texas have experienced success with AR pavements as well. Although asphalt rubber pavements provide the advantage of a smoother and quieter ride, they cannot be applied in very hot or cold weather. To adhere properly, the underlying pavement surface must be between 85^{o}F and 145^{o}F which becomes difficult in cooler climates, especially when night paving, where pavement temperatures often drop below 85^{o}F.

Stone Matrix Asphalt

Stone matrix asphalt was developed in Europe and has been used in the United States since 1991. The stone-on-stone contact as well as the high binder content provide its strength and increased resistance to rutting. States such as Wisconsin, Georgia, Michigan and Missouri were among the first to use the mix. By 2002, an estimated 15 million tons of SMA was placed in over 250 projects in the US. [8]

In 1992, following Europe’s SMA success, the Marlyand State Highway Administration (MDSHA) started specifying SMA on its major highways and has since constructed over 85 SMA projects on highways with traffic counts averaging more than 20,000 daily. With a total of over 1,300 lane miles of paving, the typical Maryland mix designs have high asphalt binder contents classified using the Superpave Performance Grading (PG) system. Most Maryland SMA projects have used either modified PG 70-22 or modified PG 76-22 binders. Mineral fillers and binders are typically used as well to provide adequate binder consistency and prevent binder drain-down during transport and paving. The most common nominal aggregate sizes used in Maryland SMA mixes are 12.5 mm and 19 mm. Maryland pavements, which were evaluated after ten years, showed little to no rutting nor increase in roughness, and little decrease in friction. Cumulative rut depth averaged 0.14 in. for the 12.5 mm mixes and 0.13 in. for the 19 mm mixes, and cumulative International Roughness Index (IRI) values averaged 75.7 in. per mi. for the 12.5 mm mixes and 97.1 per mi. for the 19 mm mixes. [9]

In addition to the increased rutting resistance, SMA also provides reduced tire splash and reduced tire noise. Although SMA mixes typically cost 20 to 50 percent more than conventional dense-graded asphalt mixes, (10 to 30 percent for MDSHA), the increase in pavement life (25 to 40 percent) due to reduced rutting and increased durability usually outweighs the increased cost. [9]

CONCLUSION

Despite the potential effects of extreme weather on asphalt pavements, asphalt concrete is still the most common paving material used in the United States. Some of the many factors contributing to its wide acceptance are its low initial cost, its flexibility and speed of construction and its complete recyclability.

To address the effect of increased precipitation, asphalt pavements such as porous open graded friction courses, are designed to allow drainage through the surface layer, and are able to minimize hydroplaning and reduce splash and spray. States such as Oregon and New York have used porous asphalt to mitigate flood damage and reduce environmental issues resulting from storm water contamination of lakes and rivers. Porous asphalt also has the potential to reduce the urban heat island, but because of its ability to clog, sand for snow and ice removal is not recommended.

To combat the effects of increased temperatures, stone matrix asphalt provides a durable mix with high resistance to rutting and has been used in the United States since 1991 by states such as Wisconsin, Georgia, Michigan, Missouri and Maryland. The state of Marlyand, who has specified SMA for use on its major highways since 1992, conducted a ten year evaluation, which showed little to no rutting in the pavements. Although SMA mixes typically cost more than conventional dense-graded asphalt mixes, the increased pavement life typically outweighs the cost.

Other pavement types, such as asphalt rubber, have shown success in a diverse range of climates, and have proven to reduce noise and improve ride quality. In Arizona, asphalt rubber has been used successfully in its desert and alpine regions for over 25 years. Other states such as California, Florida, and Texas have experienced success with AR pavements as well. Although asphalt rubber pavements cannot be applied in very hot or cold weather, they provide an economical highway rehabilitation solution and also help reduce the amount of scrap tires discarded in landfills.

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