The Use of Recycled and Innovative Materials in Asphalt Concrete Pavements

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Introduction

Asphalt roads were first introduced to the world in 1870, so apparently, they have been vastly improved since then. However, in our current society, due to environmental and economic concerns, merely creating new asphalt roads is just not good enough. To overcome this problem, many of today's roads that are re-paved, or even entirely new roads, are made with recycled materials in the pavement. Recycled materials can be used as aggregate or binder in the asphalt mix, and different materials are better at being one rather than another. New materials are continually being researched and developed to find the most efficient, economical product to use on our roads. In this report, different types of recycled materials are mentioned and discussed how they can be used in recycled pavements.

Reclaimed Asphalt Pavements

One of the most common materials used in these pavements is recycled asphalt. Recycled asphalt pavements (RAP) is the reclaimed and reprocessed pavement material containing asphalt and aggregate (Okafor 2010). RAP contains aggregates and aged binder. Engineers choose to use RAP in projects because of the environmental benefits, the price, and other factors such as strength. Along with the strength, RAP has a lower specific gravity and lower water absorption than other aggregates (Okafor 2010). This could be correlated to the considerable amounts of low-density

Fig. 2 - RAP being used in a hot mix

Fig. 1 - RAP Stockpile

asphalt-mortar coatings on the recycled aggregate which could reduce the overall density of the material. Plus, the material is already coated with a layer of asphalt, which prevents full water absorption by the aggregate (Okafor 2010). Recycled asphalt sells for about $18.00 per ton, but the price varies. The average compressive strength is 25 MPa.

Plastic Wastes

One of the most commonly recycled materials in our society is plastic. Plastic is all around us in everyday lives, so researchers took it upon themselves to try to incorporate plastic into our roads as a binder. They investigated the applicability of polyethylene terephthalate (PET) as strength modifiers in asphalt road construction. Polyethylene terephthalate is the most common member of its plastic "family" and can be found in clothing, linens, and most plastic bottles (Badejo et al. 2017). To start the experiment, samples of thoroughly washed, naturally dried and shredded PET wastes were collected. They then measured the original optimum binder content in the asphalt and

Fig. 3 - Plastic bottles before recycling

replaced it with the plastic wastes in 1, 3, and 5% increments (Badejo et al. 2017). The samples were subjected to Marshall Stability (MS) and Marshall Flow (MF) tests (Badejo et al. 2017). The result of testing showed that the 1% PET modified asphalt was found to be useful for pavement construction and reduces the quantity of plastic waste in our environment. The average starting price for a ton of plastic wastes is $0.12-$0.19. Plastic wastes provide asphalt with an average compressive strength of 23.8 MPa.

Used Rubber Tires

Another commonly used material in pavements is used rubber tires. These tires can come from cars, trucks, trailers, and many other venues as well. To be used in pavements, recycled rubber tires (aggregate) are mixed with asphalt binders to produce an asphalt-rubber pavement mixture (Uju 2010). Along with regular pavements, these recycled granular materials are also mixed with unbound coarse aggregate and a type of polyurethane binder to form a porous pavement system called Flexipave® (Uju 2010). This practice is so common because, according to the EPA, the United States generates about 280 million scrap tires a year. Due to the porous nature, recycled rubber tire pavement is being used to decrease the amount of runoff water and also to improve and control stormwater quality and quantity (Uju 2010).

Fig. 4 - Tires before, during, and after the recycling process

Also, due to the rubber nature of the tires, it is most commonly used in flexible pavements as opposed to rigid ones. Used rubber tires come at about $300.00 per ton and add a compressive strength of about 20.68 MPa to the asphalt.

Recycled Shingles

Along with the problem with trying to dispose of the used shingles, and with the recent spike in asphalt and cement prices, there is increasing pressure to find such acceptable recycled supplements to virgin materials. To combat this, researchers are using asphalt shingles in hot mix asphalt pavements more and more as an aggregate (McGraw et al. 2015). Studies were conducted to evaluate the influence of recycled asphalt shingles addition to the low-temperature properties of asphalt mixtures prepared with RAS (McGraw et al. 2015). The addition of recycled shingles appeared to affect properties in a more negative way, although it also increased only slightly the stiffness of the binders. Along with that, the increase of asphalt shingles in the mix caused thermal stresses inside the pavements that weakened the project as a whole. Overall, in this experiment, the researchers decided the evidence be inconclusive but recommended looking for other materials to use. Shingles start at $40.00 per ton and can rise to over $600.00 per ton depending on the economy. RAS in pavement makes the maximum compressive strength about 90 MPa.

Fig. 5 - Stockpile of asphalt shingles

Used Motor Oil

With the increased importance of conserving materials and the environment, all of these types of recycled materials are becoming ever more popular. Most famous of all is RAP. Since RAP has been exposed to years of ultraviolet degradation and environmental weathering, the material has aged and cannot be used as a direct substitute for aggregate and binder in new asphalt pavements (DeDene 2011). Used waste engine oil has potential to be one of those materials used to restore the old binder. In DeDene's report, he performed three types of tests, two asphalt binder tests, and one laboratory mixture test. In these tests, they used aged asphalt as well as new asphalt to see how used motor oil would compare to the binders regularly used on new roads. In all, they concluded that used motor oil is a feasible option for binder replacements in recycled asphalt pavements. Waste engine oil can reduce the stiffness and improve the low-temperature properties of asphalt binders blended with RAP (DeDene 2011). Waste engine oil can also soften asphalt pavements without having a detrimental effect on the moisture susceptibility (DeDenne 2011). The beauty of used motor oil is the availability and price. Most people have nowhere to put their used motor oil, so they give it to repair shops, and because of this, it can sell for as low as $0.50 per gallon. The used motor oil gives the asphalt an average compressive strength of 22 MPa.

Bio Asphalt

Perhaps the newest breakthrough in recycled and renewable pavements, bioasphalt is an asphalt alternative made from non-petroleum based renewable resources. In bioasphalt, renewable sources like sugar, rice, corn, potato starches, and other plants are converted into a type of bitumen binder for the asphalt (Min et al. 2015).

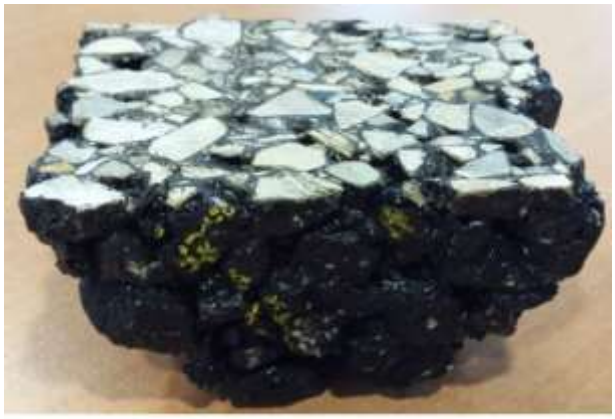

Fig. 6 - A chunk of bioasphalt

The most commonly used material for this is algae or microalgae (Min et al. 2015). The benefits of using alternative binders are that they can help save natural resources and reduce energy consumption while maintaining, and in some cases improving, pavement performance (Min et al. 2015). Overall, the compressive strength of bioasphalt could be compared to that of regular asphalt, however, there are many other benefits to using bioasphalt rather than regular like the economic and environmental impacts. However, a further modification of bioasphalt for higher temperature is required to increase its performance against rutting (Min et al. 2015). Bioasphalt is still relatively new compared to other types of recycled and renewable asphalts, so more research needs to be done before it becomes a viable source for most of the roads in America.

Summary

Overall in today's ever-changing world, one thing is certain - sustainability is vital. A significant part of our infrastructure needs an answer on how to fulfill that category, and that is what scientists and engineers are working on now. With the information and

knowledge we have today, it is not wrong to think that we could potentially have roads made out of recycled materials that last for generations in the future.

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Photos

Fig. 1 - http://www.morerap.us/resources/reports.html

Fig. 2 - http://albertaroadservices.ca/residential-services/recycled-asphalt-paving/

Fig. 3 - http://www.waste360.com/plastics/plastic-bottle-recycling-firm-wins-two-ge-awards

Fig. 4 - http://www.pallmannindustries.com/Recycling%20of%20Tires.htm

Fig. 5 - http://smartgrowth.org/event/designing-producing-high-reclaimed-asphalt-pavement-recycled-asphalt-shingles-mixtures/

Fig. 6 - https://www.wur.nl/en/article/Bioasphalt.htm