Asphalt Sustainability

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Does a green material lead to a green pavement?

A pavement engineer's perspective

I've worked in the field of pavements for 33 years. One of my non-asphalt friends says that makes me a "Roads Scholar." I know better.

Learning never stops in this business. The evolution of material specifications, improved construction practices and pavement design methods for asphalt pavements has resulted in a renewable list of topics to understand. That's a good thing, as it's a reflection of our industry's commitment to produce better-performing pavements through new technology.

An important area to understand is pavement sustainability. What does it mean for a pavement to be sustainable and what are the steps to get there?

This subject is very complex for a pavement engineer to understand, with a whole new vocabulary to learn and many layers to unpeel. Our objective through articles like this is to educate asphalt pavement stakeholders about the topic of sustainability. We will try to provide references for you to delve further into the topic if you choose.

Performance critical to true sustainability

In our last issue, Dr. Chait Bhat explained the four pillars of pavement sustainability as defined by FHWA: environment, social, economic and performance[1]. As a pavement engineer, I believe performance is critical to supporting the other three pillars. I also believe without performance, the other three pillars crumble.

Let's look at a common resurfacing activity for an asphalt pavement: mill and fill. If we can achieve longer life compared to the "standard mix" by utilizing premium materials, adding sufficient virgin binder for durability, and achieving excellent compaction, then sustainability will be enhanced. Less maintenance will be needed, and the resurfacing time will be extended, all resulting in less impact on the environment.

Conversely, choosing a mix alternative based only on its initial environmental impact – what some would call a "greener mix" – without looking at the impact on performance, can lead to unintended consequences. While incorporating waste materials in asphalt pavements sounds like an environmentally friendly practice, it can be just the opposite – if it leads to early cracking, increased maintenance activity and shorter resurfacing intervals. These all result in more material and equipment usage and more emissions over the life cycle of the pavement. The key takeaway is that we need to be more holistic in our approach to pavement sustainability.

Not only does performance bolster the environmental pillar of sustainability, but also the economic and social pillars. Life cycle cost analysis (LCCA) is the systematic approach for determining the most cost-effective alternative, and the service lives of the various treatments are key input parameters to the LCCA.

For the social pillar, reduced lane closures, work zones and traffic delays along with improved safety and a smooth ride are some of the social benefits to a well-performing durable asphalt surface.

We must realize different materials often have different performance periods.

Use of Environmental Product Declarations (EPDs)

Some state agencies are moving towards requiring cradle-to-gate EPDs for various construction materials during procurement. Cradle-to-gate EPDs report potential environmental impacts from material extraction, transportation, and production. A cradle-to-gate EPD typically uses a "declared unit" (e.g., a short ton of material) and does not define a "functional unit" (e.g., expected service life for the pavement in which the material is going to be used).

A critical detail in the International Organization for Standardization (ISO) standards 14025[2] and 21930[3] states that EPDs shall only be comparable if they have "equivalent functional units" in addition to other requirements. This is captured in National Asphalt Pavement Association (NAPA)'s Product Category Rule[4] (PCR) as follows: "When asphalt mixtures have different performance expectations, the asphalt mixtures can only be compared by using EPDs as a data input for an LCA (Life Cycle Assessment) that includes additional life cycle stages relevant to the functional unit defined in the LCA study." In simple terms, EPDs of materials with different expected services lives should not be compared.

Recycled (aged) binder

Responsible recyclability is an important advantage of asphalt pavement. However, using high percentages of aged, recycled binder (from RAP and RAS) without properly accounting for the high RBR (recycled-binder-ratio) can result in brittle mixes that are prone to cracking and raveling, resulting in a shorter service life.

Several tools are available to help with designing high RBR mixes. These include effective binder rejuvenators[5], balanced mix design with a validated cracking test[6], and increasing virgin binder content by assuming less than 100% of the RAP/RAS binder is activated for volumetric mix design. For example, Georgia DOT utilizes a 60% effective binder contribution for RAP[7].

Road ahead

When done correctly, cradle-to-gate EPDs of construction materials are an excellent building block towards quantifying the initial environmental footprint. But when comparing EPDs of material alternatives, we must realize different materials often have different performance periods. Glossing over this fact by comparing EPDs of different material options (e.g., mix A versus mix B) with likely performance differences is short-sighted and could derail us in our goal of achieving sustainable pavements.

Determining a low-carbon material should incorporate performance within the life cycle of the final product (e.g., pavements) and not be based solely on initial environmental impact.

This will require extending the rigor of the LCA post cradle-to-gate by establishing pavement-level Product Category Rules (PCRs) and cradle-to-grave EPDs. Now that's a mouthful, especially for a pavement engineer.

References:

1. https://www.fhwa.dot.gov/pavement/sustainability/ref_doc.cfm
2. ISO 14025, Environmental labels and declarations — Type III environmental declarations — Principles and procedures, 2020.
3. ISO 21930, Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services, 2017.
4. https://www.asphaltpavement.org/uploads/documents/EPD_Program/NAPA_Product_Category_Rules_%20final.pdf
5. Epps Martin, et al, Evaluating the Effects of Recycling Agents on Asphalt Mixtures with High RAS and RAP Binder Ratios, NCHRP Research Report 927, 2020.
6. https://www.asphaltpavement.org/expertise/engineering/resources/bmd-resource-guide/performance-test-resources
7. http://asphaltmagazine.com/coac-georgia