Reducing Cradle-to-Gate Embodied Carbon Content of Paving Grade Concrete – A New Guide
Questions and Answers
11/14/2023

The questions submitted during the webinar follow with answers that our speakers have provided.

1. PLC is also a type of blended cement. Why is the PLC and its implementation strategy separated from that of other blended cements?

We answered this during the call, but I will elaborate further here. It is true that PLC is a blended cement (ASTM C595) but we treated it separately as 1) it is being used to replace portland cement (ASTM C150) nationally (currently over 50% of cement sold in the US is PLC) and is therefore considered as the "base" cement, and 2) PLC is often blended with supplementary cementitious materials (SCMs) such as fly ash, natural pozzolan, or slag cement at the concrete plant.

2. How do performance-based mixes work on small projects, where the quantity of concrete is not great, and the budget does not allow for a lot of testing?

Defining a "small" project is difficult, but it is common that state DOT specifications often designate "minor concrete" for use when the project is small. Minor concrete has different requirements than concrete specified for larger project reflecting the smaller project budget, including testing. Some performance tests, such as bulk or surface resistivity, are actually easier and cheaper to conduct than conventional testing, such as compressive strength. So, it is possible to design performance specification for use with minor concrete, but it will be different than what might be implemented for larger projects. This area is still evolving so we will need to see how this develops.

3. If an agency wants to create the EPD for concrete pavement, how and what do you suggest starting?

The good news is that the agency does not "create" the EPD, but instead requires it. Conceptually this is not difficult, but the details on how to use EPDs in procurement get complicated. The Colorado DOT has been going through a multi-year implementation effort and has learned a lot in the process that they have been talking about. Hopefully we will get a good update from them at the next meeting of the National Concrete Consortium. Other states have been using FHWA Climate Challenge funding to support EPD implementation, including Minnesota and Iowa. And the ACPA is in the process of developing an EPD tool to assist their contractors in providing EPDs to states when requested. It seems that the new $2B in IRA funding that the FHWA will be making available to state DOTs through grants will support the use of materials with substantially lower embodied carbon and part of this process is the implementation of a statewide EPD program. And the cost for a concrete supplier to get into an EPD program has decreased significantly in the last few years, removing a major barrier. Bottom line is that support exists once the state agency expresses the will to move forward with EPD implementation.

4. So is the 1L type cement blended or does the manufacturer simply turn down the temp and not convert all the limestone to CaO so that we use less fuel?

ASTM C595 (AASHTO M 240) Type IL cement is most often produced by intergrinding limestone with portland cement clinker, calcium sulfate (e.g., gypsum), and other permitted grinding aids after clinker production. This is the same process that occurs for ASTM C150 (AASHTO M 80) Type I portland cement

(which allows up to 5% limestone by specification), just more limestone is added during grinding (typically 8-12%, but up to 15% allowed by specification). The kiln operations for producing portland cement clinker remain the same.

5. What software/databases are DOT's using to house EPD GHG's to be easily reported & mined later?

There is currently no national database that houses concrete EPDs generated for DOTs that separates them by usable classes such as paving concrete or structural concrete. The largest repository of concrete EPDs in the US is by the Carbon Leadership Forum accessible through their EC3 tool (https://carbonleadershipforum.org/ec3-tool/) which classifies concrete by compressive strength. The National Ready Mix Concrete Association (NRMCA) publishes concrete specific EPDs verified under their program (https://www.nrmca.org/association-resources/sustainability/environmental-product-declarations/) and publishes regional benchmark reports for different types of concrete mixtures classified by compressive strength. It is likely that this situation will change in the near future as state DOT begin the process of collecting EPDs for the purpose of benchmarking GHG emissions.

6. When and how can we obtain a copy of the guide?

The document is going through final stages of review, copy-editing, and formatting. Keep an eye on CP Tech Center's LinkedIn page and website for more information about when and how a copy will be available.

7. Is it true that carbon created from power generated will count towards the embodied carbon of fly ash? Coal is not burned to create fly ash but rather create power and fly ash is a waste byproduct, so wouldn't it make sense that this would really be a carbon negative material aside from carbon created from moving it?

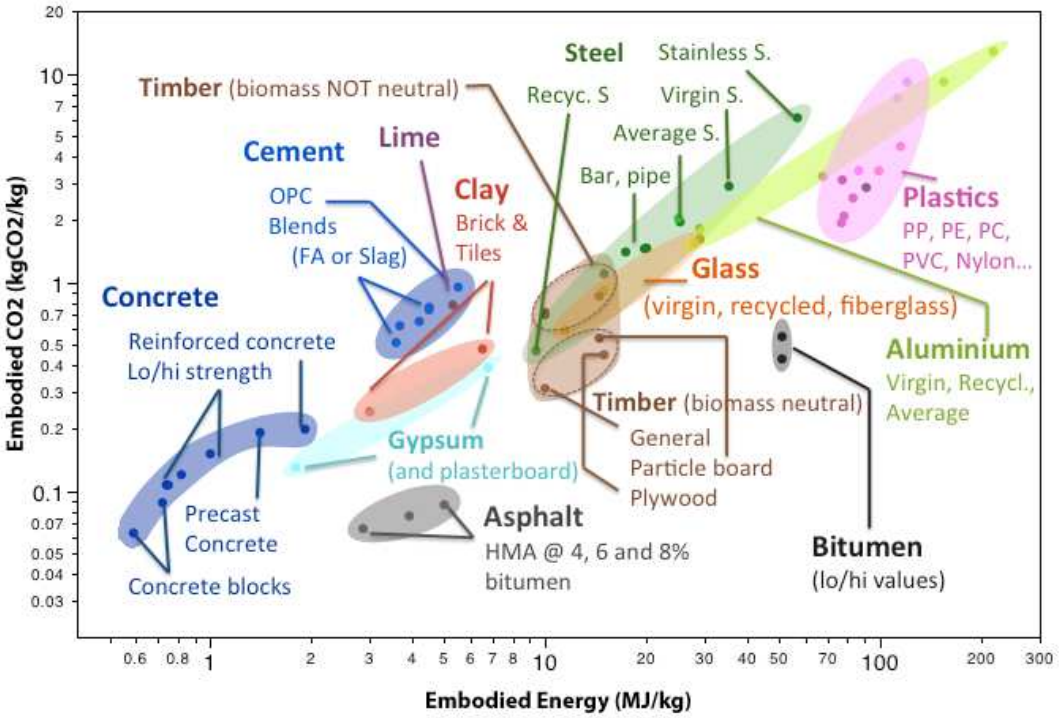
This is a question of "allocation" as outlined in the product category rules (PCRs) for concrete and fly ash. Currently, fly ash is considered a "waste" and therefore none of the GHG emissions associate with burning coal to produce electricity are attributed to the fly ash. Only the emissions incurred in process and transporting fly ash are currently assigned to it.

There are some that argue that there should be an allocation of some of the GHG emissions released due to burning coal to the fly ash as it has economic value, and is therefore not a waste, but actually a co-product. If this were to happen, the GHG emissions assigned to fly ash would increase, and those attribute to the electricity produced by burning coal would decrease. This issue is currently being sorted out by the fly ash PCR committee which is currently working on this issue. You can reach out to this committee to provide public comment when it is sought (https://acaa-usa.org/publications/product-category-rule/).

8. On a first look basis, asphalt appears to have a lower embodied carbon. In the future, will this be evaluated on a life cycle basis rather than first look? The continued rehab of asphalt would most likely make it a higher carbon pavement choice than concrete.

When looking at Stages A1-A3 (i.e., mining/extract through material production) it would appear that concrete has a higher embodied carbon than hot-mix asphalt although even that question is more complicated than it seems (see below). The PCR for concrete is different than for hot-mix asphalt and how the total GHG emissions associated with oil extraction, storage, transportation, refining, and processing to produce asphalt binder are not clearly understood, making it impossible to draw a direct comparison between the two materials. That said, the high carbon intensity of producing portland cement by current means is indisputable and something that needs to be addressed. For this reason, it

is recommended that the focus not be on which is better, asphalt or concrete, but how to improve each to reduce their carbon footprint to net zero by 2050.



From data provided by Hammond and Jones (2011), Inventory of Carbon & Energy V2

As far as the life cycle goes, efforts are underway to include use stage impacts, including pavement-vehicle interaction on fuel consumption, and emissions associated with future maintenance/rehabilitation through pavement life cycle assessment. One clear trend is vehicles get better fuel efficiency on smooth pavements and therefore regardless of whether a highly trafficked pavement is asphalt or concrete, keeping it smooth will reduce excess fuel consumption and emissions to the point of dwarfing Stage A1-A3 emissions.

All this said, it is best for us to keep our focus on the immediate and short-term goals of achieving significant carbon reduction for Stage A1-A3, whether we are constructing with concrete or asphalt, while maintaining or improving long-term performance.

9. Are the cementitious capabilities of these alternatives similar to Portland Cement?

Not sure at this point what "alternatives" are being considered, but in general we can replace portland cement clinker with limestone and supplementary cementitious materials to a point (approximately 50% total clinker replacement) and incur improved long-term strength and durability. This is not universally true, and therefore the use of performance testing is critical. Generally, the concern with replacing clinker is in the early-age strength. This effects constructability, impacting when a newly placed pavement can be used for construction traffic, when can dowel holes be drilled to support an adjacent lane, etc. The reduction in early-age strength can be overcome but must be recognized as a risk to the agency and contractor and therefor a barrier to innovation. Will need to change or expectations and specifications to accommodate this risk as we implement low carbon alternatives.

10. How does FHWA view carbon “avoidance” vs “reduction” in carbon accounting? I know ISO 14000 is something American regulators may have interest in updating/expanding to be more inclusive of various production stage techniques to cut carbon.

The scope of this guide is meant to provide a resource for those interested in working towards reduced embodied carbon emissions of concrete materials, as captured in an Environmental Product Declaration.