Semi-Annual Progress Report

TIDC Transportation Infrastructure Durability Center AT THE UNIVERSITY OF MAINE

Project Number and Title: Recycling Infrastructure Assets and Reduction of Transportation System Greenhouse Gas Emissions
Research Area: Thrust 3 New Systems for Longevity and Constructability
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Co-PI(s): *K. Wayne Lee, University of Rhode Island*
Reporting Period: *4/1/19 to 9/30/19*
Date: *10/2/19*

Overview: (Please answer each question individually)

Provide overview and summary of activities performed during previous six months….
The last six months were spent framing the study, selecting appropriate Life Cycle Analysis (LCA) software, dataset and impact assessment methods to conduct the study's LCA analyses, and deriving a survey instrument to document baseline asphalt and preferences from Departments of Transportation (DOTs). With regards to the larger study frame, study goal was stated to be the design of better performing Reclaimed Asphalt Pavement (RAP) materials (with performance to include environmental impacts). To this end, the following tasks as stated in the proposal would be completed:

- Comparison of Life Cycle Cost Analyses (LCCAs) of varied baseline asphalts, with and without RAP, obtained from the DOTs
- Performance ranking of baseline asphalts
- Interpretations of trends
- Design of mixes with enhanced performances given trends observed

Pre-stated comparisons entail use of an LCA software product. Products fall within varied categories cost-wise and with regards to their efficiencies at duplicating the average environmental impacts of asphalt pavements designed within the northeastern region of the nation. Some are designed specifically for the conduct of pavement, or asphalt pavement, LCA analyses while others are of a more general application nature. Some software may be flexible in the use of external datasets while others may be restricted to use imbedded datasets. Datasets may be transparent in their origins and review means or may not. Varied assessment methods exist as well. Thus, both software, including its assessment method(s), and dataset may be selected independently in some cases.

LCA software inventoried include: PaLATE V2.2 (PaLATE V2.2 2011), UK asphalt pavement LCA model (Huang et al. 2009), PE-2 (Mukherjee & Cass 2012), ECORCEM (Dauvergne et al. 2014), DuboCalc (Rijkswaterstaat 2015), CO2NSTRUCT (FernándezSánchez et al. 2015), VTTI/UC asphalt pavement LCA model and Athena Impact Estimator for Highways (ASMI 2012), Umberto LCA+. Datasets inventoried include: Boustead, EcoInvent, ELCD, Exiobase, GaBi, GEMIS, U.S. LCI, World Food, CPM LCA Database, European Life Cycle Database. Finally, assessment methods documented include: CML, 2001, Eco-indicator 99, Ecological Scarcity, EDIP 2003, ILCD 2011, ReCiPe 8, TRACI 2.0, EPA, USEtox. As earlier explained, although some software may originate from other regions, they may or may not afford the use of datasets purely applicable to the US or its NE region.

Pre-software comparison effort entailed reviewing those efforts already undertaken within the literature. Santos J. et al., 2017, proved that great variabilities in assessed environmental impacts exist dependent upon the choice of LCA software used. The study concludes for the need of formal consensus framework for pavements, local databases of materials and processes, accurate and comprehensiveness level of datasets tailored to impact category and impact assessment method; and sensitivity analyses to ascertain study credibility. Dovetail Partners Inc., 2017, compared three (3) databases from public sources, US Life Cycle Inventory Database, Critical Path Method (CPM) LCA Database, and the European Life Cycle Database, along with three (3) private LCA tools, ecoinvent 3.0, GaBi, and SimaPro. The study makes explicit a sound basis on which to compare datasets and LCAs for study purposes, albeit not necessarily for pavement structures. Its comparison criteria included credibility of information, ease of searching for data, understandability of datasets, and available breadth of processes by which to compare tools. The study further details the particular means of gauging each criterion. Since ISO 14040, 2006, provides a comprehensive standard for LCA conduct, Dovetail Partners Inc., 2017, also weighed heavily the compatibility with the ISO standard as comparison criterion as well.

AzariJafari, H et al., 2016, outlines the research challenges and opportunities for pavement LCA studies by mainly pinpointing areas of neglect by contemporaneous studies. These areas can serve to reinforce the assessment criterion on breath of processes as modeled by individual software tools. They comprise (not an extensive list) inventory analysis such as surface roughness, noise, lighting, albedo, carbonation, and earthwork in addition to locally applicable data collection, consequential and temporal consideration of pavement life cycle, and sensitivity analysis.

The reliability and the validity of actual LCA tools utilized in carrying the study will determine the study's ability to meet project goals. A comparison framework for this study will weigh heavily on the criteria stipulated by Dovetail Partners Inc., 2017, as reinforced by the concerns of AzariJafari, H et al., 2016. Overall preference scores for software and datasets, not to forget assessment methods, which may favor one particular criterion over another may be computed to afford a ranking of candidate LCA study tools. To derive such scores, criterion weights may have to be pondered. To assess the criteria, the study will levy demos and Youtube videos as well as full LCA tools when available. For software within the private domain, software assessment cannot entail pre-purchase. Hence, only demos would be utilized to gauge software performance per the criteria stated. For university owned software, assessment entails the use of the full software product. And similarly, full software assessment applies to the software LCA tools within the public domain. This assessment approach will favor university-owned and public domain software. No weights are thus anticipated in the software preference criteria to convey the unattractiveness of tool purchases.

With regards to data collection of baseline asphalt mix, a list of DOT contacts in the asphalt pavements/materials division is being established. A student will obtain mix information from the contacts. If needs be, a survey instrument will be designed to collect this quantitative data along with other qualitative ones, tentatively the costs to apply to varied environmental impacts for instance, once LCA tools are selected.

Provide context as to how these activities are helping achieve the overarching goal of the project…
The project seeks to assess a preferable RAP asphalt mix design that minimizes the total construction and environmental cost of pavements. Given the need to differentiate the environmental cost impacts of varied asphalt pavements with varied mix designs, construction techniques, use, maintenance schedules, etc., the software of choice would need to be sensitive to the differences in design, construction, use maintenance and schedule parameters to reflect measured differences in environmental impacts or impact costs. Further a cradle-to-cradle study approach is sought, given the intended use of RAP Asphalt. Finally, to reach realistic LCA results, the environmental and cost factors utilized within the impact assessment processes would need to be regionally relevant. Realism here relates to the total construction and environmental cost ranking of mixes. And not necessarily to their absolute values. Hence, the selection of appropriate software to conduct analyses bears heavily on the validity of results.

Describe any accomplishments achieved under the project goals…
A review of relevant literature describing varied asphalt LCA software packages, and comparing the same or just regular LCA software was conducted. Software demo videos were also probed, and where possible the full software product was deployed. From this literature review derived a framework to select preferable software. And from this framework has emanated a potential candidate although more work needs be done to reach a final selection.

Describe any opportunities for training/professional development that have been provided…
An undergraduate student conducted a significant portion of the review. Two others are conducting independent study work associated with the study themes.

Describe any activities involving the dissemination of research results (be sure to include outputs, outcomes, and the ways in which the outcomes/outputs have had an impact during the reporting period)…
The study is in its first year and as such has mostly involved so far the preliminary work necessary to actually deploy its methodology. Hence, result dissemination would be premature.

Participants and Collaborators:

List all individuals who have worked on the project.
Natacha Thomas, Associate Professor, Civil and Environmental Engineering
K. Wayne Lee, Professor, Civil and Environmental Engineering

List all students who have participated in the project. (Include name, email address, class standing, major, and role in the research)
Stephan Zaets, Senior, Civil and Environmental Engineering, main study researcher involved in all study aspects (unfortunately lost to DOT Co-Op recruiting beyond the summer.)
Tam Tram, Senior, Civil and Enviromental Engineering, LCA Software Comparisons (Independent Study Worker).

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Appolonia, Appy, Senior, Civil and Environmental Engineering,
Collection of baseline asphalt mixes by DOTs
(Independent Study Worker).
Sharai, Ali, Ph.D. Student, Civil and Environmental Engineering, main study researcher involved in all study aspects
(replacement of Stephan Zaets)

What organizations have been involved as partners on this project? What was their role?

Name of Technical Champion: Dr. Wilfred Hernandez, P.E.
Title: Safety Specialist/EDC Coordinator
Organization: FHWA – RI Division
Phone number: 401-528-4033
Email: Wilfred.hernandez@dot.gov

Mr. Hernandez helped mostly with deploying overall outreach towards the community of pavement researchers and practitioners within the broader region.

Have other collaborators or contacts been involved? If so, who and how?
None

Changes:

Discuss any actual or anticipated problems or delays and actions or plans to resolve them…
Our main student researcher accepted a Co-Op opportunity with RIDOT for the whole academic year. New student worker has been recruited, but it will take some time for this student to familiarize himself with the study. In the meanwhile, faculty is filling the void left by the student departure.

Discuss any changes in approach and the reasons for the change…
None anticipated

Planned Activities:

Description of future activities over the coming months.
Final software and dataset will be selected and dry/screening runs will be conducted to ensure proper selections.

References

Athena Sustainable Materials Institute (ASMI). 2012. Impact estimator for highways: user guide.
AzariJafari H. et al., "Life cycle assessment of pavements: reviewing research challenges and opportunities," Journal of Cleaner Production, No 112 (2016), pp 2187-2197.
Blankendaal, T., Schuur, P. & Voordijk, H. 2014. Reducing the environmental impact of concrete and asphalt: a scenario approach. Journal of Cleaner Production 66(1): 27-36.
Dauvergne, M., Jullien, A., Boussafir, Y., Tamagny, P. & Proust, C. 2014. Logiciel ECORCE-M, version multilangues.
Fernández-Sánchez, G., Berzosa, A., Barandica, J. M., Cornejo, E. & Serrano, J. 2015. Opportunities for GHG emissions reduction in road projects: a comparative evaluation of emissions scenarios using CO2NSTRUCT. Journal of Cleaner Production 104: 156-167.
Guinée, J. (ed.) 2002. Handbook on life cycle assessment: operational guide to the ISO standards. Series: eco-efficiency in industry and science. Dordrecht: Kluwer Academic Publishers. PaLATE v2.2 for Greenroads 2011. Software and user guide modified by Civil & Environmental Engineering Department, University of Washington (UW).
Huang, Y., Bird, R. & Heidrich, O. 2009. Development of a life cycle assessment tool for construction and maintenance of asphalt pavements. Journal of Cleaner Production 7: 283-296.
PE International. 2012. Gabi Manual. PRé Consultants. 2016.
SimaPro Tutorial. Rijkswaterstaat, 2015.
DuboCalc version 4.01.1.
Santos J.et al., Transportation Research Record Journal of the Transportation Research Board 2646(1):28-38 · January 2017.
Dovetail Partners Inc., 2017, A Review of Life Cycle Assessment Tools (http://www.dovetailinc.org/report_pdfs/2005/dovetaillca0105.pdf).
Santos, J., Ferreira, A. & Flintsch, G. 2015a. A life cycle assessment model for pavement management: methodology and computational framework. International Journal of Pavement Engineering 16(3): 268-286.
Takano, A., Winter, S., Hughes, M. & Linkosalmi, L. 2014. Comparison of life cycle assessment databases: a case study on building assessment. Building and Environment 79: 20-30.
Umberto LCA+ User Guide, https://www.ifu.com/en/