MPC-376

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Project Title:
Title: Improved Understanding of Pavements Impacts and Cost-Effective Designs Based on Mechanistic-Empirical Methods.

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Research Needs:
The specialized trucks used in the oil industry today are vastly different from the traditional ones used to transport grain and other commodities produced in rural regions. The continuous operation of heavy trucks poses great challenges to the state of good repair, especially in areas of suboptimal soils and freeze-thaw cycles. Roads designed to last for 20 years under traditional

truck traffic are lasting five years under intense oil-related movements (NDDOT, 2006). Oilfield pavement analyses conducted thus far have utilized adjustments to traditional design procedures (e.g., AASHTO 1993) based on equivalent single axle load (ESAL) factors originally derived from road test. Several studies have been claimed that traffic is a controversial parameter in the 1993 AASHTO Guide. The fact that the guide relies on a single value (e.g. ESAL) to represent the overall traffic spectrum is questionable (C.W. Schwartz and R. L.Carvalho, 2007). Zhang et al. (2000) have found that ESAL, used to quantify damage equivalency in terms of serviceability or even deflections in the 1993 AASHTO Guide, is not enough to represent the complex failure modes of flexible pavements. Today it is widely accepted that load equivalency factor is not a sufficient technique for incorporating mixed traffic into design equations. In addition, the trucks used during the AASHTO road tests are modest in comparison to the trucks utilized in the oil industry today.

To address some of the limitation of its original design guide, AASHTO developed a new Mechanistic Empirical Pavement Design Guide (MEPDG). It combines mechanistic and empirical methodologies by making use of calculations of pavement responses such as stress, strain, and deformation using site specific inputs from climate, material and traffic properties. Moreover, it allows incorporating traffic changes into the MEPDG procedure by adjusting and validating the calibration coefficients to consider the potential traffic change.

Research Objectives:
With the new guide, various implementation challenges must be overcome by agencies wanting to use it. The primary objective of this project is to facilitate the implementation of the newly developed MEPDG so that roads serving the energy industry can be designed to carry the very heavy and unique traffic associated with drilling activities. In addition, regional strategies for mitigating the impact of drilling activities on local roads will be investigated. Initiating a regional effort of this type will ensure more effective allocation of limited resources to impacted local governments. In addition, ensuring the adequacy of local roads will provide oil and gas industries with the means to get equipment to drilling sites and deliver their products efficiently to markets year round.

Research Methods:
The following major tasks have been included in the scope of the study:

Task1: Literature Review: A national and state literature review pertaining to MEPDG implementation and local validation will be performed with the objective of identifying analysis techniques, data requirements and MEPDG positive and negative aspects. The review will cover journal articles and DOT agencies' reports.

Task2: Data Collection: the primary inputs required to run MEPDG include (NCHRP 1-37A, 2004):

- General site information, such as design life, construction factors, and design reliability
- Analysis parameters, such as pavement conditions, pavement key distresses and smoothness
- Pavement structure, such as pavement foundation/subgrade, layer thickness, and paving materials

- Environmental factors such as temperature and moisture
- Traffic characterizations, baseline volume, vehicle distribution, axle load spectra

Default values from the MEPDG software are used for general site information and analysis parameters inputs. The pavement structure and material properties data will be obtained from local Department of Transportation (DOT).

Environmental factors are generated by MEPDG through the Enhanced Integrated Climatic Model (EICM). The following data are required:

- Hourly air temperature
- Hourly precipitation
- Hourly wind speed
- Hourly percentage sunshine
- Hourly relative humidity
- Elevation and water table

The above mentioned data can be obtained from weather stations close to the project location from United States from the National Climatic Data Center (NCDC). NCDC database contains over 800 weather stations containing at least 24 months of historical hourly data across the United States.

MEPDG (2004) recommended level 1 traffic input data for high volume roads. It requires the vehicle count by class and by direction and lane. Axle load spectra distributions are needed for each vehicle class from axle weight data. Traffic volumes by vehicle class are forecast with certain growth rate for the design analysis period. The load spectra for each class are used to estimate axle load. Tire contact pressures, tire spacing, and axle spacing can be default or user defined. The detailed traffic inputs are generated from the Weigh-In-Motion (WIM) stations located close by the selected site/sites under study. Truck configurations are obtained from local DOT.

Step3: Analysis and Evaluation: In this task, Implement MEPDG with collected local input data is performed. Local validation is performed. The performance results will be compared between with MEPDG and 1993 AASHTO.

The MEPDG is an iterative processed guide. The structure or material selection is adjusted until a satisfactory design is achieved. It basically requires the following steps:

- Definition of a trial design for specific input characteristics, such as traffic, environmental, site condition
- Definition of design criteria for acceptable pavement performance at the end of the design period
- Define reliability level for each one of the distresses considered in the design
- Calculation of monthly traffic loading and seasonal climate conditions
- Modification of material properties in response to environmental conditions
- Computation of structural responses (stress, strain, and defection) for each axle type and load and for each time step throughout the design period
- Calculation of predicted distress (rutting, fatigue cracking) at the end of each time step throughout the design period using the calibrated empirical performance models

- Evaluation of the predicted performance of the trial design against the specified reliability level. If the trial design does not meet the performance criteria, the material design must be modified and another trial calculation repeated until the design criteria are met.

The MEPDG design flow chart is shown in Figure 1

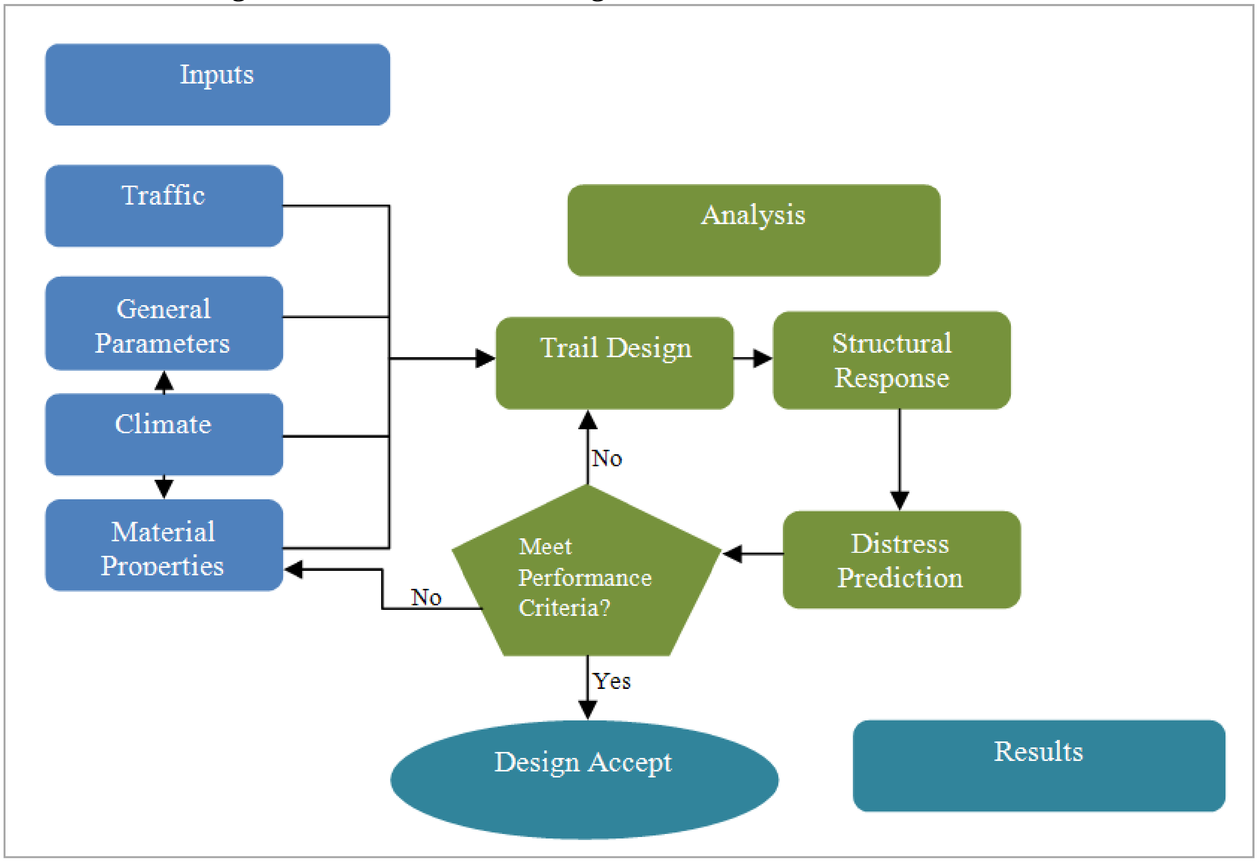

Figure 1. MEPDG Pavement Design Flow Chart

Step4: Preliminary Evaluation of MEPDG: Indirect comparison between 1993 AASHTO guide and MEPDG is performed. The 1993 AASHTO guide predicts single pavement condition, Pavement Service Index (PSI). The MEPDG predict directly the structural distresses and PSI in no longer employed. The difference of the two design approaches makes the direct comparison of results incompatible. However, the comparison between 1993 AASHTO and the MEPDG is an important to understand the differences between the two design approaches and to justify the value to implement the new pavement design process. The comparison is essential of an implementation process. The indirect comparison is performed in this study. Pavements are designed using the 1993 AASHTO guide and performance of the pavement sections are evaluated using MEPDG. The MEPDG predicts should be consistent regardless project location and traffic levels, if 1993 guide is as good as MEPDG guide assuming MEPDG predictions are correct values.

Step5: Final Report: A final report will summarize all the tasks and findings including: 1) Summary of input prioritization 2) Identification of sources to obtain necessary inputs 3) Summary of sensitivity analysis 4) Recommendations

Expected Outcomes:
In North Dakota, South Dakota, Montana, and Wyoming, state agencies all face the fact that specific truck used in oil industry increase dramatically. Oil field pavement analysis and pavement design incorporate better understanding with oil truck configurations is needed.

The project will explore the use of 1993 AASHTO pavement design guide and MEPDG. The Project will evaluate and compare the 1993 AASHTO and MEPDG pavement design and pavement performance. Moreover, the project will review how different pavement design guides incorporate oil trucking information and how different the pavement will perform under different design guide.

The project will directly provide a roadmap for implement MEPDG and local validation. It is no doubt that the research project findings and contributions will advance the implementation of the MEPDG and promote the application of MEPDG among state DOT agencies.

Relevance to Strategic Goals:
The research project and its potential outcomes directly related to State of Good Repair and Livable Communities. The project directly focuses on evaluating and implementing a sophisticated pavement design guide to provide a better lasting pavement and better prediction of pavement performance which in turn will provide livable communities and assist a better state of good repair decisions.

Educational Benefits:
Students who are interested in learning pavement design, pavement performance, and pavement preservation decision makings can be involved in the project in different levels by studding difference between 1996 AASHTO design guide and MEPDG.

Work Plan:

All the project tasks will be completed from April 1, 2012 to March 31, 2013. The last one and half months of the project will be dedicated to reviewing and finalizing the final report. A detailed project schedule is provided in the table below.

Table 1: Proposed Project Schedule

Task	Description	Months from work authorization											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Literature Review												
	a. Identify key sources												
	b. Review and analyze sources												
	c. Prepare memorandum for this task												
2	Data Collection												
	a. Familiar with MEPDG software												
	b. Identify the priorities of the inputs												
	c. Identify the resources of the data and achieve the data												
3	Analysis and Evaluation												

	a. Select a trial design and run the models												
	b. Verify the design against the performance criteria												
	c. Modify the design until performance criteria and reliability are met												
	d. Verify the design												
4	Preliminary Evaluation												
	a. Design test sections using 1993 AASHTO guide												
	b. Forecast the test sections' performance using MEPDG												
	c. Compare the results												
5	Final Report												
	a. Draft final report												
	b. Prepare and finalize the final report												

Project Cost:
Total Project Costs: $300,000
MPC Funds Requested: $150,000
Matching Funds: $150,000 Source of Matching Funds: General Funds, NDDOT

TRB Keywords: Asphalt Pavement; Highway Design; Pavement; Pavement Design; Industrial Trucks

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