MPC-562
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Project Title:
Evaluation of Durability and Structural Performance of Concrete with Embedded Inductive Coils

University:
Utah State University

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Research Needs:
A major impediment to public acceptance of electric vehicles is their very limited travel range. An exciting potential solution to this problem is In-Motion Electric Wireless Power Transfer. This proposal addresses initial investigations of the problem from the perspective of the actual civil infrastructure.

In order for the future adoption of this technology, roadways will need to be modified to allow the transmission of power to vehicles as they travel. Successful adoption of In-Motion Wireless Power Transfer will require advances in the efficiency of the overall electrical system, improvements in tracking of the actual vehicles, and significant developments in the civil infrastructure.

This proposal will address the durability and constructability of coils in Portland cement concrete. The stringent electrical specifications will be monitored while repeated cycles of simulated truck tire loadings are inflicted on constructed specimens.

Research Objectives:
1. To develop several possible in-pavement wireless power transmission options along with laboratory and test track validation of each alternative.
2. To determine appropriate concrete mixes and coil configurations that are feasible options for test track beta testing.
3. To define a cost effective construction process that could lead to the installation of coils in a field application.

These outcomes will be achieved through the use of conceptual designs, numerical analyses, testing of laboratory specimens, and field trials at the USU SELECT EV test track.

Research Methods:
This project fits within a larger initiative of developing and demonstrating In-Motion Wireless Power Transfer. From the Civil Infrastructure perspective the process can be divided into 3 parts.

1. Conceptual Design of several alternative in-pavement inductive coils. Within this effort includes structural modeling, thermal modeling, and electrical efficiency modeling regarding the strength, shape, and applicability of the magnetic field.
2. Construction and testing of several specimens under laboratory conditions. This testing will occur at the Systems, Materials, and Structural Health (SMASH) laboratory located at Utah State University. Several servo-hydraulic cylinders are programmable to execute up to one million cycles on each specimen. It is anticipated to subject the specimen to less than one hundred thousand cycles.
3. Installation of prototype coils in the EV Select Test track for investigations of power transfer efficiency. This cross disciplinary task is also necessary for tracking, and electrical purposes.
4. Future (not included in this project) installation in actual pavement on a test section of pavement.

Expected Outcomes:
The expected outcome of this research is a report detailing the results of the modeling, testing, and trials. Additionally, functioning embedded coil prototypes will be available for long term testing on the EV Test Track located at Utah State University. Following this work, will be further development into solving additional problems such as transferring power at highway speeds and working to improve efficiency in the power transfer process.

Relevance to Strategic Goals:

- State of Good Repair
- Environmental Sustainability

The aspect of this research that is so universal is that it crosses over many of the strategic goals of the USDOT. This work addresses the durability and applicability of an electrified roadway (State of Good Repair), while also addressing the goals of sustainability for the future infrastructure. The concept of an energized roadway that allows for the traveling public to be powered while driving quietly and without carbon emissions (Environmental Sustainability, Livable Communities) truly addresses multiple goals of USDOT.

Educational Benefits:
This proposed project will involve a graduate student who will utilize the research opportunity as a master's thesis, or possibly a major part of a PhD thesis. In addition, at least one undergraduate student will also work at the SMASH lab to assist in the experimental testing.

In addition to these students, all work related to electric vehicles and wireless power transfer will involve the EV (Electric Vehicle) Club located at Utah State University.

Tech Transfer:
The results of this study will be published in a report, a technical journal, a conference paper, and will also be presented in one of the SELECT Center's monthly brownbag webinars. In addition, all research done in this area will be presented as a poster in the annual SELECT Workshop which occurs in the fall of each year.

Work Plan:

1. Literature Review
2. Conceptual design of several alternatives for in pavement power units
3. Construction and testing of several prototypes under laboratory conditions
4. Installation of prototype coils in the EV Select Test track for investigations of power transfer efficiency and structural integrity
5. Write a report documenting all findings

The results of this research will have a relatively long path to full adoption. However, the problems addressed in this work must be solved prior to wide adoption of the concept of electrified roadways and in-motion wireless power transfer.

The results of this particular phase of this project will answer some of the initial questions regarding feasibility of placing these units in pavement for use in long term installations. This work will also address the durability of different detailing practices so that the best practices can advance.

In order to achieve the objectives outlined earlier in this proposal, the following work plan will be implemented including the explicitly described tasks.

Task 1 (2 months)
Literature Review. Several groups are working on this problem worldwide. Many important lessons have been learned, that will help us to progress to viable designs in the most efficient way possible.

Task 2 (3 months)
Conceptual Design of several alternatives for in pavement power units. This task includes a significant effort in: 1. structural modeling and investigation of various materials, 2. thermo modeling and investigation of the thermo effects of each design, 3. Electrical efficiency modeling, and 4. evaluation of details for in-pavement durability.

Task 3 (6 months)
Construction and testing of several prototypes under laboratory conditions. This testing will include strength testing as well as durability testing including fatigue testing.

Task 4 (4 months)
Installation of prototype coils in the EV Select Test track for investigations of power transfer efficiency and structural integrity.

Task 5 (3 months)

Write a report documenting all findings which will aid in future work on this topic.

Project Cost:

Total Project Costs:	$119,467.48
MPC Funds Requested:	$59,733.74
Matching Funds:	$59,733.74
Source of Matching Funds:	Select Center and CEE department funds