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“Technical Research and Development for Road Policy Quality Improvement” Study Summary

No.	Title	Principal Researcher
No. 2020-6	Development of a System for the Practical Application of Dynamic Wireless Power Transfer Roadway for EVs	Takefumi SHINDO, Honorary Researcher, Taisei Corporation

In this contract study, we improved power supply efficiency by examining existing systems, designed the concept of the entire system, including the consideration of a vehicle-to-infrastructure communication system that automatically controls power transfer, and designed a pavement structure that meets the durability required for expressways, etc. to realize a highly efficient and versatile wireless power transfer roadway system based on the electric field coupling method that is applicable to expressways where heavy vehicles travel. Then, we verified the validity of the design by constructing a test wireless power transfer roadway for experimental 10 kW class wireless power transfer to a moving vehicle and pavement structure investigation, etc. We also organized basic specifications, including safety measures against the electromagnetic field radiated by the wireless power transfer system, collated insights from this study, and created (draft) guidelines for the pavement design, construction and maintenance methods toward social implementation.

1. Backgrounds and Objects

In a previous study on the wireless power transfer roadway system using the electric field coupling method, we constructed a 10 m straight track outdoors to experimentally transfer power of 3 kW to a small vehicle moving at 10 km/h or less wirelessly in the MIC Strategic Information and Communications R&D Promotion Programme (SCOPE). However, the issue of decreased transmission efficiency arises if water accumulates in the pavement body.

In this study, we worked on developing a wireless power transfer roadway that can continuously transfer power of 10 kW for moving vehicles with a transmission efficiency of 70% by enhancing waterproofing and drainage. We also considered pavement materials and structure, targeting fatigue durability for traffic level N7, at which the pavement fails due to fatigue after a wheel load of 5 tons is applied 35 million times over 10 years, to apply the roadway to expressways where heavy vehicles travel. Then, we considered pavement materials and structure, and experimentally constructed a 20 m wireless power transfer roadway.

2. Activities in Research Period

Fig. 1 shows a full picture of this study. Working on the following four issues, we organized basic specifications including safety measures against the electromagnetic field radiated by the wireless power transfer system and created guidelines for the pavement materials and structure design, construction and maintenance methods toward the implementation of the system in society.

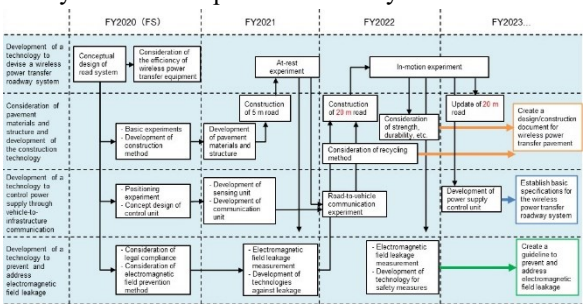

Fig. 1 Overall picture of the study

(1) Consideration toward the development of a technology to devise a wireless power transfer roadway system

We built a wireless power transfer roadway system that can transfer power of 10 kW and mounted a power receiving unit on a trailer attached to a (non-electric) vehicle, and experimented with in-motion wireless power transfer.

(2) Consideration of pavement materials and structure and development of the construction technology

We designed a pavement structure targeting traffic level N7, at which the pavement fails due to fatigue after a wheel load of 5 tons is applied 35 million times over 10 years, and experimentally constructed a 20 m wireless power transfer roadway. We also verified its fatigue durability, maintainability, and recyclability and created (draft) guidelines for the structural design, pavement materials and structure design, construction, and maintenance methods.

(3) Consideration toward the development of a technology to control power supply through vehicle-to-infrastructure communication

We developed a system for vehicles to detect information from roads and turn the power transfer system on and off. We also mounted a prototype in the wireless power transfer roadway system to consider its applicability to in-motion wireless power transfer.

(4) Consideration toward the development of a technology to prevent and address electromagnetic field leakage

We measured electromagnetic field leakage during the wireless power transfer experiment to evaluate whether the Radio Act can be complied with in terms of effects on drivers and pedestrians, interference with other wireless systems, etc. We also collated basic specifications, including safety measures.

3. Study Results

This study revealed the following insights:

(1) We confirmed that power can be transferred continuously and wirelessly to vehicles moving at 20 km/h with maximum and average transmission efficiencies of 62.7% and 58.1%, respectively, and collated the issues.

(2) We developed a pavement structure applicable to expressways where heavy vehicles travel and constructed a 20 m wireless power transfer roadway. We established and documented a standard construction procedure through each task concerning this roadway. We also verified its strength and durability and confirmed that the bearing power of the pavement body and road surface properties do not deteriorate after a wheel load of 5 tons is applied 33,494 times. We also compared a design method based on the multilayer elasticity theory with 3D FEM to consider the design method as the structural design method for wireless power transfer roadways and collated issues toward its practical application.

(3) We developed a program for an in-vehicle sensor to detect magnets embedded on road to automatically turn wireless power transfer equipment on and off and verified its functions during the dynamic wireless power transfer experiment at 20 km/h.

Fig. 2 Construction of transmission electrodes

Fig. 3 Dynamic wireless power transfer experiment

(4) We considered measures against electromagnetic field leakage and confirmed that the electric and magnetic field strength on the trailer did not surpass the guidelines value for human body safety (controlled environment). We also measured the road surface and radiated emissions to confirm that the Radio Act can be complied with.

4. Papers for Presentation

1) Sonshu Sakihara, Tetsuo Endo, Takefumi Shindo, Masakazu Jomoto, Minoru Mizutani and Takashi Ohira, "A Demonstration of Wireless Power Transfer Roadway System based on Electric Field Coupling," The 6th International Electric Vehicle Technology Conference, no.20231059, Yokohama, May 2023.

2) Minoru Mizutani, Shoi Yokono, Takashi Ohira, Takefumi Shindo, Tetsuo Endo, Sonshu Sakihara, Masakazu Jomoto, Kenji Karaki and Takeshi Watanabe, "System for the Practical Use of the Wireless Power Transfer Roadway Using the Electric Field Method I: Application of the Electric Field Method to the Wireless Power Transfer Roadway," The 34th Japan Road Conference, Tokyo, Nov. 2021.

3) Tetsuo Endo, Sonshu Sakihara, Takefumi Shindo, Minoru Mizutani, Takashi Ohira, Masakazu Jomoto, Kenji Karaki and Takeshi Watanabe, "System for the Practical Use of the Wireless Power Transfer Roadway Using the Electric Field Method II: Wireless Power Transfer Roadway System Using the Electric Field Coupling Method," The 34th Japan Road Conference, Tokyo, Nov. 2021.

6 presentations/symposia, 3 patent applications, 1 news release (covered by 3 newspapers), 3 magazines

5. Study Development and Future Issues

- We must improve the transmission efficiency of the wireless power transfer roadway experimentally constructed in this study, which is about 60% on average, toward its commercialization. We will develop a roadway with better pavement materials and structure, building on the study result. We will also expand the result to the demonstration of dynamic wireless power transfer for altered EVs.
- The strength and durability must be verified on a road with more practical conditions to use a pavement structure applicable to expressways, where heavy vehicles travel on open roads. We will use the study result to build an environment where real heavy vehicles can travel at high speed on the wireless power transfer roadway and will evaluate performance characteristics, including strength, durability and traveling performance, under conditions close to the demonstration on open roads.
- We confirmed differences in the elastic coefficient between each layer during comparison with the finite element method, although we evaluated the structure according to the multilayer elasticity theory in this study. We will consider setting the boundary conditions for each layer and will improve the accuracy of the design method based on the multilayer elasticity theory to establish a structural design method equivalent to the TA method.

6. Contribution to Road Policy Quality Improvement

We have participated in the Cabinet Office's SIP3 study project, "Building of Smart Energy Management System," and promoted research and development to realize wireless EV chargers to encourage the spread of EVs. As part of the application of the study result to implementation, we plan an implementation and high-speed in-motion demonstration on the next-generation test road course, a core facility in the Taisei Group, and active proposals for the MLIT new technology introduction promotion plan. We believe that we can contribute to the provision of roads that help realize a future low-carbon society by enhancing our efforts toward their implementation.

7. References, Websites, etc.

https://www.taisei.co.jp/about_us/wn/2022/220921_8962.html