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

No.	Title	Principal Researcher
No.2020-7	Study of Coil Embedment for Dynamic Wireless Power Transfer	Tokyo University of Science Associate Prof. Takehiro Imura

In order to realize wireless charging while driving, the electrical characteristics (efficiency, power, etc.) and mechanical characteristics (durability, etc.) of coils buried on the roadside are compared with those of various types of coils to establish a technology for embedding coils in asphalt after improving their electrical characteristics and mechanical strength, evaluate aging deterioration, optimize embedding depth, and show the possibility of The results will show the possibility of optimizing the embedding depth, size, material, low-cost coils, etc.

1. Backgrounds and Objects

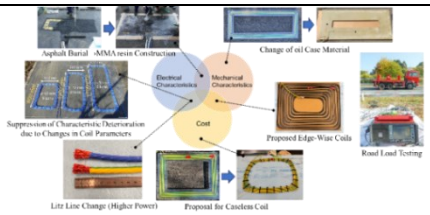
As the demand for electric vehicles has been increasing in recent years, the short cruising range and the lack of charging infrastructure have become obstacles to their widespread use. The design of roadside power transmission coils and the establishment of embedding technology are very important factors in DWPT, but there are concerns that embedding the coils will deteriorate the electrical characteristics of the coils and the mechanical strength of the pavement. Therefore, the objective of this study is to establish a coil design and embedding technique that improves both electrical characteristics and mechanical strength, and ensures long-term durability against driving large vehicles when the coils are embedded in asphalt pavement.

2. Activities in Research Period

Design coils considering withstand voltage and current, evaluate their electrical characteristics and mechanical strength when embedded in asphalt pavement, and study embedding technology.
The coils will be embedded in asphalt pavement, and FWD tests will be conducted as well as running loading tests using large vehicles to evaluate the mechanical strength of the pavement and the electrical characteristics of the coils before and after running.

3. Study Results

By reducing the coil size, the deterioration of coil characteristics due to asphalt burial was suppressed, and by using an MMA resin mixture for embedding, further improvement in electrical characteristics and mechanical strength was confirmed. By reviewing the litz wire, the allowable current value was increased, and a 50 kW class of high power in terms of VNA conversion was successfully achieved. By proposing a caseless coil that does not use a plastic coil case, we were able to significantly reduce the cost per coil. We proposed a thin edge-wise coil, which is expected to reduce coil cost and improve mechanical strength, and confirmed that it has excellent heat dissipation characteristics due to the large surface area of the coil. In addition, measurement of the heat generation characteristics of the coils in air showed that the maximum temperature of the edge-wise coils increased by 38°C. However, the maximum heat generation in asphalt pavement was 5.2°C. Therefore, the influence of heat generation during burial is considered to be small. The results of driving loading tests conducted by the Public Works Research Institute showed that BWP coils were not damaged by driving loads of up to 500,000 rpm, and the coils and pavement were sound. Since we were able to confirm that caseless and GFRP case coils were not damaged in the IWP installed in 2023, we believe that the coils will remain strong enough even if they are buried in the surface layer.



4. Papers for Presentation

・EVTec2021

Takehiro Imura, Koki Hanawa, Kanta Sasaki and Nagato Abe, "Coil Performance and Evaluation of Pavement Durability of Dynamic Wireless Power Transfer System using Ferrite-less and Capacitor-less Coil for Road Construction Methods," 5th International Electric Vehicle Technology Conference (EVTeC2021), May. 2021.

・WPTCE2023

Koki Hanawa, Takehiro Imura, Yoichi Hori, Hiroyuki Mashito and Nagato Abe, "Proposal of Coil Embedding Method in Asphalt Road Surface for Dynamic Wireless Power Transfer," *2023 IEEE Wireless Power Technology Conference and Expo (WPTCE)*, San Diego, CA, USA, 2023, pp. 1-5

・WPTCE2024

Naoya Sasa, Takahiro Yamahara, Seho Kim, Takehiro Imura, Grant Covic, Yoichi Hori, Hiroyuki Mashito and Hiroki Tanaka, "Thermal Modelling of IPT Coil Embedded in Resin for the Roadway," *2024 IEEE Wireless Power Technology Conference and Expo (WPTCE)*, Kyoto, Japan, 2024.

5. Study Development and Future Issues

With this achievement, the structure of the base layer (middle layer) and surface layer installation of the asphalt mixture layer has been determined with the direct burial of polycarbonate S-type coil cases and coated Litz wire coils, and transmission efficiency of 95% or higher has been secured for the power feeding characteristics.

In the future, we would like to see the results of practical application of the system utilized in actual road tests, such as confirmation of the effect of power supply power and time at each speed level by a vehicle equipped with a power receiving coil at a power supply power of 10 kW or more, evaluation of leakage magnetic fields, and confirmation of the temperature rise of the pavement in relation to the operating time of the power supply coil.

Regarding the burial location of the power-feeding coil, since the confirmation of damage caused by traveling between wheels (BWP) through loading tests of large vehicles in the Public Works Research Institute has confirmed that the damage is 10 times smaller than that at wheel passing locations (IWP, OWP), and the possibility of long-term operation is confirmed, we would like to We would like to aim for installation and dissemination of the system at locations where it is less affected by wheel load of large vehicles between wheels.

6. Contribution to Road Policy Quality Improvement

With this achievement, we were able to verify a structure that has a transmission efficiency of 95% or higher for pavement-buried power-feeding coils and that does not break even when directly loaded by large vehicles 200,000 times or more (7,000,000 times or more between wheels).

Through demonstration tests on actual roads, we will be able to study systems that can be operated with a DC current of 400 V and a current of 20 to 30 A (8 kW to 12 kW), and even with an output of 20 kW (higher output), and solve problems in actual road installation, bringing the system closer to practical application.

The possibility of thin edge-wise coils has also been discovered, and a technology that can reduce the cost of improvements when installed on pavement is now in sight. Reduction of cutting and installation costs for pavement, which is the current social infrastructure, is expected to be the key to widespread use of this technology, and we hope that this will be the case in the future.

7. References, Websites, etc.

https://www.rs.tus.ac.jp/imura.lab/