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

No.	Title	Principal Researcher
No.2021 - 7	Technical Research and Development on High-Durability Fly Ash Concrete Pavement Based on Data Assimilation	Nihon Univ. Prof. Ichiro Iwaki

This research project aims to develop and implement a highly durable fly ash (FA) concrete pavement as a viable alternative to conventional asphalt pavement, utilizing data assimilation techniques. Following comprehensive evaluation of the durability and workability of concrete incorporating FA and expansive additives (Ex), the optimal mix design was selected. Subsequently, full-scale manufacturing test and pilot construction were carried out, with the proposed high-durability continuously reinforced concrete pavement (CRCP) deployed on a national road. Furthermore, a multiscale analysis was conducted using experimental data as input values, leading to the development of an analytical tool capable of evaluating the long-term durability of high durability concrete pavement.

1. Backgrounds and Objects

CRCP is designed to distribute fine cracks through the restraint provided by continuous steel bars placed within the pavement, offering superior durability and ride quality due to the absence of joints. However, in snowy and cold regions, there is a case that has been reported where internal steel rebars have severely corroded in less than 10 years of service, caused by the intrusion of water mixed with deicing agents (mainly NaCl). Therefore, to promote the widespread adoption of CRCP in such climates, it is essential to control crack widths effectively and enhance the concrete's durability, particularly its resistance to chloride penetration.

This study focused on the development and implementation of high-durability FA concrete pavement as an alternative to asphalt pavement.

2. Activities in Research Period

Regarding the development and implementation of high-durability CRCP, this project 1) firstly investigated appropriate mix designs and the durability of FA-blended pavement concrete at the elemental level, 2) secondly constructed a full-scale CRCP via mechanical placement at the Nihon University College of Engineering campus, assessing its constructability and quality, 3) thirdly executed full-scale field construction on a national road in Akita Prefecture; and 4) developed an analytical model using data obtained from these experiments to evaluate the crack risk, durability, and fatigue resistance of FA concrete pavement.

3. Study Results

At the laboratory scale, the fresh properties and durability of FA-blended concrete were evaluated to determine the optimal FA replacement rate. Pre-construction studies were conducted, which included assessing the constructability of full-scale level and a pilot construction. Regarding the actual construction, despite harsh

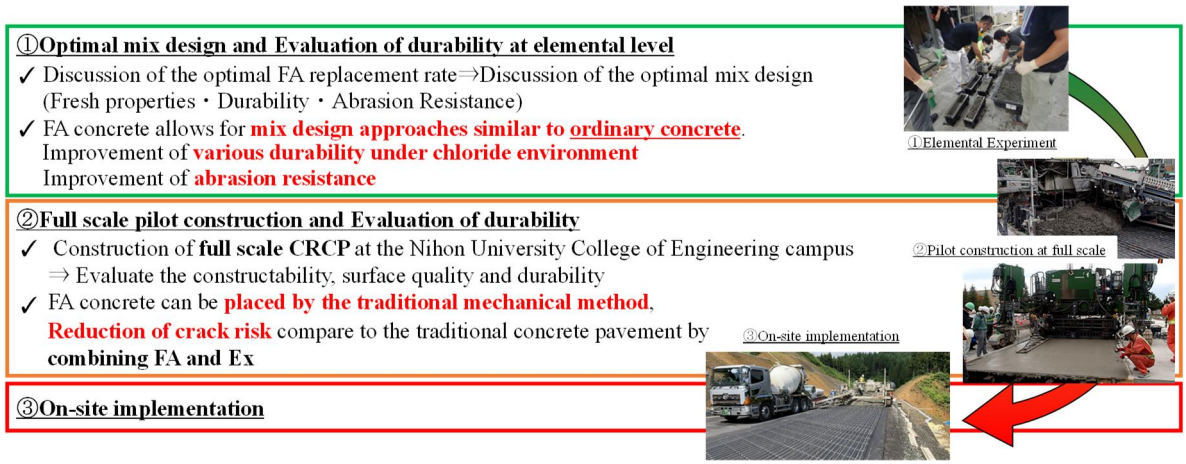

Figure-1 Development and implementation of high durability CRCP

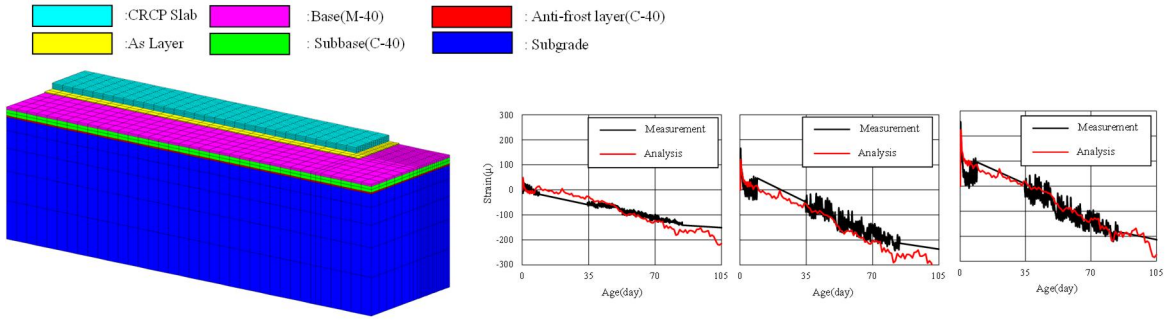

Figure-2 FEM Model of high durability CRCP that can evaluate the crack risk

environment conditions—specifically, an ambient temperature of 38°C—the construction was completed without any delays or issues. Until now, no crack leading to structural problem has been observed, confirming the effectiveness of the proposed high-durability CRCP with FA and Ex mitigating excessive crack widening attributed to the Ex (Figure-1). Additionally, the FEM model (Figure-2) developed based on various data collected from both trial and actual construction accurately captured the expansion and shrinkage behavior of concrete within CRCP slab across various mix designs. This demonstrates that the model created in this study can be used to assess the risk of cracking in CRCP under diverse material and environmental conditions. Furthermore, it was shown through multiscale analysis based on data assimilation that high-durability CRCP can maintain its performance for 100 years.

4. Papers for Presentation

1) H.E. Joo, T. Nagata, Y. Takahashi, Cracking Risk Evaluation on Continuous Reinforced Concrete Pavement with Supplementary Cementitious Materials and Expansive Additive, Journal of JCI, 46(1), pp.565-570. 2024
2) Ainai. G, Kannno. H, Maeshima. T, Iwaki. I.: Development and Implementation of Highly Durable Continuous Reinforced Concrete Pavement using Both Fly Ash and Expansive Agent, Journal of JSCE, Vol.81, No.1, 2025.

5. Study Development and Future Issues

In the future, in order to evaluate the long-term performance of the constructed pavement, ongoing surveys and durability test will be conducted. Further investigation will be carried out to elucidate the mechanisms by which FA blended concrete improves abrasion resistance, and appropriate mix design methodologies will be explored, taking into account quality variations of FA. These findings will be incorporated into the FEM model (data assimilation) to improve the accuracy of concrete pavement deterioration prediction. Additionally, a “Guideline for High-Durable Concrete Pavement,” summarizing insights obtained from this research, will be developed to promote the wider adoption of high durable concrete pavement especially in snowy and cold regions.

6. Contribution to Road Policy Quality Improvement

This research demonstrates that the incorporation of fly ash significantly enhances the durability of pavement concrete, and the use of Ex concurrently mitigates the crack risk. A FEM model has been established, enabling a quantitative, long-term evaluation of crack behavior and fatigue resistance by considering construction conditions, mix characteristics, and weather variables. This suggests that durability-focused pavement maintenance planning can be established from the design stage. As a result, it is expected to contribute to improving the accuracy of pavement condition diagnostics and optimizing the timing and methods of repairment, thereby supporting long life and reduced life cycle cost in road administration. Furthermore, the on-site implementation process leading up to field application on a national road serves as a valuable reference for the deployment of innovative pavement material. It is anticipated that these research findings will support the realization of sustainable road infrastructure through their incorporation into technical publications by MLIT, JSCE, and the Japan Road Association, leading to nationwide dissemination and standardization.

7. References, Websites, etc.

1) Nikkei Construction, October 2023 Issue, pp.12-17.
2) Nikkei Cross Tech: "High-Durability Concrete Pavement through Local Production and Local Consumption" https://xtech.nikkei.com/atcl/nxt/mag/ncr/18/00031/101200059/
3) Scheduled for publication in Concrete Techno, July 2025 Issue.