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

No.	Title	Principal Researcher
No.2020-8	Development of durable prestressed concrete structure using stainless PC strand, anchorage and reinforcement	Nagaoka Univ. of Tech., Prof. Takumi Shimomura

The purpose of this research is to develop pre-tensioned and post-tension prestressed concrete structure with high durability without fear of corrosion by using stainless steel for all internal steel materials.

1. Backgrounds and Objects

In order to complete durability of the prestressed concrete structure without being affected by environmental conditions or construction quality, it is effective to develop a PC structure in which all internal steel materials such as reinforcing bars, PC tendons, sheaths and anchorages are made of non-corrosive materials. Therefore, we try to develop highly durable pre-tensioned and post-tensioned PC structures using existing stainless reinforcing bars, stainless steel PC steel materials, and a new prototype stainless steel PC anchorage.

JIS and the JSCE guidelines have been established for stainless steel reinforcing bars, and the technical foundation for adopting them to concrete structures has been prepared. Stainless steel PC steel materials have already been commercialized, but PC structures using stainless steel PC steel tendons have not yet been put to practical use in Japan, although they are available overseas. Furthermore, the post-tensioned PC structure, in which all the internal steel materials, including the anchorages, are made of stainless steel, has not been developed in the world.

2. Activities in Research Period

1) Pre-tensioned PC structure using stainless steel

Load carrying behavior of pretensioned PC members using stainless PC steel strands is examined. Corrosion resistance of stainless PC steel strands is examined.

2) Stainless steel PC anchorage

Stainless steel PC anchorage for single-strand and multi-strands anchoring the ends of stainless PC steel strands are developed and its corrosion resistance is examined.

3) Post-tensioned PC structure using stainless steel

Post-tensioned PC beams are made using the developed anchorages, and its load-carrying behavior is tested. Friction between the stainless PC strands and the sheath is examined.

4) Investigation for practical use of PC structure using stainless steel

Based on the outcomes in this research, points to note in design and construction of PC structures using stainless steel are considered. Its life cycle cost under various conditions and clarify the merits of practice are investigated. A draft for standardization of stainless PC steel materials and fixtures will be proposed.

3. Study Results

1) Pre-tensioned PC structure using stainless steel

It was confirmed that the same design and response analysis as conventional PC members are possible for pre-tensioned PC members using stainless PC strands. It was confirmed that the corrosion rate of stainless PC strands is much slower than that of ordinary steel, less than 1/10, and that the corrosion rate is not affected by inducement of tension.

2) Stainless steel PC anchorage

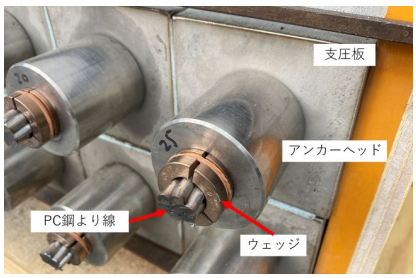

Photo 1 Stainless steel PC anchorage for single strands

As a result of trial and error with the types, shapes, and surface treatments of the stainless steels used for the wedge and anchor head of the PC anchorage, we have achieved a PC anchorage for single strands with stable anchoring efficiency of 95% without fracture nor deformation (Photo 1). Using the specifications of the developed single-strand PC anchorage, we prototyped a multi-strand PC anchorage system (Photo 2).

Photo 2 Stainless steel PC anchorage for multi strands

3) Post-tensioned PC structure using stainless steel

It was confirmed that the same design and response analysis as conventional PC members are possible for post-tensioned PC members using stainless PC strands and anchorage. It was confirmed that the value of the conventionally used coefficient of friction can be applied to the calculation of the friction between stainless PC strands and the sheath.

4) Investigation for practical use of PC structure using stainless steel

The stress-strain relationship of stainless PC strands has a smaller yield point and rupture strain than ordinary PC strands. Therefore, it is better to use a stress-strain relationship model and a design value of rupture strain that take these into account. For PC structures using stainless PC strands, it is necessary to confirm that the failure mode is not the rupture of the PC tendon in the ultimate limit state. For other matters, the same design method as ordinary PC members can be employed.

It was confirmed that PC girders using stainless PC steel are superior to conventional structures in terms of life cycle cost in cases of small and medium-sized bridges. A draft standard for stainless PC steel strands and a draft standard for PC anchorage using stainless steel were prepared.

4. Papers for Presentation

1) Kazuya Uragami and Shinichi Miyazato, Evaluation of corrosion resistance of stainless PC strands, JSCE Chubu branch convention, 2022.3.

2) Mina Sekine, Shinichi Miyazato and Yosuke Azuma, Examination of corrosion of SUS PC anchorage, JSCE Chubu branch convention, 2022.3.

3) Takumi Shimomura, Yuya Komatsu and Shunsuke Saito, Development of durable PC structure using stainless steel for all internal steel materials, Symposium on Developments in Prestressed Concrete, pp.37-42, 2022.10

4) Kazuya Uragami and Shinichi Miyazato, Evaluation of corrosion rate of stainless PC strands, Symposium on Developments in Prestressed Concrete, pp.411-416, 2022.10

5) Kazuya Uragami, Hiroto Ito and Shinichi Miyazato, Influence of chloride ion content on corrosion rate of stainless reinforcement, JSCE Chubu branch convention, 2023.3.

5. Study Development and Future Issues

As for the pre-tensioned PC structure, it is technically ready for practical use. For example, it can be applicable to precast PC slabs for road structure. Since the stainless PC anchorage for post-tensioned PC structures has only been completed as a prototype in the laboratory, in order to apply it to actual structures, it is necessary to enable it to be mass-produced stably. In order to widely apply the technology developed in this study to the infrastructure, it is better to formulate design and construction standards and guidelines under consensus of members in committees of academic societies.

6. Contribution to Road Policy Quality Improvement

The prestressed concrete structure with stainless steel developed in this study has no fear of corrosion. Therefore, it is expected that this technology will greatly contribute to reduce maintenance cost of concrete bridge when it is adopted under severe chloride prone environment.

7. References, Websites, etc.

Website is not available.