A STUDY ON REPAIR STRATEGY OF SEVERELY DAMAGED RC STRUCTURES BY USING SACRIFICIAL ANODE CATHODIC PROTECTION

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論 文 名　：A STUDY ON REPAIR STRATEGY OF SEVERELY DAMAGED RC STRUCTURES BY USING SACRIFICIAL ANODE CATHODIC PROTECTION
（深刻な損傷を受けた RC 構造物の犠牲陽極方式電気防食による補修工法に関する研究）

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論 文 内 容 の 要 旨

Chloride-induced corrosion is one of the major causes of deterioration in the marine environment that leads to performance degradation and premature failure before the expected service life. From the literature, cathodic protection (CP) is one of the reliable repairing methods that has proven to control chloride-induced corrosion. Therefore, sacrificial anodes, which is one of CP types with less instruments and maintenance requirements, have been used to limit the extent of concrete replacement due to chloride contamination and extend the service life of damaged RC structures. However, the specification of the repair method by sacrificial anodes in RC members is still unclear. The objective of this study is to find a suitable repair strategy on severely damaged RC beam structures by sacrificial anode cathodic protection (SACP). This dissertation mainly consists of seven chapters.

Chapter 1 explains the background of study, research objectives and limitations, research contribution and standing point, and dissertation arrangement.

Chapter 2 describes the literature review from the previous studies related to durability issues in RC structures due to chloride-induced corrosion; corrosion inspection, assessment, and monitoring method; and repair method of chloride-induced corrosion in RC structures.

Chapter 3 presents the fundamental research on the utilization of sacrificial anodes in laboratory cases. From the viewpoint of arresting macro-cell corrosion due to heterogeneous chloride concentration after five years of observation, the point sacrificial anodes in the repair part is still generating protection to the segmented steel bars indicated by the depolarization test value. The longer the span of repair part, the higher depolarization value was measured. In the preparation of sacrificial anode application, it can be reported that rust removal process on steel surface in repair concrete is the most desirable initial condition of steel bars when the sacrificial anode is applied to it. Regarding the temperature in the exposure condition, it can be reported that the application of sacrificial anodes in low temperature around -17°C performs a good result until three years, but four years of utilization sacrificial anodes in high temperature (40°C) presents less effective protection due to crack formed around the steel bar protected by anodes. The experiment to reduce the high anode consumption in the early connection was succeeded in the last part of this chapter by the implementation of half of the initial sacrificial anode current flow by using the impressed-current method.

Chapter 4 demonstrates repair methods by SACP for five severely damaged RC beams in more than 40 years. RC-1 and RC-2 present the time-lapse application of sacrificial anodes in patch and non-patch repair. Sacrificial anodes were installed in patch repair to protect its area only due to the electrochemical incompatibility of polymer mortar and existing concrete. After one year, the additional sacrificial anodes were applied in the non-patch repair. Both RC-1 and RC-2 show good protection identified by depolarization and improved steel bar conditions in all cross-sectional area of the beams. RC-3 and RC-4 present the application of sacrificial anodes in non-patch repair only while the corrosion inhibitor was painted in the steel bar surface in the patch repair area. The corrosion inhibitor membrane reduces the required electric current for attaining the steel bar potential change in the patch repair. So, the application of corrosion inhibitor is recommended in RC structures repaired by sacrificial anodes. From RC-1 to RC-4, it can be seen that small current flow generated by sacrificial anodes affects not only polarization but also improvement of the steel bar condition. Depolarization values of more than 100 mV cannot have a significant effect on the improvement of steel bar conditions. The application of sacrificial anodes in the patch and non-patch repair is also presented in RC-5. The obtained result indicates that the repair method by combining a different kind of sacrificial anodes in the patch and non-patch repair presented no significant polarization of rebar nor current flow. Therefore, the combined sacrificial anodes in the patch and non-patch repair method at the same time with closer distance could not be a suitable repairing system.

Chapter 5 illustrates the utilization of titanium wire sensors (TWS) as a new embeddable corrosion monitoring sensor in four RC members repaired by sacrificial anodes cathodic protection. TWS is working as a corrosion monitoring sensor in concrete with stable potential reading in around the areas wherein it is embedded until 18 months of exposure. It is indicated by the stable potential development and it was not affected by current density of sacrificial anodes during observation period.

Chapter 6 formulates the proper SACP application method in the deteriorated RC beams. The installation of sacrificial anodes in patch repair delivers limited protection in patch repair only. If the sacrificial anodes were installed in existing concrete, it could cover protection not only in existing concrete but also in some part of patch repair. The application of sacrificial anodes both in the patch and in non-patch repair can protect a bigger area, but the time-lapse application is important. The design parameters of SACP application including environmental conditions, structural deterioration degree, and repairing technology are performed in this chapter by the different protective current density and depolarization set value.

Chapter 7 conveys a summary, conclusions, and recommendations for future research.