論 文 の 内 容 の 要 旨

論文題目　Proposal of soundness assessment method of reinforced concrete structures affected by carbonation
（炭酸化の影響を受けた鉄筋コンクリート構造物の健全性評価法の提案）

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It is commonly known that Reinforced concrete (RC) is a highly durable material as the concrete is a protective barrier for the steel rebars, allowing the development of RC structures. However, such materials deteriorate over time due to the corrosion of steel reinforcing bars (rebars), which is one of the most common causes of degradation of RC structures. The corrosion of the steel rebar is initiated by the chloride ingress or carbonation. The resulting corrosion products precipitate and then generate tensile stress, promoting the appearance of cracks to an unacceptable level regarding their service life. Even fundamental and clear understandings of corrosion-related degradation exposed to the widely variable exposure situations are still lacking, as well as the different controlling mechanisms of the corrosion process, the insufficient engineering application in the field, and the gap between laboratory and real conditions. The engineering strategies dealing with degraded RC structures rely on experience and are mainly empirical. On the other hand, the service life of carbonated RC structures and chloride-containing RC structures were predicted by the probabilistic carbonation assessment method and critical chloride content prediction only considering the initiation phase of carbonation progress or the chloride penetration, currently. However, at the end of the initiation phase, the RC structure may still have adequate residual serviceability and strength. Therefore, to meet the durability requirements of corrosion-affected RC structures, service life prediction after the initiation phase is now receiving more attention. As a result, there have been trends towards extending the service life definition of RC structures prone to steel corrosion.

Therefore, theory-based approaches for reliable durability assessments and service-life predictions of RC structures considering the propagation phase of the corrosion process are necessary, which are crucial for monitoring the performance and determining the maintenance planning of existing RC structures and designing durable and sustainable new RC structures. This thesis is mainly focusing on the carbonation-induced corrosion in RC structures.

Firstly (in **Chapter** Error! Reference source not found.), the dependence of RH and temperature on carbonation-induced corrosion behavior and the corresponding corrosion controlling mechanisms were clarified by electrochemical experiments on the carbonated reinforced mortar under various environmental conditions and microstructure characterization analysis of carbonated mortar:

The decreasing trend of the electrical resistivity of carbonated mortar and the increasing trend of the corrosion rate of steel occurred with increasing temperature and RH conditions because of the mobile ions in the pores and the increased condensed electrolyte. The temperature dependence of electrical resistivity decreased with increasing water content in the mortar. The temperature peak value for the increase in corrosion rate was 40 ℃ under high RH conditions, caused by the decreased dissolved oxygen content.

The corrosion control mechanisms were verified by the correlation between the corrosion potential and corrosion rate of the steel rebar, and the correlation between electrical resistivity of the mortar and the corrosion rate. The linear relationship between the reciprocal of electrical resistivity and carbonation-induced corrosion rate, and the increase of the corrosion rate with the corrosion potential shifting more negatively indicate that the corrosion process in carbonated mortar is under resistive control in most cases.

The regression analysis model of the electrical resistivity of cement materials and the linear correlation between the reciprocal of the electrical resistivity of the mortar and the corrosion rate of the steel rebar enable an engineering application to estimate the corrosion rate of steel rebars under different exposure conditions when the corrosion process is under resistive control within specific exposed conditions (under 68% to 84%RH with temperatures ranging from 20℃ to 50℃, and 91% to 97% RH with temperatures ranging from 20℃ to 40℃)

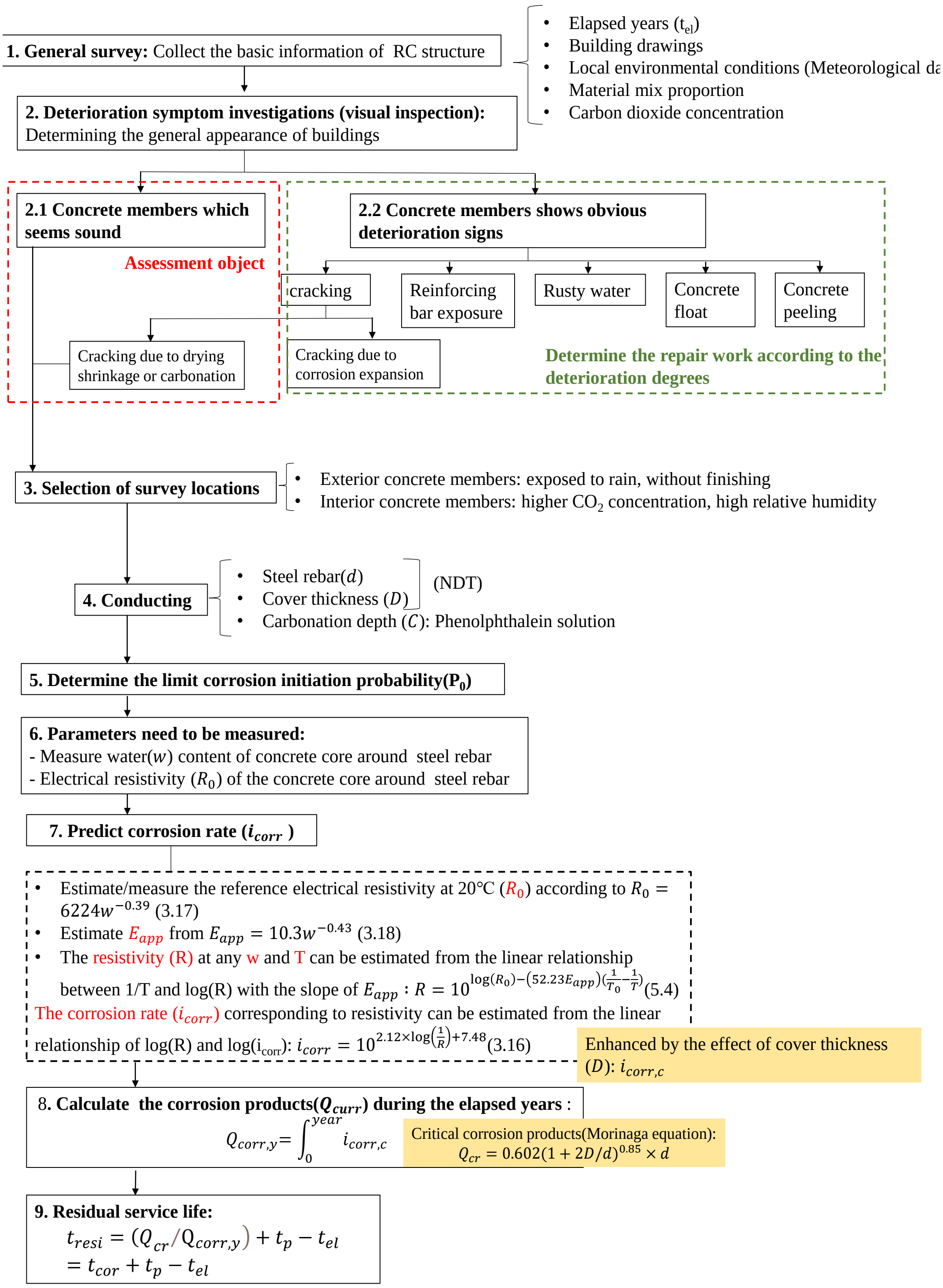
In practical cases, the cover thickness is thicker than the cover thickness of 5 mm used in the experiment. Therefore, a more precise and empirical corrosion rate prediction method was proposed considering the effect of cover thickness based on the proposed equation proposed in Chapter **Error! Reference source not found.** (in **Chapter 4**):

The increase of cover thickness inhibits the corrosion rate of steel rebar due to the increase of effective diffusion layer for oxygen and water content, causing the lack of oxygen and water content for corrosion reaction when the cover thickness increases, the effect of RH and temperature on corrosion rate decreases because the water content and oxygen penetration in mortar would remain at a depth ranging from 30 to 40 mm.

A more precise and safe corrosion rate prediction equation considering the effect of cover thicknesses was proposed based on the reference value of corrosion rate obtained in Chapter. **Error! Reference source not found.**.

The proposed corrosion rate prediction method was verified by the electrochemical results of the carbonated slag-based mortar with four different replacement ratios of BFS (30%, 50%, 60%, and 70%) in **Chapter 5**, exposing to different RH and temperature conditions: The relationship between the measured corrosion rate and calculated corrosion rate values in reinforced slag-based mortar shows that the estimation based on the prediction method proposed in **Chapter 3** is a reliable and safe method for evaluation of corrosion behaviors in carbonated cementitious materials.

Finally, a soundness assessment for RC members has been proposed based on the proposed corrosion rate prediction method discussed in Chapters 3 to 5 in **Chapter 6**, with references to the related Japanese standard specifications.



Overall soundness assessment process flow