Development and application of Plastic Optical Fiber sensors for corrosion monitoring

侯, 亮

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論文内容の要旨

氏　　名　　　　　　　　　　　　侯　亮

専　　攻　　　　　　　　　　工学研究科 市民工学専攻

論文題目（外国語の場合は，その和訳を併記すること。）

Development and application of Plastic Optical Fiber sensors for corrosion monitoring（プラスチック光ファイバーセンサーの開発と腐食モニタリングへの応用）

指導教員　　　　　芥川真一

A precise understanding of the corrosion status of metals is crucial for accurately assessing the structural integrity of all construction employing metal components. As metal corrosion was an electrochemical process, it occurred at specific locations and times within an environment that was conducive to corrosion, leading to the discoloration of the affected area. If the corrosive environment persisted, corrosion would proceed across the surface and penetrate the metal. Depending on the extent of the corrosion, a structure linked to or in contact with a corroded region might undergo deformation.

As previously outlined, research and development related to the detection of corrosion in metals have been approached from multiple perspectives, resulting in the creation of highly precise techniques for acquiring specific data (such as the presence of corrosion and its location, extent, and influence on neighboring structures) from each of these perspectives. However, to efficiently manage the extensive infrastructural assets in the forthcoming era of big data, methods should extend beyond the existing expensive and high-precision techniques. Therefore, a strategic approach should involve the use of sufficient cost-efficient sensors while integrating them with additional data to obtain insights into corrosion phenomena, thereby enabling a comprehensive evaluation of the condition of the infrastructure in general. We introduced a novel corrosion-detection sensor utilizing plastic optical fiber (POF) to address these challenges. This paper presents a fundamental study of POF corrosion sensors through the feasibility analysis of POF sensing methods.

This paper comprises six chapters as follows.

Chapter 1, "Introduction," covers fundamental corrosion concepts, types, impacts, and underscores the significance of corrosion monitoring. Additionally, it presents the research background and the main content of this paper.

Chapter 2, "Previous Research," reviews prior studies on corrosion monitoring, categorizing techniques into direct and indirect monitoring. It also discusses existing research on observation methods employing POF sensors. Additionally, it proposes a corrosion monitoring method based on fiber optic sensing and analyzes its feasibility in subsequent chapters.

Chapter 3 describes a series of experiments conducted using a new plastic optical fiber (POF) sensor to monitor the corrosion process of steel plates. Electrolytic corrosion experiments were performed on a 5 mm thick steel plate immersed in an aqueous solution. A POF sensor mounted on the upper side of the steel plate and deflected downward detected the progression of the corrosion zone formed on the bottom side of the plate. The results indicated that the POF sensors could detect the initiation of the corrosion front when it reached the 1 mm and 2 mm marks associated with the thickness of the corrosion zone. These POF sensors were specifically designed for optically identifying corrosion; thus, the data obtained from these sensors can be processed using newly developed smartphone graphic application software or recognized visually. This method offers a straightforward and cost-effective approach to verifying the corrosion status of structural components.

Chapter 4 describes a novel POF sensor design. Expanding on the previous chapter, this new sensor incorporates an innovative structure that efficiently utilizes bidirectional optical transmission in POF, streamlining the installation process and halving the total cost of POF cables when monitoring multiple points. Additionally, an ultra-compact pseudo-sensor with dimensions of 5 mm in length and 2.2 mm in diameter is introduced for corrosion depth detection, with its functionality validated through experimentation. The proposed sensor's concept, basic structure, various experimental findings, as well as its effectiveness, prospects, and economic benefits, are comprehensively discussed.

Chapter 5 examines the viability of using POF sensors to monitor wire corrosion in stay-cabled bridges. Additionally, it introduces a novel POF sensor for water detection and validates its functionality through experimentation. The configuration of the POF sensor is tailored to the real-world steel cable structure, and experiments simulating cable wire corrosion are performed. This chapter offers a new, convenient, and cost-effective solution for bridge corrosion monitoring.

Chapter 6 provides a summary of the study's findings in the "Conclusion" section.

（別紙１）　論文審査の結果の要旨

氏名	侯　亮　(Hou Liang)		
論文題目	Development and application of Plastic Optical Fiber sensors for corrosion monitoring （プラスチック光ファイバーセンサーの開発と腐食モニタリングへの応用）		
審査委員	区　分	職　名	氏　名
	主　査	教授	芥川　真一
	副　査	教授	森川　英典
	副　査	准教授	三木　朋広
	副　査		
	副　査		印

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The contents presented in the draft version of the thesis cover very important issues on development and application of an innovative method for corrosion monitoring. In particular, the new POF sensors and a combined use of the graphic application software developed for a smartphone provide a set of methodology which would probably be the most effective, in terms of monitoring cost, way to monitor corrosion initiation and its progress in arbitrary steel structure in the world. Hence the proposed methods have a potential to be applied and used in numerous sites around the world where monitoring budget may not necessarily be sufficient.

The thesis submitted satisfies the evaluation criteria for a doctoral thesis of the Graduate School of Engineering, and the candidate, Hou Liang, is approved to have the qualification for obtaining the degree of Doctor of Philosophy in Engineering.