

POF センサーを利用した鋼構造物の腐食モニタリングに関する基礎的研究

神戸大学 学生会員 Hou Liang

神戸大学 正会員 芥川 真一

JFE 商事テールワン(株) 正会員 友重 勇気

JFE 商事テールワン(株) 正会員 木村 隆志

1.Introduction

Health monitoring of engineering infrastructure is becoming increasingly important. Steel corrosion is one of the most common structural flaws in steel structures. Although various methods for detecting steel corrosion, such as weight loss and electrical approaches, have been used, the lack of real-time corrosion measurement approaches limits their application. The color change can be used to monitor corrosion. Sensors made of plastic optical fiber (POF) can detect color change caused by corrosion and can provide real-time monitoring. As a result, the POF sensor could be a viable candidate for detecting steel corrosion. In this article, a corrosion detection method based on POF sensors is developed. The sensing principle is discussed, as well as laboratory accelerated corrosion tests. The relationship between the corrosion patterns and sensor signals is investigated and validated through experiments. Accelerated laboratory corrosion tests are implemented to validate the feasibility of the proposed sensing system. With validation, the results of this study could be extended to multiple types of applications such as steel plates in steel-strip-reinforced earth wall.

2. Principle of plastic optical fiber sensor

For sensor 1, shown in Fig.1, a POF sensor is not watching corroded surface directly, but it is rather watching color change caused by flow and penetration of the corrosion-colored liquid. The distances d between the two fibers are set to 4.5 mm, 5 mm, and 10 mm, respectively. The thickness of the steel plate in the experiment is 0.1mm. For sensor 2, shown in Fig.2, A pipe-type sensor is a sensor with multiple optical fibers inserted in a single pipe, as shown in Fig.2. Each optical fiber plays the role of a light source or light receiver by choice. The plastic pipe with an inner diameter of 3 mm is used and seven 1 mm optical fibers are installed in the pipe. In this study, one central fiber is used as a light source, and six as light receivers, reading the light reflected from the object. The space ahead of the seven POF is filled with adhesive whose thickness is 3mm. This will achieve the best possible reception of the POF signal. The thicknesses of the steel plates used in the experiments were 0.1 mm, 0.2 mm, 0.3 mm, 0.4 mm, and 0.5 mm.

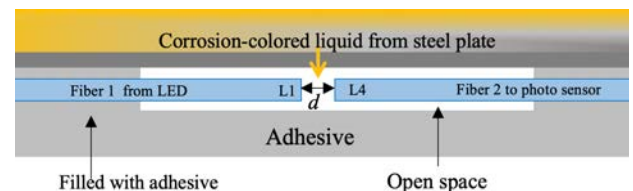


Fig.1 Sensor 1 for steel plate

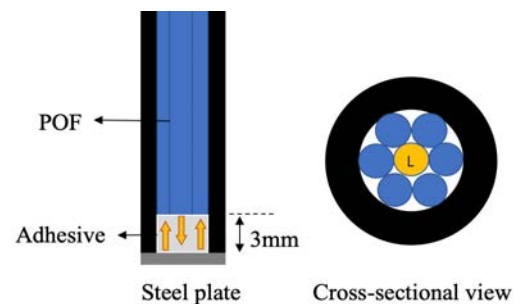


Fig.2 Sensor 2 for steel plate

Keyword Corrosion, Steel plate, Monitoring, Plastic optic fiber

Address 〒657-8501 1-1 Rokkodai-cho, Nada-ku, Kobe Department of Civil Engineering, Graduate School of Engineering, Kobe University TEL 078-803-6015

3. Saltwater spray experiment

The basic experiment for steel corrosion detection using POF (indoor electric corrosion experiment) has confirmed that steel corrosion can be detected. To put the corrosion sensor into practical use, it is necessary to confirm whether corrosion can be measured in the field (outdoor environment). Therefore, the purpose of this study is to confirm whether corrosion can be detected in an outdoor environment. Since it takes a long time to measure corrosion in a real environment, a corrosion acceleration test was conducted in an outdoor environment to verify it.

As a corrosion acceleration method, a simple saltwater spray system was constructed to circulate the saltwater in a container, as shown in Fig.3. The brine was sprayed continuously at all times. And the optical information of POF was measured over a period of 5 months.

The optical information of POF is captured by a live camera installed outside to capture the image of the POF tip. The experiment started on November 11, 2021. Because the amount of data is very large, only the images of every Thursday are taken here for optical information processing into data form using image analysis software²⁾, as shown in Fig.4. The first and second rows of marked fibers in the screenshot of the camera are the optical intensity data of 6 fibers of a steel plate of 0.2 mm thickness in the following graph. The last row is the optical information of one gap sensor with a distance of 5mm and one gap sensor with a distance of 10mm.

It can be observed that the light intensities change for a short period with a large drop. This is since the data is obtained only for the picture every Thursday and is not continuous. But the light intensity also experienced a significant decrease, indicating that corrosion reached the monitoring area of the pipe sensor and the liquid generated because of corrosion flew into the monitoring area of the gap sensor.

4. Summary

It was found that the POF sensors can be used for corrosion detection of steel plates in steel-strip-reinforced earth wall. The success in monitoring such data using POF sensors and the newly developed image processing application software promises an effective monitoring system at a relatively low cost.

5. Reference

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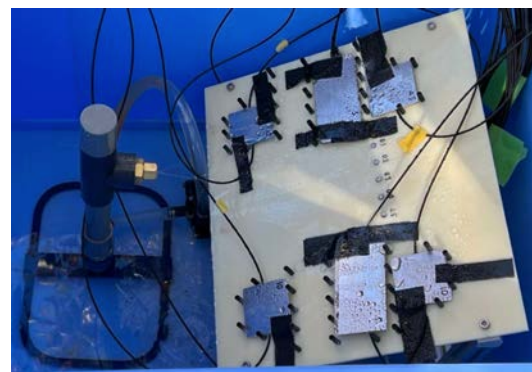


Fig.3 Overview of the steel pipe experiment

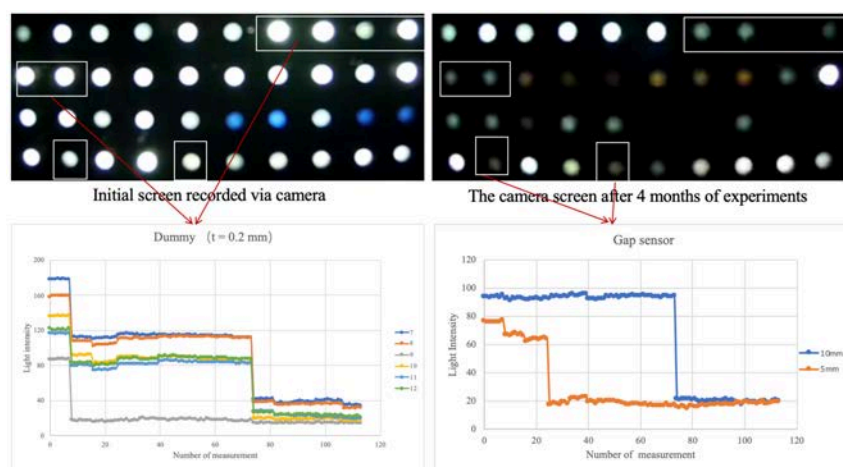


Fig.4 Corrosion captured by pipe-type sensor and gap sensor.