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POST-GRADUATION PROGRAM IN STRUCTURES AND CIVIL CONSTRUCTION

ISRAEL NILTON LOPES SOUSA

OPTICAL SENSOR SYSTEM FOR CORROSION MONITORING

FORTALEZA

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ISRAEL NILTON LOPES SOUSA

OPTICAL SENSOR SYSTEM FOR CORROSION MONITORING

A Dissertation presented for the Graduate Program in Civil Engineering: Structures and Civil Construction of the Federal University of Ceará, as a fulfillment of the requirements for the Degree of Master. Area within the Graduate Program: Civil Construction.

Advisor: Prof. Esequiel Fernandes Teixeira Mesquita, Ph.D.
Co-advisior: Prof. Antônio Eduardo Bezerra Cabral, Ph.D.

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Approved in: ___/___/_____.

COMMITTEE MEMBERS

_____

Prof. Esequiel Fernandes Teixeira Mesquita, Ph.D. (Advisor)
Federal University of Ceará

_____

Prof. Antônio Eduardo Bezerra Cabral, Ph.D. (Co-advisor)
Federal University of Ceará

_____

Prof. Camilo Arturo Rodriguez Diaz, Ph.D.
Federal University of Espirito Santo

_____

Prof. Paulo Fernando da Costa Antunes, Ph.D.
University of Aveiro

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“Experiment is the only means of knowledge at our disposal. Everything else is poetry, imagination.”

(Max Planck)

ABSTRACT

Corrosion is one of the main degradation phenomena to act on metallic structures, resulting in great economic losses. As a result, different techniques to evaluate and monitor this parameter have become the object of study in recent years. There is a great tendency towards the use of optical fiber sensors for monitoring different parameters, thanks to their advantages over traditional electronic sensors, for example, possible use in aggressive and/or explosive environments, immunity to electromagnetic fields, electrical isolation, low weight and size, longer useful life, among others. Optical accelerometers have also gained prominence, integrating the characteristics of optical sensors, and allowing a greater possibility of applications. The application of these sensors is already widespread for monitoring temperature, stress, strain, refractive index, acceleration, and relative humidity, among others. However, despite the wide possibilities of use in engineering structures, there is still a need for further studies on its application in other areas, such as monitoring corrosion in metallic structures, in particular, in pipelines for the transport of flammables. The variation of the natural frequency of a material is related to the variation of its thickness and stiffness, parameters related to corrosion. This relationship establishes the principle governing the measurements of this work. In this way, it is proposed in this dissertation the development and implementation of an optical sensor based on Bragg gratings for continuous monitoring of the loss of thickness in metallic elements subjected to controlled corrosion, in a generalized and uniform way in a carbon steel plate 1020, as well as the development of an optical fiber accelerometer based on Bragg gratings together with pairs of optical fibers based on the same principle for monitoring the corrosion of a pipeline section of the same material, buried and subjected to controlled corrosion, through monitoring the variation of its natural frequency. The results obtained were promising and indicated the detection of corrosion through fiber Bragg gratings on the metallic plate, with a coefficient of determination superior to 67% to all nine sensors, however, in the monitoring of the pipe section, only the optical fiber accelerometer was able to identify corrosion properly by identifying the variation of the natural frequency, with a coefficient of determination equivalent to 74.43% throughout the monitoring.

Keywords: Fiber Bragg gratings, Optical fiber sensor, Optical fiber accelerometer, Corrosion, Buried pipelines.

RESUMO

A corrosão é um dos principais fenômenos de degradação a atuar sobre estruturas metálicas, resultando em grandes perdas econômicas. Dessa forma, diferentes técnicas para avaliar e monitorar esse parâmetro tornaram-se objeto de estudo nos últimos anos. Observa-se uma grande tendência à utilização de sensores de fibra óptica para monitoramento de diferentes parâmetros, graças as suas vantagens sobre os sensores eletrônicos tradicionais, como por exemplo, possível utilização em ambientes agressivos e/ou explosivos, imunidade a campos eletromagnéticos, isolamento elétrico, baixo peso e tamanho, maior vida útil, entre outras. Os acelerômetros óticos também tem sido objeto de estudo, integrando as características dos sensores ópticos permitindo uma maior possibilidade de aplicações. A aplicação desses sensores já se apresenta largamente difundidas para o monitoramento de temperatura, tensão, deformação, índice de refração, aceleração, umidade relativa, dentre outros. Apesar das amplas possibilidades de utilização em estruturas de engenharia, ainda se destaca a necessidade de uma ampliação de estudos acerca da sua aplicação em outras áreas como no monitoramento da corrosão em estruturas metálicas, em especial, nos dutos de transporte de inflamáveis. A variação da frequência natural de um material está relacionada a variação de sua espessura e rigidez, parâmetros relacionados à corrosão. Essa relação estabelece o princípio governa as medições deste trabalho. Desta forma, propõe-se nesta dissertação, o desenvolvimento e implementação de sensores óticos com base em redes de Bragg para monitoramento contínuo da perda de espessura em elementos metálicos submetidos a corrosão controlada, de forma generalizada e uniforme em uma placa de aço carbono 1020, assim como o desenvolvimento de um acelerômetro óptico com base em redes de Bragg junto a pares de fibras óticas com base no mesmo princípio para o monitoramento da corrosão de uma seção de duto de mesmo material, enterrada e submetida a uma corrosão controlada, através do monitoramento da variação da sua frequência natural. Os resultados obtidos foram promissores e indicaram a detecção da corrosão através das fibras ópticas com base em redes de Bragg na placa metálica, com coeficiente de determinação superior a 67% para todos os nove sensores, no entanto, no monitoramento da seção do duto, apenas o acelerômetro ótico foi capaz de identificar a corrosão adequadamente, através da variação da frequência natural, com coeficiente de determinação de 74.43% ao longo do monitoramento.

Palavras-chave: Redes de Bragg, Sensor de fibra óptica, Acelerômetro óptico, Corrosão, Dutos enterrados.

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