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Various Methods for Determining Cracks in the Infrastructure, a Review

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ABSTRACT

The paper aimed to present the different ways of determining the cracks. Cracks are the lines on the surface of something along which it has split without breaking apart. There are many ways we can determine like with the help of strain gauge, DMI technology, etc. In this review, an effort has been made to find out the various methods by which we can find the cause and location of the cracks. In this review, various methods, technologies, sensors' articles are reviewed and on the basis of that study has been done. This study has been done. This study helps the civil engineers and researchers to find out the location and cause of cracks.

Keywords: crack detection, capacitive strain sensors, soft elastomer capacitor, strain gauge

INTRODUCTION

Cracks are one of the main reasons for deterioration of infrastructure (Kong et al., 2018). Cracks with no doubt are signals for our failure, but in the same phase we have to find the reason behind the cracks. We have to find the reason so that they can be controlled and we can be safe from our vast loss in the economy. Cracks cause can be any like temperature, material's quality or any procedure by which we build our structure. The following review of the literature confirms the different types of technologies by different types scientists and researchers to determine the cracks in the slab, concrete, steel bridge, retaining wall or any other part of our infrastructure.

MATERIAL AND METHODS

Cracks evaluation by strain gauge

Cracks are the building problem to the infrastructure, there are many practices which have been done to tackle with cracks. For example, De Backer et al. (2003) used the strain gauge directly to the concrete surface, as a controlling mechanism on the effectiveness of the post-tensioning of large concrete beams. They also deliver a case study stating the validity of this method. Also when the practical execution of the measurements is carried out with the utmost precision, this method delivers reliable and precise results but taking into account the specific working conditions. This problem is also related to temperature change and type of infrastructure, So Dilrukshi and Dias (2016) stated about the cracks that the building survey and physical model observations demonstrate that the movements generated on walls due to the temperature of the roof slab follow the pattern of those diurnal temperature variations. They explain that the pattern (type and location) of cracking depends significantly on whether the wall is load-bearing or framed by the reinforced concrete elements. They state that cracks can be formed in the wall just under the concrete beam or at the masonry - concrete beam interface, usually at the weaker of the two. Both types of structural arrangements give diagonal cracking near the ends of the walls, with the crack orientation steeper in load-bearing walls. In long walls, the formation of diagonal cracks at the ends is more likely, but both types of cracks could form.

DMI technology for cracks determining

So as the technology shows its dignity, many new technologies come. Ranson et al. (2007) conducted DMI technology and in that, they conduct experiments which were to demonstrate the utility of the DMI technology to measure strain around a hole in a plate subjected to cyclic loading and crack growth in the hole and ultimately to the surface of the plate. In their experiments, two edges of the gage were parallel to the direction of cyclic loading. They also tell that the orientation of the gage and its ability to detect crack initiation and crack growth is independent of the orientation of the gage, because the gauge measures orthogonal extensional strains and associated shear strains. They use DMI technology permits periodic inspection of a DMI gage centered on a fastener hole containing a fastener on in-service equipment to determine the presence of cracks at scheduled inspection intervals or after an unusual loading. This comment is based on the discussion by Timoshenko and Goodier cited above. This does not mean that electrical resistance gages do not have a role. They also suggest that electrical resistance gages may be more economically and technologically informative, if deployed differently than currently deployed on surfaces with fastener hole.

FBG optical strain gauge

To increase the precision for crack determining, Kaklauskas et al. (2019) used strain profiles of the reinforcement bars attained from the FBG optical strain gauge and ordinary tensor strain gauge in a comparison. In addition, they carried out numerical calculations using the stress transfer approach to obtain the numerical strain variation along the reinforced concrete prism reinforcing bar. In their experimental techniques, they provide strain variations along the steel bar with reasonable accuracy and smoothness, however, the specimen strain results of the fiber Bragg grating optical gauge test displayed anomalies, particularly near the end of the specimen. Then the measured strains which they use were larger than the strain value estimated for a bare bar assuming the experimental value of the modulus of elasticity of the bar. In addition, the FBG recordings were lacking consistency regarding the symmetry condition of the left and the right side of the member. Due to fluctuations in the strain values recorded by FBG sensors and the rather rare spacing between the sensors, it cannot be firmly asserted whether the phenomenon was related to the debonding effect proposed in previous research by the authors. Their effect implies altered bond behavior between the reinforcement and the concrete material surrounding it around the location of the cracks or elements' ends. A comparison of the numerical results with appropriate experimental strain curves of the steel reinforcement showed that the Model Code 2010 bond-slip equation could provide sufficiently accurate results when coupled with the stress transfer approach for the Ø20 mm specimens. However, their additional tests with different diameter bars and reinforcement ratios would help them either affirm or negate the findings. Some discrepancies in numerical and experimental strain comparison appeared at the highest loading of the FBG specimen. The overall observed behavior was parabolic, with steeper strain gradients at higher loading stages. Their approach to stress transfer can provide very comprehensive results of reinforcement and concrete strains, the bond stress and slip values over the entire distribution of the element, provided the implemented bond-slip model was accurate.

SEC (Soft Elastomer Capacitors) and basic function on crack estimation

A study that was focused on examining the suitability of a novel large-area strain-based sensing technology for monitoring fatigue cracking. Kong et al. (2018) have presented a study that was focused on examining the suitability of a novel large area strain-based sensing technology for monitoring fatigue cracking in steel bridges. They take SEC which is a large-size, flexible, low-cost, and mechanically-robust capacitive strain gage, and has a wide strain measuring range, making it a promising tool for monitoring cracks in bridges. Their studies have verified the SEC's capabilities for monitoring low-cycle fatigue cracking, but high cycle fatigue cracking is characterized by a small crack openings, which presents was a new challenge for a capacitance-based sensor such as the SEC. To achieve that monitoring solution for fatigue cracking in steel bridges, they use the pk-pk amplitude of the sensor's measurement to construct an indicator of crack growth. Then they establish a crack monitoring algorithm to compute CGIs as a normalized pk-pk amplitude in the frequency domain. The sensor's capabilities and the proposed algorithm was evaluated through experimental testing under various stress ratios, R. They got some conclusions that the developed algorithm was able to overcome noise infiltration, and resulted in an excellent correlation between increasing fatigue crack length and increasing CGI. Therefore, the proposed crack monitoring algorithm was validated by the test data. They state that the proposed crack monitoring algorithm was able to robustly monitor the growth of high cycle fatigue cracks under various loading conditions and provide consistent results for the three stress ratios that were studied. With the introduction of the monitoring algorithm, the SEC was found to be capable of serving as a monitoring device for propagating fatigue cracks in steel bridges.

Detection, localization, and quantification of cracks by SEC(soft elastomeric capacitors)

Yan et al. (2019) studied the novel sensing skin for the detection, localization, and quantification of cracks in concrete. The sensing skin, constituted from an array of soft elastomeric capacitors (SECs), is an inexpensive, durable, and robust sensing solution that can be leveraged to measure strain over large surfaces. Their strain measurement values were collected in the form of discrete point values among the network. The spatiotemporal comparison of strains enables the detection, localization, and quantification of cracks. The sensing skin was first introduced and validation results preliminarily conducted on small-scale reinforced concrete beams were presented. Initial characterization of a free-standing SEC led to a gauge factor that they used to map electrical signals to strain and thus, cracks. Time series measurements from the SECs and visual observations from crack growth were in agreement. Their sensing capability was further studied by deploying a sensor network of 20 SECs onto the surface of a full-scale post-tensioned concrete beam. A bending test with a loading and unloading sequence was conducted until structural failure, and data from the SECs and visual observation of cracks collected. Results demonstrated that data collected from the distributed SEC network correlated with crack-induced damage. The extraction of time series features, among which the maximum relative change in capacitance at each loading step, showed good agreement with the observed normalized crack length. Sensors 2019, 19, 1843 11 of 12 Overall, the SEC network showed capable of detecting, localizing, and quantifying cracks in concrete.

CONCLUSION

Cracks which are initiators for other problems can be determine in our infrastructure in many ways by using many technologies. So in this literature review, you can find out how we can have different technologies overcoming each other by the time. Cracks which are inbuild the concrete can be evaluate by strain gauge. Similarly, DMI technology, FBG strain gauge and SEC can also evaluate cracks' abnormality. The literature reviewed in this case does not fully fill with the ideal work. However, there can be many alternatives which are yet to invent or discover

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