

Study on the Fatigue Damage Assessment of Concrete Bridge Deck by Developing a Type of Carbon Fiber Mortar Sensor

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1. INTRODUCTION

There are a lot of aging bridges existed in Japan and around world, resulting to a need of the simple and efficient self-warning method that can differentiates the bridges with severe damages. Carbon Fiber Mortar (CFM) is a kind smart material which is able to show its own mechanical status. However, since the feature of CFM has still remained unclear in many aspects such as the atmosphere influence, calibration and measurement errors, and so on, its application in structural damage inspection is still quite limited. Therefore, this study aims to investigate the feasibility of investigating the structural fatigue damage based on the electrical conductivity of the mounted CFM.

2. TEST SETUP

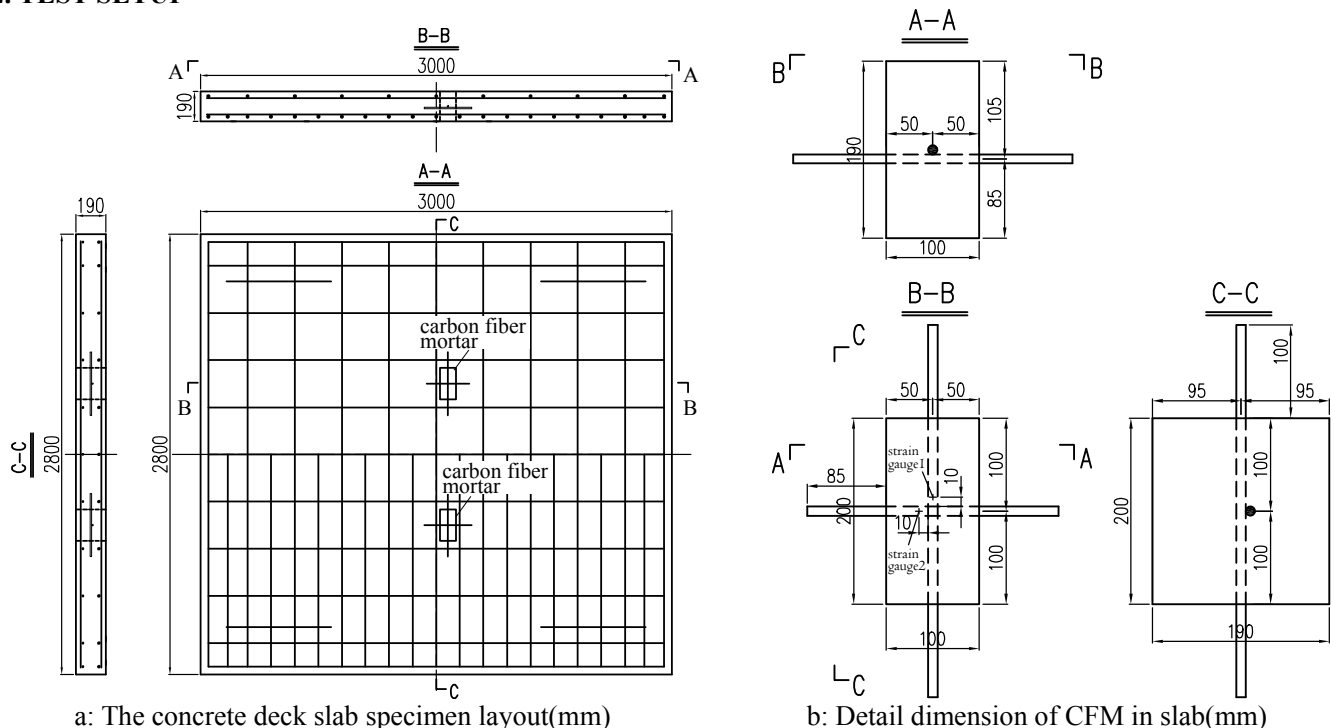


Fig. 1. The concrete deck specimen and CFM detail.

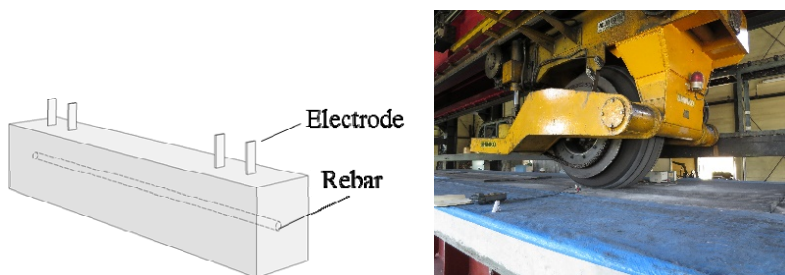


Fig.2. Material specimen.

Fig. 3. wheel test.

There were two concrete deck slab specimens (N1 and N2) prepared for the wheel loading fatigue test. The layout of concrete deck slab are shown in Fig. 1. The volume percentage of carbon fiber in N1 specimen was 0.4% while the one in N2 was 0.2%. On the other hand, CFM material test specimens as shown in Fig.2 were prepared as well to investigate several typical effects on the electrical conductivity of CFM.

Keywords: Carbon Fiber Mortar; sensor; concrete slab; wheel load fatigue test; electrical conductivity.

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The wheel loading fatigue test setup is shown in Fig. 3. The wheel load was 160kN. The fatigue load cycles on N1 and N2 were respectively around 135000 cycles and 215200cycles.

In addition, the static investigations during the test process were carried out, such as the deflection development, crack distribution, conductivity measurement of CFM. The HIOKI IM3533 electrical resistance meter was used to measure the 1kHz AC electrical resistance and then deduce the corresponding electrical conductivity.

3. TEST RESULTS

The deflections at the center of the slab specimens became relative stable after dramatic increases during the initial 1000 cycles. The longitudinal and transverse cracks can both be observed at the bottom side of slabs. However, the crack passing through CFM area had not been found during the test.

Fig. 4 summarizes the part of the material test results concerning about the relationship between atmosphere temperature and electrical conductivity of CFM. It can be seen that the electrical conductivity increases with the temperature obviously. Fig. 5 summarizes the measured results of the electrical conductivities of CFM in N2 specimens. The raw data with the influence the atmosphere effect appeared stable compared with the strain development of rebar and the deflection feature. Fortunately, an obvious conductivity reduction tendency can be observed after the temperature compensation, indicating the fatigue damage development. Although the detail sensitivity of the CFM to the structural fatigue damage remains unclear, it can be confirmed that it's possible to apply the CFM's conductivity to warn the serious structure damage at present.

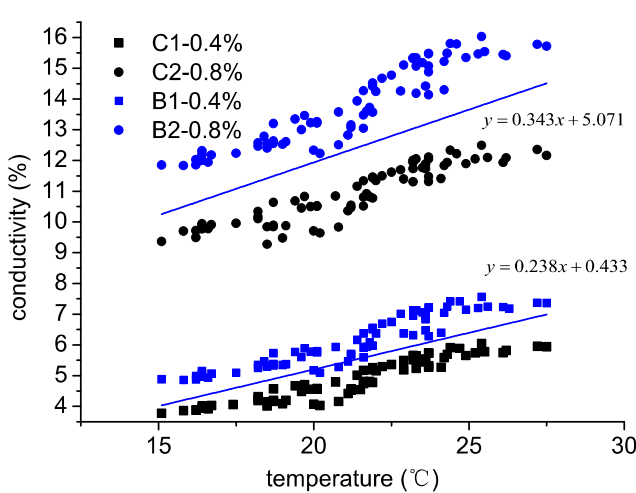


Fig. 4.

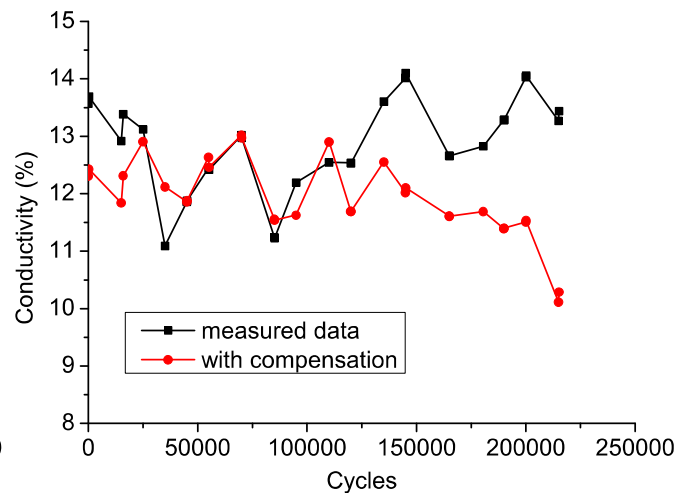


Fig. 5.

Fig. 4: Relationship between temperature and electrical conductivity; Fig. 5: Relationship between conductivity and fatigue load cycles in N2 specimen

4. CONCLUSIONS

The applicability of Carbon Fiber Mortar (CFM) on sensing the structural fatigue damage was discussed in this paper in terms of the results of the material tests and the fatigue wheel loading test on concrete deck slabs.

1. CFM's conductivity was sensitive to the atmosphere temperature. And rebar inside the CFM can influence the conductivity as well.
2. Although the detail sensitivity of the CFM to the structural fatigue damage remains unclear, it can be confirmed that it's possible to apply the CFM's conductivity to warn the serious structure damage at present.

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