DESIGN AND INVESTIGATION OF A SCOUR MONITORING SYSTEM WITH FIBER BRAGG GRATING SENSOR

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Fiber-optic sensor has its unique advantages, with a light weight, low loss, and immunity to electromagnetic interference, etc. It can be used in a variety of harsh environments and under high electric field strength to do the environment monitoring. Several fiber sensors design based on fiber Bragg grating (FBG) for numerous physical detections such as temperature, pressure, tilt, vibration, displacement, refractive index [1-3], etc. To the best of our knowledge, there are a few papers using FBGs to sense the bridge scour [4-5].

According to statistics approximately 60 % of all bridge failures reason is caused by water erosion. Nowadays, bridge scour monitoring is an important security issue. In this paper, we propose a new design using FBG sensing element for bridge scour depth monitoring. It is combined with gear mechanisms and fiber optic sensing system (see Figure 1). We design a maximum measurement bridge scour depth of 4 m which has been to meet the needs of bridge safety. The circumference of the pulley is 0.2 meter and the pitch of the threaded screw rod is 1 mm. This dimension is designed to let the threaded screw rod rotates one thread into the screw holes on the left side, when the heavy hammer pulls down the pulley for one rotation. We design to allow the sensor head (silicone rubber) can be applied maximum downward depth of 20 mm. This means that the pulley can be rotated 20 turns. Therefore, the FBG can be protected not easy to break and be achieved the depth measurement of 4 m.

Figure 1 depicts an overview of the fiber-optic sensor measurement system be used for the detection of bridge scour depth. The output beam of a broadband source (BBS) is connected to the first port of optical circulator (OC), and the FBG sensor is connected to the second port of OC. When the BBS propagating light enters port 1 and emitted from port 2, if the wavelength satisfied the Bragg condition will be reflected back to the OC and exited from port 3 into the optical spectrum analyzer (OSA). Then we can observe the amount of the central wavelength shift of the FBG and obtain the scour depth.

The sensing element of FBG was embedded in silicone rubber which is 14 cm long, 3 cm wide and 1 cm high. And both ends of silicone rubber are fixed to a metal sheet. We experiment with different materials of metal sheet to compare central wavelength shift and measurement ranges. The length, width and height of the metal sheet are 50 mm, 20 mm and 0.3 mm. The metal sheet materials include silicon manganese steel, manganese steel and cyanide tungsten steel. Figure 2 shows the experimental results. In Figure 2, the silicon manganese steel can achieve our design goal that the scour depth up to 4 m will be measured. And the maximum measurement scour depth of cyanide tungsten steel and manganese steel are 3.2 m and 3.6 m, respectively.

Keywords: Fiber Bragg grating, scour depth monitoring, fiber sensor.

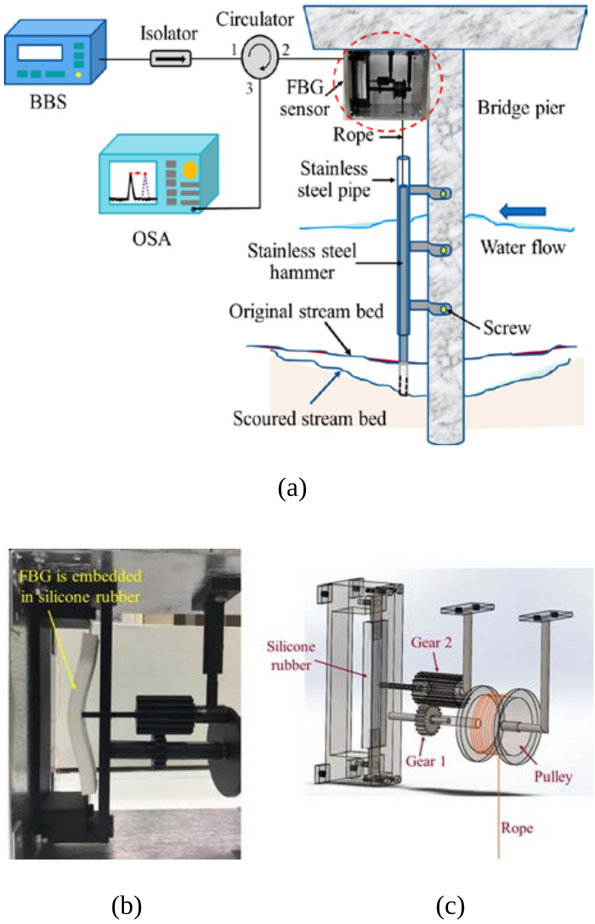

Fig.1 The configuration of the proposed bridge scour depth sensor: (a) the schematic of fiber sensing system, (b) the amplification of FBG sensor, (c) the structure of FBG sensor.

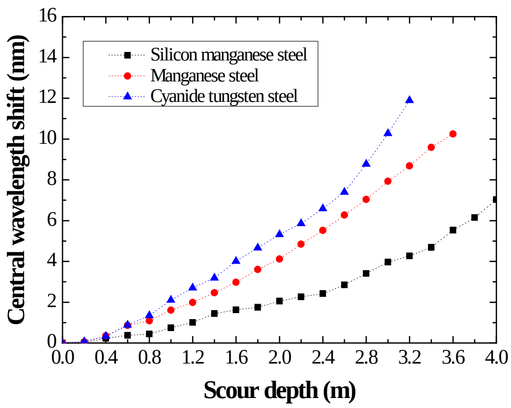

Fig. 2 The central wavelength shift as a function of bridge scour depth for different metal materials.

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