Identification of Cable Damage Based on the Bridge Health Monitoring System

Liang Zhu
Civil Engineer
CCCC Highway Consultants Co., Ltd.
Beijing, China
liangzhu1980@163.com

Liang Zhu, born 1980, received his civil engineering degree from Zhejiang University.

Feng Liangpin
Department Manager
CCCC Highway Consultants Co., Ltd.
Beijing, China
flp_cn@126.com

Feng Liangpin, born 1972, received his bridge engineering degree from Tongji University.

Li Na
Department Vice Manager
CCCC Highway Consultants Co., Ltd.
Beijing, China
ln_prc@yahoo.com.cn

Li Na, born 1972, received her road engineering degree from Tongji University.

Summary

Cable is the key component of cable-stayed bridge. The rustiness and the damage of cables inevitably cause the change of cable force, girder alignment and the status of the structure. As a result, it threatens the security of bridge. In present paper, latest methods to monitor cable force and girder deflection are introduced. By means of sensitivity analysis, a cable damage identification method based on the deflection and cable force monitoring is addressed and applied to the analysis of a single tower cable-stayed bridge.

Keywords: cable; girder; cable force; deflection; monitor; damage.

1. Introduction

Since the corrosion damage causes the modification of internal forces, even the overall damage of the structure, the monitoring or detection of cables is very necessary. Over the last decade, the bridge structural health monitoring system has been installed on many important long span bridges to monitor the bridge operating state. On the one hand, the cable damage results into the change of cable force and its re-distribution. On the other hand, the change of cable force induces the deflection of the bridge deck. In present paper, by means of sensitivity analysis, a cable damage identification method based on the deflection and cable force monitoring is addressed and applied to the analysis of a single tower cable-stayed bridge.

2. Cable force and girder deflection monitoring

The cable force monitoring methods in operation mainly include (i) Pressure sensor, (ii) Acceleration sensor, (iii) Laser Doppler vibrometer[1], (iv) Magnetoelastic sensor, (v) FRP-OFBG Smart cable. The current methods for girder deflection monitoring in operation include (i) measurement robot, (ii)laser deflection instrument, (iii) GPS, (iv) liquid pressure measurement system of open or closed connected pipes.

3. Monitoring system for Shenzhen-Hong Kong Western Corridor Bridge

Fig. 1: Shenzhen-Hong Kong Bridge, in China

The Shenzhen-Hong Kong Western Corridor Bridge (See figure 1) is connecting Hong Kong and Shenzhen across Shenzhen Bay. Its total length is about 5.5km. It consists of two cable-stayed bridges and a series of continuous beam bridge. The main bridge is a single inclined tower and single cable plane cable-stayed bridge. The main bridge in Shenzhen side has three spans with the length of 180+90+75m. The tower is the concrete structure and the girder is a steel box structure with the width of 38.6m. Bridge construction began in 2003 and was completed in 2007.

There are 24 cables on the bridge. Accelerometers are placed on half of the cables to measure the cable vibrations and obtain the cable force. Liquid pressure monitoring system of closed connected

https://doi.org/10.2749/222137809796088512

pipe is adapted to monitor the deflection of the girder.

4. Sensitivity analysis for cable damage identification

The finite element model was build for analysis. Simulate different cable damage and analyze the condition changes of cable force and girder deflection due to the damage.

4.1 The Sensitivity of cable force to cable damage

If damage happened, such as cable wire rustiness or break, the force of the damaged cable will be changed and other cables' force will be re-distributed to reach a new equilibrium state. All the cable force changes were separately analyzed when 10% damage of each cable happened. The results are:

(i) When the 10% damage happened, the force of the damaged cable is significantly reduced. The most decrease is 9.73%;

(ii) Except for the damaged cable, other cable forces aren't changed significantly (less than 1%).

(iii) The sum of all the cable force is reduced, so that the bearing reaction force is increased. If the longest cable is damaged, the total change reaches the maximum.

(iv) The accuracy of vibration method to monitor cable force is about 5%. The cable force is sensitive to the damaged cable but not sensitive to the health cable.

4.2 The Sensitivity of Girder deflection to Cable Damage

The girder deflection change is separately analyzed when 10% damage of each cable happened. Partial results are shown in Fig. 2.

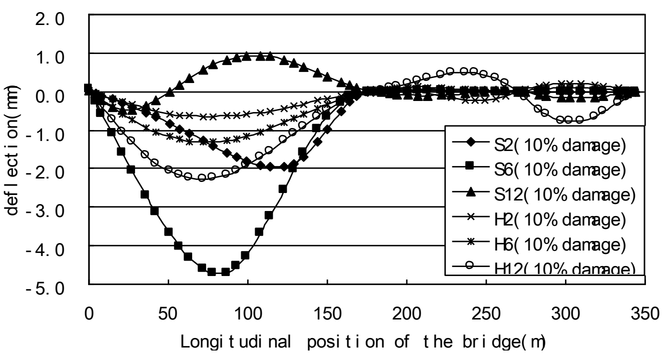

Fig. 2: girder deflection due to10% cable damage

wings are observed:

the cables near to the midpoint of the n have 10% damage, the deflection pan is downward. The deflection he maximum (4.7mm) when the is damaged.

the cables of the side span have e damage, the deflection of main so downward. The maximum is mm.

(iii)Only the deflection of the main span is sensitive to the main span cable damage.

5. Conclusions

The measurement accuracy determines the effectiveness of damage identification based on bridge health monitoring system. If the measurement is accurate, the identification is reliable. For the structural health monitoring system of cable-stayed bridge, this method can be used for sensitivity analysis to optimize the layout of sensors.

6. References

[1] KEITA K., TAKESHI M., YOZO F., NORIYUK M., SHUJI U., and HIROYASU S., "Development of a Super Remote Laser Sensing System for Monitoring of Cable-Supported Bridges", *The 6th international cable supported bridge operators' conference*, Takamatsu, Japan , 2008, p.77-84.