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Development of a structural health evaluation system for cable bridges by using seismic accelerometers

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ABSTRACT

A program for structural health monitoring of cable-stayed bridges using seismic accelerometers is developed. Various response indices in monitoring structural safety and serviceability of the bridges are discussed. A systematic approach to process the raw data for generating appropriate response indices is proposed. The system is verified using data sets of a test-bed structure. The program for the structural condition evaluation is composed of four parts each of which corresponds to the major process of the structural health evaluation: (i) format conversion of the raw data, (ii) noise filtering, (iii) generation of response indices, and (iv) condition evaluation. Decision of limit states included in the condition evaluation step is discussed and an example of the graphic user interface of the program is represented.

1. INTRODUCTION

For the public safety management, the use of a structural health evaluation system based on seismic accelerometers is in increasing demand. Due to the recent development of sensor and measurement technologies, the number of monitoring systems installed on important structures such as cable bridges is rapidly increasing (Jang et al. 2010). The condition assessment system is useful for pre-earthquake disaster planning and post-earthquake recovery programs. The majority of the monitoring software in the field are developed by the equipment providers and hence have not been verified their reliability in structural condition assessment. Therefore, it is importance to develop a reliable health monitoring software that can generate appropriate response indices of the structure (National Disaster Management Institute, 2012, 2013, 2014). In this paper, major components of a health monitoring software and a data matrix to generate response indices are discussed. The data matrix represents the interrelationship between the measured data from the seismic accelerometers and the response indices.

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2. STRUCTURE OF THE ANALYSIS PROGRAM

The program is composed of four parts each of which corresponds to the major process of the structural health evaluation. The first part is the format conversion process where the compressed format of the acquired acceleration data is converted to text format for numerical calculations (Fig. 1). SEED or MiniSEED is widely used for recording the raw data from seismic accelerometers (IRIS 2012). The compressed format of the raw data need to be converted to text data for further analysis procedures. Physical factors are needed to make text data from the raw data, which is the record of changes in voltage acquired from the accelerometer sensors. Physical factor is calculated from the sensitivity value for the recorder and the response value for the accelerometer. Physical factor is calculated from the sensitivity value for the recorder and the response value for the accelerometer and acceleration in gal is obtained by multiplying the physical factor to the count values in the raw data. For instance, the physical factor is calculated as 2.336×10^{-4} from Eq. (1), if the sensitivity and the response values are given as 1.1921 μV/count and 0.5102 V/(m/sec^2), respectively.

$$\text{physical factor} = \frac{1.1921}{0.5102}\cdot\frac{\mu V/count}{V/(m/\sec^2)} = 2.336\times10^{-4}\ gal/count \tag{1}$$

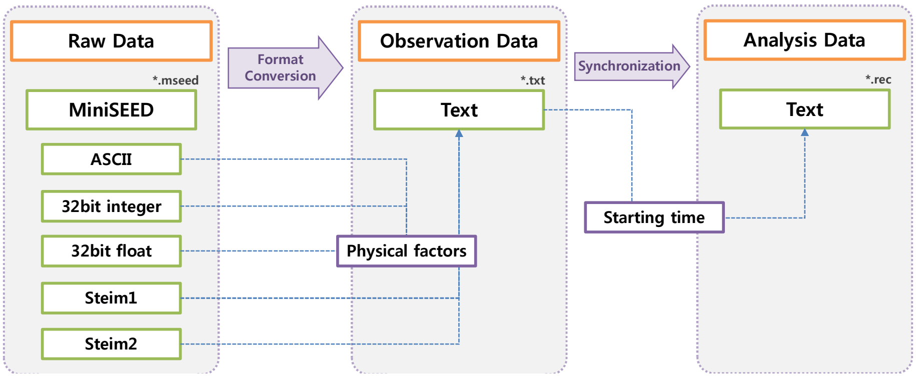

Fig. 1 User interface of the health monitoring system

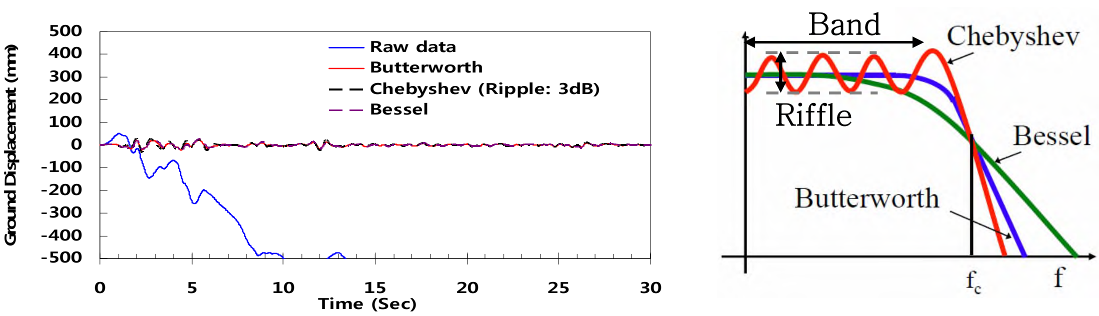

Fig. 2 Comparison of processed data with different filters

The second step is the noise filtering process. Since there are various sources of noise in the measured accelerogram, processing data without noise filtering will