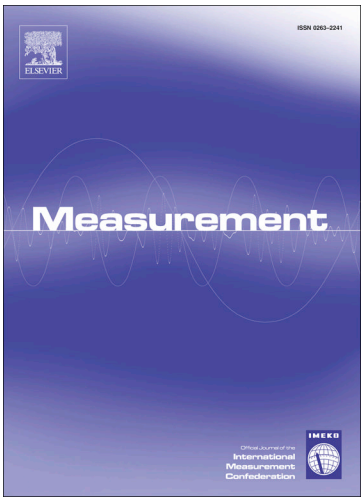

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An Automatic Extraction Algorithm for Measurement of Installed Rock Bolt Length Based on Stress Wave Reflection

Ming Lei [a,†], Weijie Li [b,†], Mingzhang Luo [c,*], Gangbing Song [b]

[a] School of Computer Science, Yangtze University, Jingzhou, Hubei, 434023, China; 6611972@qq.com;
[b] Department of Mechanical Engineering, University of Houston, Houston, Texas, 77204, USA; wli27@uh.edu (W.L.); gsong@uh.edu (G.S.);
[c] School of Electronics and Information, Yangtze University, Jingzhou, Hubei, 434023, China;
* Correspondence: lmz@yangtzeu.edu.cn (M.L.);
† The co-first author. These co-first authors have equal contribution to this work.

Abstract: A rock bolt is a reinforcing bar commonly used in geotechnical engineering, and it plays an important role for the safe operation of the reinforced structures, such as tunnels, underground stations, and stabilized slopes. The length of an installed rock bolt is an important quality index that ensures the performance of a rock bolt for the stability of the reinforcing structure. In this paper, based on the general principle of stress wave propagation, the method of Automatic Extraction Algorithm (AEA) is developed using self-correlation analysis to measure the length of an in-service rock bolt, whose length is mostly embedded. The propose method has advantages of simple computation and high accuracy. Through laboratory experiments and field tests, we compared the performances of AEA with the traditional Phase Analysis Method (PAM) and the results demonstrated that the proposed AEA showed improved performance in terms of both detection speed and accuracy in rock bolt length estimation. In addition, the AEA method was successfully implemented in several engineering scenarios with high accuracy.

Keywords: Stress wave; Rock bolt; Rock bolt length estimation; Self-correlation analysis; Automatic Extraction Algorithm (AEA); Phase Analysis Method (PAM)

1. Introduction

Recent decades have witnessed the rapid advances in structural health monitoring (SHM) [1-6] and Non-destructive Evaluation (NDE) [7, 8], which also receive increasing attention from geotechnical engineering, underground engineering, and tunneling engineering [9]. A rock bolt is a reinforcing element commonly used in such engineering and plays an important role for the safe operation of reinforcing structures. The length of an installed or in-service rock bolt is an important index for anchorage quality [10]. The independent inspection of the lengths of installed rock bolts is critical to guarantee the installed rock bolts satisfy the design requirements. If the installed rock bolt length is insufficient, the reinforced structure would suffer from collapse and leads to catastrophic losses both economically and environmentally. It is therefore significant to accurately inspect the length of installed rock bolt to ensure the safe operation of the reinforced structure.

For an in-service rock bolt, since most of its length is embedded and only one end is exposed, it is a challenge to estimate its length. Taking the advantage of a rock bolt as a wave guide [11-13], the stress wave reflection method has been widely used for the non-destructive evaluation of in-service rock bolts [14-18]. When using this method to evaluate the rock bolt length, inaccurate result often occurs. There are several reasons for such an issue. The signal noise ratio (SNR) of reflected wave signal is low due to the noisy environments. Most importantly, it is the improper analysis and processing of the stress wave signal. At present, rock bolt length detection mostly relies on the experience of the operators [19, 20],