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Damage Assessment of Prestressed Concrete Girders Using Crack Fractal and Frequency

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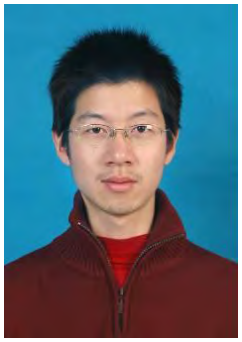

Shenghua TANG, born in 1985, received his civil engineering Ph.D. degree from Hunan University, China. His main area of research is related to structural damage identification.

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1 Abstract

Two novel approaches are proposed in the present study to assess the damage degree of girders based on the fractal analysis of crack patterns and natural frequency. Two full scale simply-supported prestressed concrete box girders were firstly designed and subjected to three-point repeated load bending tests. Concrete cracking, deformation and natural frequency of the girder were investigated during the test. Then, the box-counting method was improved by rectangle box to analyze the fractal dimension (FD) of girders based on the flexural crack pattern in each loading stage. It shows that the surface crack patterns of the tested girders possessed definite fractal character. The FD of the girders has also an approximately bilinear relationship with the natural frequency of girders. The turning point is very close to the yielding of the prestressed tendons in the girders. Based on this, a damage index is proposed to estimate the remnant stiffness of the girders based on the FD of visible cracks. The FD frequency curves can also be employed to discriminate the damage grades of the girders. Both of the two approaches have been verified with high accuracy.

Keywords: fractal dimension; damage assessment; crack pattern; natural frequency; prestressed concrete girder.

2 Introduction

Civil engineering structures are usually subjected to various damages, such as natural disaster, deterioration. The detection and assessment of these damage are very important for the structural safety. The appropriate extraction of damage characteristic factors is crucial to effectively reflect and assess the damage of structures [1].

For concrete structures, the most obvious damage is surface cracking of concrete. Crack width and crack pattern are usually used as the convenient condition rating scales [2]. Fractal, as a new mathematical theory, can be able to describe the complex and irregular natural phenomenon [3]. It has been gradually extended to the analysis of concrete structures. Such as the cracks of reinforced concrete beam under concentrated load [4,5] and reinforced concrete shear walls under reversed cyclic loading were evaluated by means of fractal method [6-8].

However, there are few reports on the quantification of structural damage using the fractal

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