Available online at www.sciencedirect.com
ScienceDirect
Engineering Fracture Mechanics 75 (2008) 643–651
Engineering Fracture Mechanics
www.elsevier.com/locate/engfracmech

Application of DSCM in prediction of potential fatigue crack path on concrete surface

Li-Ping Guo [a,*], Wei Sun [a], Xiao-Yuan He [b], Zhen-Bin Xu [b]

[a] College of Materials Science and Engineering, Southeast University, Nanjing 210096, PR China
[b] College of Civil Engineering, Southeast University, Nanjing 210096, PR China

Received 21 November 2006; received in revised form 11 January 2007; accepted 12 January 2007
Available online 7 February 2007

Abstract

Prediction of potential fatigue crack paths on the surfaces of concrete structures was a difficult task in the past. To complete this task a Finite Element Method simulation by computers is usually employed, but bearing in mind that the numerical results are not always consistent with the experimental ones because of the effects of various environmental factors and construction quality on concrete structures. In order to inspect the damage process during the service life of structures and to confirm their detailed plan of repair and reinforcement, a new non-destructive technology is used for on-line health inspection of many important concrete structures in the world. Fortunately, along with the development of Digital Speckle Correlation Method (DSCM) in the last two decades, this new non-destructive technique has presented many advantages. To testify the feasibility and accuracy of this system, two series of concrete specimens were tested under flexural fatigue loading and a software *UU*© matched to DSCM was employed in this work. DSCM can get full-field and local displacements by comparing two speckle images on target surfaces before and after deformation. Then the full-field and local strain fields on these regions can be deduced from the longitudinal and transversal displacements. By analysis of these strain fields, the starts of potential fatigue crack paths can be predicted precisely. It is testified that DSCM system is accurate and effective in on-line prediction of potential fatigue crack path of specimens made of heterogeneous materials under flexural cyclic loading. The fractural mechanisms of the two concrete series under flexural cyclic loading were discussed. Note that the fatigue testing conditions should be kept still and clean in order to produce precise results of DSCM system.

Keywords: Flexural fatigue; Concrete; Crack path; Displacement; Strain field; DSCM

1. Introduction

Many concrete structures are subjected to repeated loadings during their service life. Under such loading conditions the modeling of fatigue propagation of developing cracks is fundamental (e.g. see Refs. [1–4]). Also, prediction of potential fatigue crack path is critical for safety evaluation and structural design of

* Corresponding author. Tel.: +86 25 8165 4819; fax: +86 25 5209 0667.
E-mail address: guoliping691@163.com (L.-P. Guo).

0013-7944/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.engfracmech.2007.01.023

important components or structures, e.g. bridges, seashore structures, runway, etc. [5]. Because of the complex stress distribution on structure surface, it is therefore a challenge for engineers and research scientists to predict the start of surface crack paths, especially in heterogeneous materials (e.g. concrete). However, cracks on concrete surface have negative effect on durability of concrete structures, e.g. corrosion of steel bars under chloride penetration and carbonation through these cracks, etc. Furthermore, inspection of crack propagation on surfaces with maximum stress is also significant for predicting the residual fatigue life of concrete structure and for making schedules of repair or reinforcement.

In recent years, a new kind of non-destructive testing technique, i.e. Digital Speckle Correlation Method (DSCM), was proposed by Yamaguchi I., Peters W.H. and Ranson W.F. [6] and was perfected in labs. It has been employed to measure the displacement, velocity, heat transfer, dectrostrictive response and 2D full-field deformation of homogeneous materials (e.g. metal and plastic) [7–17]. DSCM can get full-field or local displacements by comparing two speckle images before and after deformation, and then the strain fields on concrete surface can be deduced from the longitudinal and transversal displacements (see Section 2 and Refs. [6,8,9,11–18]). Comparison to those on homogeneous structure, the strain fields on surface of heterogeneous specimens under cyclic loading are more complicated, and they are affected by both load system and microstnicture inside of the specimens. This kind of complicated strain field on the surface of specimens under flexural fatigue loading can not be obtained by normal testing methods. Owing to the compensation algorithm used in the correlative software and to the application of ultrahigh speed digital camera, DSCM method is also suitable for analyzing the start of potential fatigue cracks by measuring the longitudinal strain on full-field or local surface of concrete.

In the present paper, prediction of potential crack path on surface of concrete under flexural fatigue loading was completed by using DSCM equipment and matching software program. The specimen and experimental preparation were presented in Section 2. The experimental and analysis results are summarized in Section 3. The analysis results are discussed in Section 4 and are compared with other experimental results presented in the literature.

2. Analysis principle of DSCM system

The 2D DSCM system is consisted of six parts as follows (see Fig. 1) [8,9]:

- Ultrahigh speed digital camera for catching speckle images.
- Camera viewer for collecting and evaluating the speckle images.
- PC for presenting and analyzing the displacement or strain fields.
- Fiber optic illuminator for illuminating the target surface of specimen.
- Tripod for fixing the digital camera.
- Matching numerical program for presenting and analysis the speckle images.

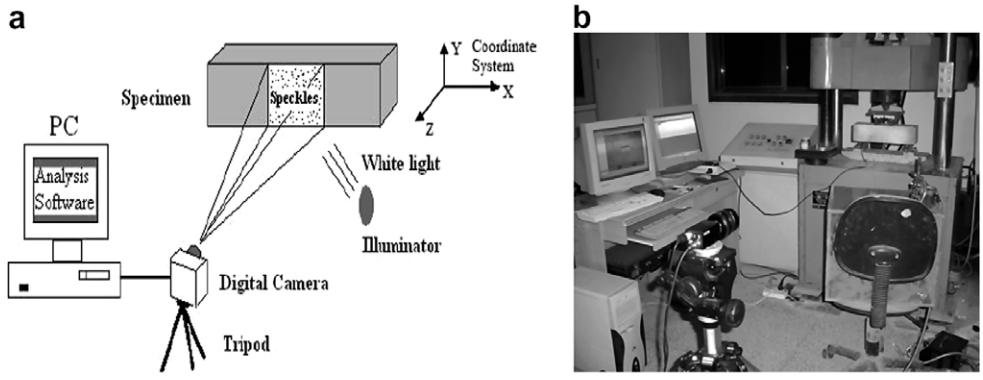

Fig. 1. 2D DSCM system set-up (a) Schematic diagram (b) The whole experimental setu-up.