11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

3D ELLIPTICAL CRACK DEPTH ESTIMATION FROM 2D SURFACE DISPLACEMENT OBSERVATION

Pierre Pineau[1], Julien Réthoré[1], Marie-Christine Baietto[1] and Marion Fregonese[2]

[1] INSA-Lyon, LaMCoS, 27 avenue Jean Capelle, F-69621 Villeurbanne Cedex, France, [pierre.pineau, julien.rethore, marie-christine.baietto]@insa-lyon.fr, lamcos.insa-lyon.fr
[2] INSA-Lyon, MateIS, 21 avenue Jean Capelle, F-69621 Villeurbanne Cedex, France, marion.fregonese@insa-lyon.fr, mateis.insa-lyon.fr

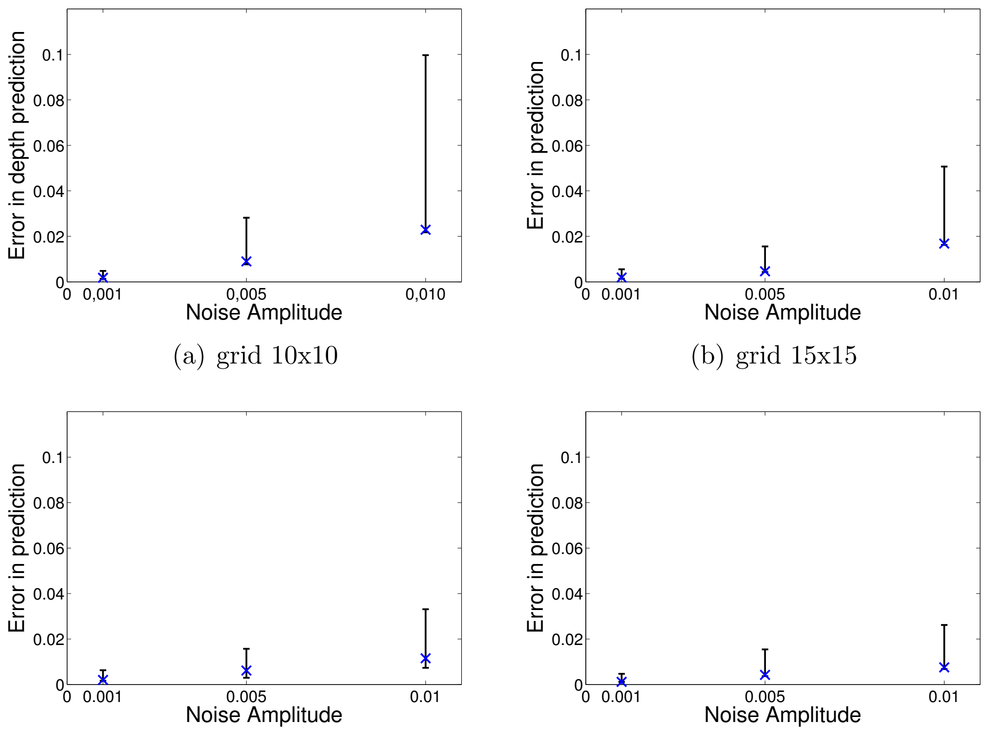
Key words: *crack depth, 2D observation, 3D geometry, FEM simulation, displacement fields virtual database*

In many cases, the 3D geometry of a crack and mainly its depth is impossible to apprehend with only 2D surface informations and requires 3D observation methods such as tomography [1]. In this work is exposed a method to determine the depth of a 3D elliptical crack from a 2D observation of displacement field on the surface.

The first step is to build a virtual database of surface displacement field with the Finite Element Method software Zset-Zcracks [2] for sampled relative depth vs. surface crack length. The database is constituted of solution fields U_s which depends on depth parameter d. Displacement fields are limited to a circular patch around the crack.
Secondly, the so-called experimental field U_e is considered around the crack tips on surface inside the circular patch of solution fields. It is projected on the virtual database and an optimization process gives an estimated depth. The projection is a minimization algorithm for a least-squares error between Us and U_e. An interpolation process is mandatory to deal with various spacial discretizations.

The method is validated considering 2D artificial experimental fields constructed from FEM simulations. The surface displacements are interpolated on a regular grid which mimics a pixelised field and altered with a variable amplitude white noise. Several artificial experimental fields are generated for various grid size and noise amplitude.
Excellent results are obtained with average relative error inferior to 3% for the estimation of crack depth (Fig. 1) for a noise with magnitude as high as displacements. Two intuitive aspects are spotted : estimation of crack depth is better with a finer grid and a smaller noise, it corresponds to a higher resolution and precise observation of displacements.

This method will furtherly be applied to real experimental fields from displacement field



(a) grid 10x10

(b) grid 15x15

(c) grid 20x20

(d) grid 25x25

Figure 1: Relative error for depth estimation of a 5mm length and 2.3mm depth crack with 0.01 mm crack opening using a 30mm diameter 2D patch. Results are given with error bars for 10 realisations on each combination of grid and noise amplitude

measurement for single and interacting cracks in case of multiple cracking.

Acknowledgements. This work is part of the ANR project ECCOFIC. The authors thanks the French National Research Agency (ANR) for its financial support as well as all the project partners: AREVA NP, Institut de la Corrosion, Mistras Group SA, ACXCOR and ANDRA. The authors also thanks Vincent Chiaruttini from ONERA for provididing and support of Zset-Zcracks software.

REFERENCES

[1] J. Réthoré, N. Limodin, J.-Y. Buffière, S. Roux and F. Hild. Three-dimensional Analysis of Fatigue Crack Propagation using X-Ray Tomography, digital volume correlation and extended finite element simulations. *Procedia IUTAM*, Vol. **4**, 2012, 151–158.

[2] K. Ammar, F. Azzouz, D. Missoum-Benziane, V. Chiaruttini, J.D. Garaud, F. Feyel, S. Feld-Payet, N. Osipov, S. Quilici, J.Rannou, A. Roos and D. Ryckelynck. Z-set : une suite logicielle pour la mécanique des matériaux et le calcul de structures. *CSMA 2013, 11e Colloque National en Calcul des Structures, in french*