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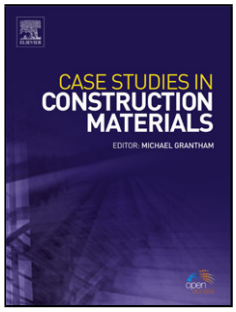

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Authors: S. Fonna, Gunawarman, S. Huzni, A.K. Ariffin

PII: S2214-5095(17)30124-9
DOI: https://doi.org/10.1016/j.cscm.2018.02.008
Reference: CSCM 150

To appear in:

Received date: 21-6-2017
Revised date: 5-2-2018
Accepted date: 6-2-2018

Please cite this article as: Fonna S, Gunawarman , Huzni S, Ariffin A.K.Boundary Element Inverse Analysis for Rebar Corrosion Detection: Study on the 2004 Tsunami-Affected Structure in Aceh.*Case Studies in Construction Materials* https://doi.org/10.1016/j.cscm.2018.02.008

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ACCEPTED MANUSCRIPT

Boundary Element Inverse Analysis for Rebar Corrosion Detection: Study on the 2004 Tsunami-Affected Structure in Aceh

S. Fonna[a,*] , Gunawarman[b], S. Huzni[a], A.K. Ariffin[c]

[a]*Department of Mechanical and Industrial Engineering, Syiah Kuala University, Jl. Tgk. Syech Abdul Rauf No. 7, Banda Aceh 23111, Indonesia*
[b] *Department of Mechanical Engineering, Andalas University, Padang 25163, Indonesia*
[c]*Department of Mechanical and Materials Engineering, Universiti Kebangsaan Malaysia, Bangi 43600, Malaysia*

* Corresponding author. Tel.: +62-651-7555874
E-mail address: syarizal.fonna@unsyiah.ac.id

Abstract

Evaluation of rebar/reinforcing-steel corrosion for the 2004 tsunami-affected reinforced concrete (RC) buildings in Aceh was conducted using half-cell potential mapping technique. However, the results only show qualitative meaning as corrosion risk rather than the corrosion itself, such as the size and location of corrosion. In this study, boundary element inverse analysis was proposed to be performed to detect rebar corrosion of the 2004 tsunami-affected structure in Aceh, using several electrical potential measurement data on the concrete surface. One RC structure in Peukan Bada, an area heavily damaged by the tsunami, was selected for the study. In 2004 the structure was submerged more than 5 m by the tsunami. Boundary element inverse analysis was developed by combining the boundary element method (BEM) and particle swarm optimization (PSO). The corrosion was detected by evaluating measured and calculated electrical potential data. The measured and calculated electrical potential on the concrete surface was obtained by using a half-cell potential meter and by performing BEM, respectively. The solution candidates were evaluated by employing PSO. Simulation results show that boundary element inverse analysis successfully detected the size and location of corrosion for the case study. Compared with the actual corrosion, the error of simulation result was less than 5%. Hence, it shows that boundary element inverse analysis is very promising for further development to detect rebar corrosion.

Keywords: Inverse analysis; boundary element method; PSO; corrosion; reinforced concrete

Introduction

The tsunami which hit Aceh on December 24, 2004 caused severe losses. The disaster claimed the lives of more than 200,000 people [1], and caused around USD 4–4.5 billion of loss [2]. Many infrastructures, including reinforced concrete (RC) buildings, were destroyed by the tsunami, and most of the existing buildings were damaged to varying degrees. Figure 1 show examples of the damage of RC building which hit by the tsunami.

The existing buildings were partially repaired for reuse. However, due to their being submerged by the tsunami, the corrosion issue became important in repairing and reusing the buildings. Immersion by the tsunami might cause the intrusion of chloride ions into the concrete, and so reach interface concrete and reinforcement. As a result, the passive layer, which protects the reinforcement, becomes damaged and corrosion might occur. The investigation results in the field at one of the existing buildings show that seven years after the 2004 tsunami, severe corrosion occurred on the reinforcing steel. Figure 2 shows the corrosion that occurred on the reinforcing steel of a building that was submerged by the 2004 tsunami. Therefore, it is important to do periodical evaluations, monitoring, and/or early corrosion detection of the RC building [3], especially of the tsunami-submerged buildings, in order to prevent premature failure, since Aceh is also susceptible to earthquakes [4, 5].

Evaluation of corrosion in RC buildings in the regions hit by the 2004 tsunami was done using the half-cell potential mapping, based on ASTM C876. Ridha et al. [4], Ridha et al. [5], Ridha et al. [6], and Fonna et al. [7] have reported the results of that evaluation. Ridha et al. [4], Ridha et al. [5] and Ridha et al. [6] explain that corrosion in RC buildings affected by the tsunami have reached an intermediate to high corrosion-risk level, whereas buildings that were built after the tsunami have a low to intermediate risk level. Evaluation 10 years after the 2004 tsunami shows that the risk of corrosion of RC buildings in the tsunami-inundation areas had an increasing tendency, and so needs further attention [7]. However, the method has a limitation. It only gives the probability of corrosion [8]. Therefore, the improvement of the current technique is needed.

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