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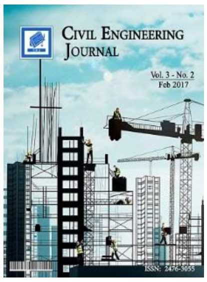

Evaluation of Load-Bearing Performance of Existing Cast Steel Node

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Abstract

This paper presents a preliminary evaluation of the load-bearing performance of an existing cast steel node in a constructed tennis stadium using numerical simulations and non-destructive field tests. Given the absolute stress values of the existing cast steel node were immeasurable, the accuracy of the numerical simulations were verified by comparing the stress increments derived from numerical simulations and non-destructive field tests. During the experiment, the existing cast steel node was loaded indirectly by moving the retractable roof to three different positions (i.e. closed, semi-opened and fully-opened configurations); thus, only the stress increments were recorded. Three simplified truss models and one solid finite-element model were developed to simulate the stress distributions with the corresponding roof positions. A comparison suggests that the stress increments simulated with the developed finite-element models were in good agreement with experimental results. Therefore, the simulated stress distributions can be used to judge the load-bearing performance of the existing cast steel node.

Keywords: Existing Cast Steel Node; Stress Increment; Numerical Simulation; Non-Destructive Field Test.

1. Introduction

To date, cast steel nodes are widely used as connecting joints in large span spatial structures, such as stadiums, airport terminals and public transportation hubs, given their advanced mechanical performance and flexible forms [1]. Due to the complex configurations and stress distributions of cast steel nodes [2], engineers often combine numerical simulations and full-scale destructive tests to ensure sufficient load-bearing capacity. Essentially, a finite-element model is developed in advance to predict the ultimate load-bearing capacity, while a full-scale experiment is performed to mimic the real-world loading conditions. The experimental results are often considered a baseline to validate the accuracy of the developed finite-element model.

However, gaps exist between laboratory tests and practical applications. First, the laboratory test method is not suitable for existing cast steel nodes. Second, given that cast steel nodes are often connected to a number of asymmetric trusses, load combinations and boundary conditions are difficult to simulate in a laboratory. Thus, to the best of the author's knowledge, field tests cannot be replaced completely.

Currently, there are four primary constraints that prevent field tests from being applied to existing cast steel nodes and experimental results from being compared to numerical simulations.

- Compared to laboratory tests, loads cannot be directly applied to an existing cast steel node.
- If loads are applied indirectly, e.g. loads applied to neighbouring structural components, the experimental results are meaningless unless the load distributions are calculated correctly.
- Traditional human-operated measurement instruments cannot be installed and operated unless there is an aerial work platform.

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