Experimental and Numerical Study of Welding Residual Stress Distribution in Shear Keys

Junhui She, Tao Chen, Kelei Ni

Key Laboratory of Performance Evolution and Control for Engineering Structures (Ministry of Education), Tongji University, Shanghai 200092, China

Department of Structural Engineering, Tongji University, Shanghai 200092, China

Contact: simon_she@qq.com

Abstract

Welding technologies are widely applied in all kinds of steel structures. No matter what kind of welding is used, the welding residual stress is always inevitable. So, in this research, a semi-destructive experiment and a numerical simulation are conducted to study the welding residual stress distributions of shear keys in the grouted connection section. The experiment uses the blind hole method on 3 flat-plate specimens of the sleeve section, to measure the welding residual stress distributions of them, which gives an approximate distribution of the real grouted connection section. Based on the experiment, a FEM numerical simulation is performed to estimate welding residual stress distribution. During the numerical simulation, EBD (Element Birth and Death) and Dflux subroutine are applied to maintain a better precision. Through the experiment and simulation, a comparison is done and a good correlation between welding residual stresses was found.

Keywords: steel structure; welding residual stress; blind hole method; finite element method; element birth & death.

1 Introduction

Welding is a widely used joining method in industry because of its advantages such as low price and ease of operation. However, extra stresses, namely welding residual stresses, are introduced due to the great localized heat input and rapid cooling of the steel structure during the welding process, which is inhomogeneous for the whole structure [1]. This is no exception in some offshore wind turbine structures, where different parts of the structure are connected by sleeves and grout in grouted connection sections. In order to increase the friction between sleeves, the sleeves are equipped with multiple shear keys. The fabrication of these shear keys is done by welding [2], and these welding actions inevitably bring additional welding residual stresses and initial defects to the whole sleeve, which have an impact on the fatigue life of the whole structure [2–4], hence many studies are done on the welding of offshore steel structures.

Jacob et al. [5] adopted the contour method of residual stress measurement to map residual stresses in the welded mock-up as well as in the CT specimens extracted from the weld region of the plate. Through the experiment, residual stresses above yield stress were found in the core region of weld specimens. These results indicate that welding residual stresses should be taken into consideration in OWT structures.

https://doi.org/10.2749/nanjing.2022.0821
Distributed by structurae