Journal of Constructional Steel Research 72 (2012) 20–28

Contents lists available at SciVerse ScienceDirect

Journal of Constructional Steel Research

Influence of residual stress on stress concentration factor for high strength steel welded joints

Jin Jiang *, Mingshan Zhao

School of Civil and Environmental Engineering, Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798

ARTICLE INFO

Article history:
Received 20 June 2011
Accepted 5 September 2011
Available online 14 October 2011

Keywords:
Residual stress
Stress concentration factor
High strength steel
Hole-drilling method

ABSTRACT

In this study, a set of plate-to-plate T and Y joints specimens made from high strength steel plates with yield stress equal to 690 MPa is investigated. The joints are fabricated by SMAW welding procedure. Two groups of specimens with different welding procedures are included: one group is composed by the joints with welding completed at ambient temperature and the other group is composed by the joints with welding completed at a preheating temperature of 100 °C. The residual stress near the weld toe is investigated for both groups. Hole-drilling method is applied to investigate the residual stress distribution and variation in joints. Sequentially coupled thermal-stress analysis is then conducted with finite element package ABAQUS to investigate the residual stress distribution in the joints. Finally, the effects of residual stress on the stress concentration factor distributions of the joints are evaluated. A new parameter is put forward in stress concentration factor evaluation to combine the residual stress effect.

1. Introduction

High strength steels, defined as steel with minimum yield strength of greater than 460 MPa, are increasingly used in industries. High strength steel was firstly used in Japan in the 1960s for construction and after that more and more countries show great enthusiasm on this area. Landmark Tower in central Yokohama is the first project using high strength steel in the construction of building in Japan [1]. The first UK project using high strength steel is the Hutton Field floating structure, 200 km off the coast of Norway. The tension-leg platform was fabricated from steel with minimum yield strength of 795 Mpa [2]. Another application of high strength steel with minimum tensile strength 600 MPa is the Shimizu super high rise building which is 550 m high comprising 127 levels for reducing the column section size [1]. In America, a research programme was initiated to develop a better performance steel specifically for use in bridges to improve the weldability, toughness and weathering resistance of existing steel grade. So, it can be concluded that HSS is applied broadly in the world for its merits such as higher strength to cost ratio and artistic. However it is still short of understanding some issues of high strength steel.

Firstly, the stress–strain behaviour of high strength steel is different from mild steel in respect that high strength steel generally exhibits reduced capacity for strain hardening after yielding. There is restriction in structural design that yield ratio is not allowed to have a value greater than 0.85 in design equations to ensure a adequate ductility in the member to develop plastic failure behaviour as a defence against brittle fracture. Secondly, it is regarded that fatigue is one of the major problem causing the degradation of offshore structures in long term integrity. Thirdly, the application of high strength steels is limited by codes and standards involving application of design formulae are restricted to steels with yield strength smaller than 500 MPa in most cases. Finally, the residual stresses due to welding in high strength steel may do harm to the integrity of structures. Residual stress not only affects the initiation and onset of the propagation of surface cracks but also changes the path of a crack as it grows below the surface. It is mentioned that the effect of residual welding stresses on the performance of welded structure is particularly significant when low stresses are applied [3]. For high strength steel structures, how serious will the residual stresses impose influence on the behaviour of those structures is still obscure. Therefore, accurately understanding of the distribution of stress concentration around welded intersection and the effects of residual stress on the stress concentration factors are of great importance since it plays a key role in the prediction of fatigue life.

In this paper, the residual stress distribution a set of plate-to-plate T and Y joints specimens made from high strength steel plates with yield stress equal to 690 MPa is investigated. To investigate the influence of preheating on the residual stress, two groups of specimens with different welding procedures are investigated for the residual stress with hole-drilling method: one group is composed by the joints with welding completed at ambient temperature and the other group is composed by the joints with welding completed at a preheating temperature of 100 °C. The plate-to-plate T and Y joints are chosen in this investigation

* Corresponding author.
E-mail address: jian0048@ntu.edu.sg (J. Jiang).

0143-974X/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jcsr.2011.09.007