Journal of Constructional Steel Research 115 (2015) 303–315

Contents lists available at ScienceDirect

Journal of Constructional Steel Research

Axial tensile behavior and strength of welds for CHS branches to SHS chord joints

Wei Wang [a,b,*], Qing Gu [b], Xinxu Ma [b], Junjie Wang [b]

[a] State Key Laboratory of Disaster Reduction in Civil Engineering, Tongji University, Shanghai 200092, China
[b] Department of Structural Engineering, Tongji University, Shanghai 200092, China

ARTICLE INFO

Article history:
Received 27 December 2014
Received in revised form 23 August 2015
Accepted 28 August 2015
Available online 14 September 2015

Keywords:
Steel tubular joints
Welded joints
Heat affected zone
Strain distribution
Effective length
Axial tensile strength

ABSTRACT

In this work, experimental investigations were conducted on the axial tensile behavior of welds connecting tubular X-joints with CHS branches to a SHS chord. Five non-rigid and three rigid welded joints were tested under monotonic loading conditions. The weld properties were specially measured using a negative mold. Next, the strain distribution, the failure modes and the strength of the welds were obtained. The results indicate that an uneven strain distribution exists in the non-rigid joints in contrast to the uniform strain distribution in the rigid joints. The strength of welds for the non-rigid joints exhibits a significant reduction compared with rigid joints. Finally a predictive formula for the axial tensile strength of the welds is proposed according to the method of effective length based on experimental research and finite element analysis, which is capable of meeting the reliability requirements of the AISC specification.

1. Introduction

Single-layer reticulated shells have become a particularly popular choice for large-span roof systems used in steel structures due to their light weight, appealing architectural appearance and ability to be rapidly constructed. Tubular sections are a common selection for the primary load-carrying members of this type of onshore structure. During practical applications, the sections are profiled and welded to form unstiffened X-joints (as shown in Fig. 1 for a typical engineering application). Research has been conducted to examine the behavior of un-stiffened joints, including tubular joint rigidity [1], the flexural behavior of tubular joints [2] and the behavior of tubular joints under cyclic loading [3–5]. Fillet welds, which are often used for their inexpensive cost and simple creation, are generally adopted in welded joints. This weld is vitally important to ensure the normal function of the joint. There are currently two design methods for fillet welds, the pre-qualified method and the fit-for-purpose method [6]. The pre-qualified method requires that the weld be proportioned to develop the yield strength of the connected branch wall at all locations around the branch. The design provision for a fillet weld, based solely on the thickness of the branch, is generally conservative and results in a relatively large weld size. The fit-for-purpose method requires that the weld be designed to resist the applied load in the branch. The design method takes the weld mechanical properties into consideration and results in an appropriate weld size.

When the applied axial load transfers from the branch to the chord in the tubular joints, the connection deformation caused by the flexibility of the connection must be considered. Therefore, the proper mode for load distribution in welds needs to be studied when the fit-for-purposed method is used to judge the strength of welds. Frater [7,8] and Packer [9] explored the strain distribution in welds for RHS joints through a series of experimental setups and proposed effective weld lengths. The AISC "Specification" [10] adopts the effective length and puts forward a weld design formula for RHS joints under axial tension. For tubular joints with CHS branches to SHS chord, nevertheless there are currently few research work (see Fig. 2). Thus axial tensile behavior testing and finite element analysis (FEA) are conducted in this paper to investigate the strain distribution, the failure modes and strength of welds for these type of joints.

2. Experimental program

2.1. Specimens

Eight X-joint specimens were tested, including five non-rigid joints and three rigid welded joints. The non-rigid joints referred to directly welded joints, varying in parameters included the width ratio β and the joint angle θ (see Fig. 3). The rigid joints were referred to butt joints with a stiffener plate. The square chord was replaced by the plate in rigid joints to eliminate flexible deformation of the welds, in

* Corresponding author.
E-mail address: weiwang@tongji.edu.cn (W. Wang).

http://dx.doi.org/10.1016/j.jcsr.2015.08.044
0143-974X/

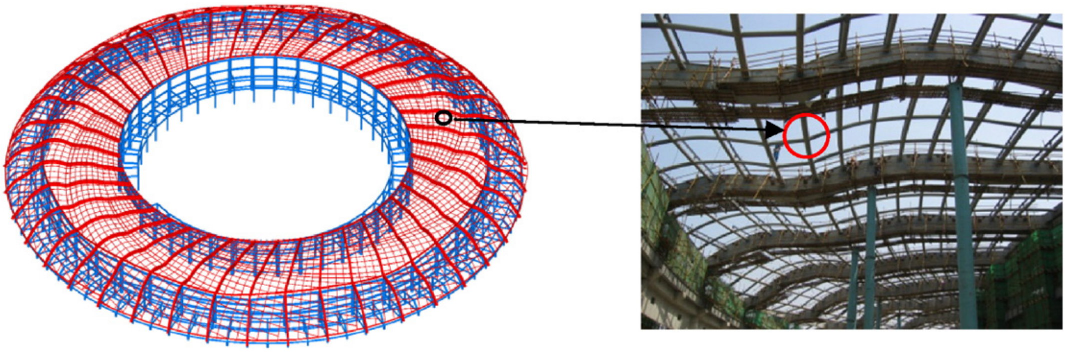

Fig. 1. Engineering application of tubular X-joints.

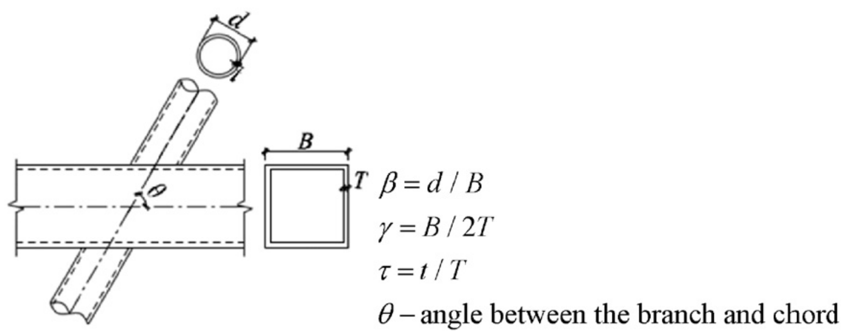

Fig. 2. X-joints with CHS branches to the SHS chord.

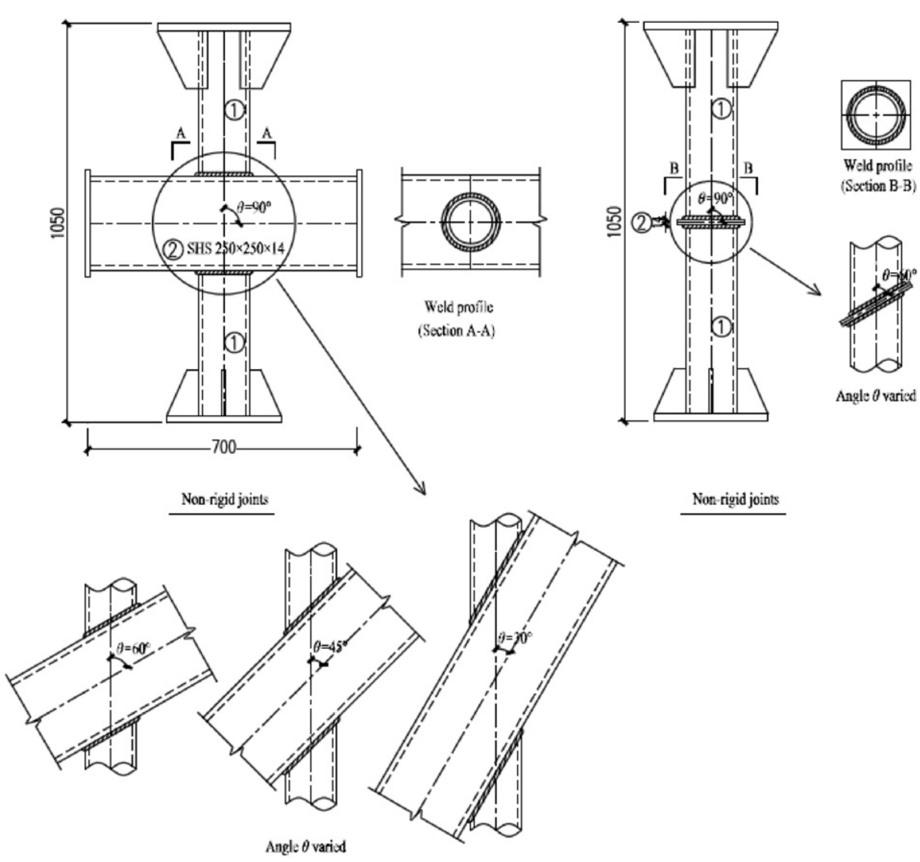

Fig. 3. Details of the specimens.