AN EXPERIMENTAL STUDY ON THE FATIGUE PERFORMANCE OF TRUSS PIPE K-JOINTS USING COVER PLATE

Tomonori TOMINAGA
Senior researcher
Nippon Steel & Sumitomo Metal Corporation
Futtu, Chiba, Japan
tominaga.4qn.tomonori@jp.nssmc.com

(For more than one author, please refer to chapter 4 of these instructions)

Tomonori Tominaga, born 1967, received his civil engineering degree from the Kyoto University, Japan. He started working for Nippon Steel Co. Futtu, Japan. He received doctor of engineering from Tokyo Institute of Technology. His main area of research is related to fatigue and bridge engineering.

Summary

New low cost pipe K-joint detail using cover plate is proposed and evaluated. This joint type is originally applied to space flame building structures. To apply this structure to bridges or offshore structures, evaluation of fatigue performance is required. In this paper, fatigue tests were conducted on 4 types of structures using cover plate. Among these, new shape of cover plate and diaphragm were effective and they showed longer fatigue life compare to conventional TKY weld joint. Also, it was found that there are difficulties in application of HSS evaluation to this type of structures.

Keywords: Steel pipe; truss structure; fatigue; cover plate; cost.

1. Introduction

Recently, application of pipes to truss bridge members has enabled lightweight and cost competitive bridges. Pipe members have mainly been applied to offshore structures and trussed roofs in the architecture field, taking structural advantage of the point symmetric cross section and the high buckling capacity. Using pipes can decrease production cost compared to built-up H-shaped or Box shaped members. However, the bridge with pipe members has problem at the panel point. Highly skilled and expensive welding is required, also increase of pipe thickness due to stress concentration.

This paper proposes the new pipe K-joint for truss bridges with pipe members and evaluates fatigue strength of 4 alternative details.

2. New pipe K-joint with cover plate

2.1 Basic design of new pipe K-joint

In the field of architecture, the cost effective K-joints which uses a cover plate proposed by Takeu-chi et al are applied to space-truss structures. The concept of the joint is that the horizontal force from diagonal member to main pipe are transferred by the shear force in the side weld of the cover plate by arranging the intersection point of diagonal member axes not on the axis of main pipe. The new pipe K-joint proposed in this paper is based on the concept using cover plate, Fig.1. Considering application to actual buildings, the static strength of the K-joint with cover plate is confirmed to be sufficient. However, the fatigue strength of the joint, which is not taken account in the design of architecture field, must be confirmed to apply them to the bridge structure.

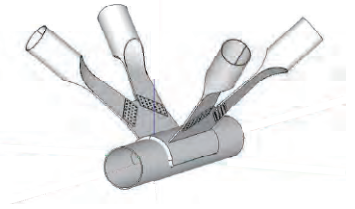


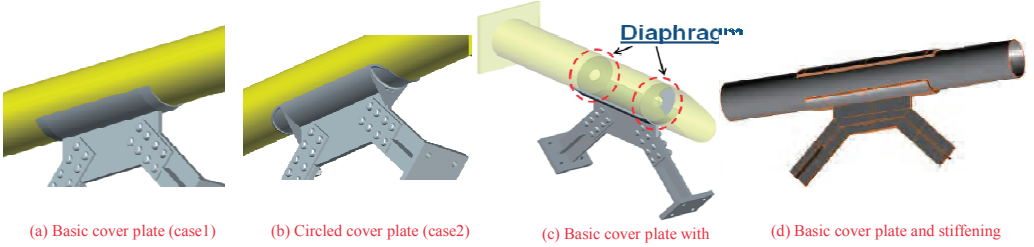
Fig 1. Pipe K-joint with cover plate

2.2 Fatigue strength improvement of the pipe K-joint

As mentioned above, conventional K-joints need thick pipes to decrease concentrated stress at the joint. The differences between the architectural detail and the bridge detail are also considered to be problems. The fillet weld in front of the cover plate generates stress concentration, which leads

to fatigue crack initiation. The difference of the size of the structure causes the deformation of the cover plate. The cover plate in the building expected to be-have as rigid body in order to generate only shear force at the side weld of the cover plate. However proportional size for the bridge leads to excessive thick cover plate.

Based on the mechanism mentioned above, 3 concepts of the fatigue proof structure are introduced. The first concept is decrease of the stress concentration at the front fillet weld by the shape of cover plate. The second is the restrain of deformation of the cover plate and connected gusset plate by adding ribs which stiffen the cover plate and the gusset plate. The third is the restraint of the main pipe's deformation. This idea also aims to decrease the stress generated at the front weld.



(a) Basic cover plate (case1) (b) Circled cover plate (case2) (c) Basic cover plate with diaphragm (case3) (d) Basic cover plate and stiffening cover plate (case4)

Fig.2 Shapes and dimensions of specimens

2.3 Specimens

Fig.2 shows the shapes and dimensions of four specimens which include improvement ideas mentioned above. The case1is the basic type which adds the fillet welds in front of the similar cover plate to pipe K-joint for architectural structures. In the case2, cover plate has circle shape and thinned-out part to decrease the stress concentration at the front weld. In addition, ribs, which are expected to stiffen the connection of cover plate and gusset plate, are set. The case2 include the first and second concepts. The case3 add diaphragms to the case1. This case adopts the third concept.

The case4 attaches the stiffening cover plate on the opposite side of the main pipe from the connected pipes by fillet welding. This case also adopts the third concepts.

3. Fatigue test of pipe K-joints

From pre static loading, the loading force ranges are adjusted to set HSS to 200 N/mm2 in the case1, 2 and 4 and 165 N/mm2 in the case3. As a result, the loading forces ranges are determined to 1-27 ton, 1-34 ton, 1-31 ton and 1-29 ton for case 1-4. Results of fatigue tests are summarized in S-N diagram, Fig.3. Results of fatigue tests conducted by Pison et al, which study the conventional pipe K-joint with the weld toe treated by grinder and the concrete filed main pipe, are also plotted.

Based on the evaluation by the nominal stress approach, classes of the case2 and 3 are improved to FAT50 and FAT56 from FAT45 of the case1. However, restraining the deformation of the main pipe, the case4, does not improve its fatigue performance from the case1. The case1 and 4 have higher fatigue strength than the conventional pipe K-joint such as "grinded" or "CFT".

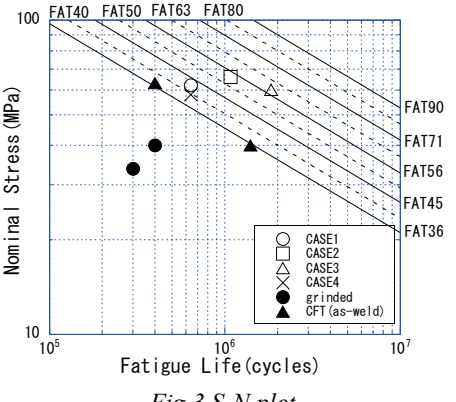


Fig.3 S-N plot

4. Summary

1) Combination of the cover plate with circled shape and thinned-out part and the ribs enhance the fatigue performance of the pipe K-joint.

2) The diaphragm also decreases the working stress. Stiffening of the main pipe by additional cover plate is less effective than the diaphragm.