Study of the Relaxation of Fillet Size Regulation for Steel Bridges

1. Introduction

The Specification of Highway Bridges stipulates that the fillet weld leg length must be $\sqrt{2t}$ mm or more (t: plate thickness in mm). This is to prevent cold cracking of fillet welds. However, about 50 years have passed since these rules were imposed and since then, many new steel products have been developed and the crack resistance of steel products has been improved. When the fillet weld leg length is particularly large, the welding cannot always be completed in a single pass. Accordingly, there are cases in which multi-pass welding is required. Therefore, a study was conducted on the relationship between fillet weld leg length and cold cracking susceptibility , and discussed conditions which would permit relaxing the above rule.

2. Results and Conclusion

As a weld crack test, the fillet welded joint test specified in the Rules and Guidance for the Survey and Construction of Steel Ships of Nippon Kaiji Kyokai was carried out. Test pieces having a 50 mm thick flange and a 12 mm or 19 mm thick web were subjected to the test (several test pieces having a 50 mm thick web were also tested). The range of P_{cm} was 0.205% to 0.272%. The welding methods used were GMAW (hydrogen content measured by gas chromatographic method: 5 ml/100 g) and SMAW (hydrogen content measured by gas chromatographic method: 11 ml/100 g and 15 ml/100 g). From the standpoint of measuring cracking susceptibility under severe conditions, the hydrogen contents were intentionally set to be high . For SMAW, a welding rod which gave a hydrogen content of 15 ml/100 g–the maximum hydrogen content conceivable for low-hydrogen based welding rods–was used. The test pieces were not preheated. First, fillet welding was performed at one side (first bead). Then, two days later, fillet welding was performed at the other side (second bead). Another two days later, cross-section samples were machined and checked for cracks.

Fig. 1 shows an example of fillet weld cracking. It can be seen that cracks propagate from the root through the heat-affected zone (HAZ) or along the fusion line. Most of the cracks occurred in the first bead: few cracks were observed in the second bead. When cracks occurred in the second bead, cracks were always observed in the first bead too. There was a tendency that test pieces having a 12 mm thick web showed higher cracking susceptibility than those having a 19 mm thick web. It is generally considered that the higher the degree of welding constraint and the larger the plate thickness, the higher the possibility of weld cracking. Since the first bead is formed before the second bead, the second bead side is subject to a higher degree of constraint.

In the present test, however, the first bead side showed more cracks than the second bead side, and the test pieces having a 12 mm thick web showed higher cracking susceptibility than those having a 19 mm thick web. These results do not agree with the above understanding. The reason for this disagreement may be qualitatively explained as follows. In the case of a fillet-welded joint, the longitudinal deformation of the vertical web acts in the direction in which the joint is pulled upward (vertical direction in Fig. 1). The amount of this longitudinal deformation is smaller when the web thickness is larger or when the first bead has already been formed. This is considered to account for the above results.

Fig. 2 shows the crack test results obtained when the fillet size was 8 mm. (PL12 corresponds to 12 mm thick web and PL19 corresponds to 19 mm thick web.) When GMAW (hydrogen content : 5 ml/100 g) is applied (normally, the hydrogen content for GMAW is 2 to 4 ml/100 g), cracks do not occur. When a low-hydrogen based welding rod (11 ml/100g, 15 ml/100 g) is used (normally, less than 10 ml/100 g for low-hydrogen based welding rods), it is possible to prevent cracking by making P_{cm} lower than 0.24%. These results hold true when the flange thickness is 50 mm, at which a fillet size of 10 mm or more is required in the Specifications for Highway Bridges . Since cracks could be completely prevented with the fillet size of 8 mm (this is close to the upper limit of the range in which one-pass fillet welding is applicable), we could confirm that it should be possible to relax the fillet weld leg length regulations (for example, adopt $\sqrt{2t}$ as the mandatory leg length when $\sqrt{2t}$ is 8 mm or less and 8 mm as the mandatory leg length when $\sqrt{2t}$ is over 8 mm).

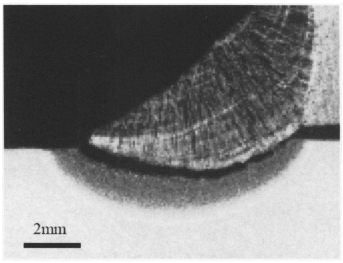

Fig. 1 Crack occurred in the fillet weld

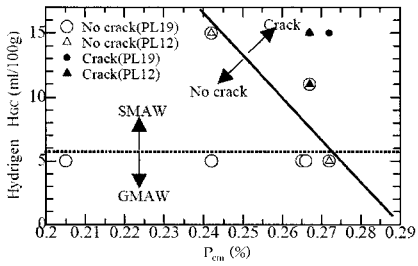

Fig. 2 Results of cracking tests of fillet welding