Fatigue Experiments on Tensile Plates with Combined Attachments

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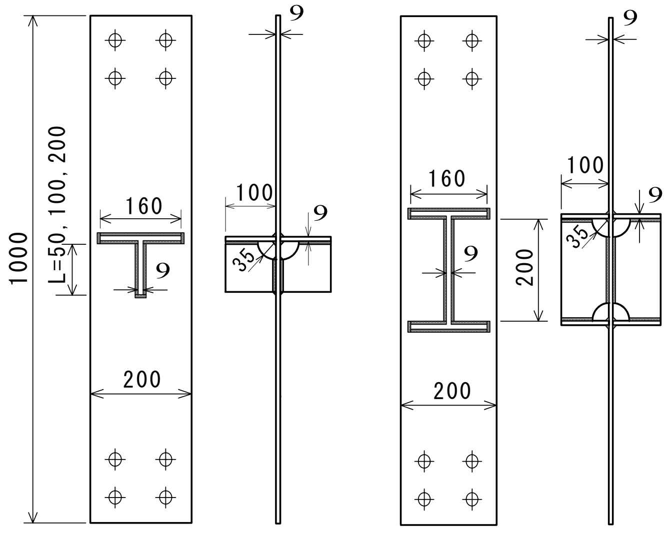
1. Objective of experiments

The combined use of attachments is often found in practice for the purpose such as providing stiffness in two perpendicular directions. Fatigue strength of single attachments, such as transverse and longitudinal stiffeners, is well known from the large amount of fatigue experiments conducted. However, very few fatigue test data are available for combined attachments. In this research, fatigue experiments are carried out on seven series of perpendicularly intersected attachments to study the fatigue behavior of combined attachments.

2. Fatigue specimens and experimental details

As shown in Fig.1, in all specimens, intersected attachments are symmetrically fillet welded to both surfaces of the tensile plate. The connection between attachments is also fillet welded. All fillet welds are 6 mm in leg length. For simplicity, the longitudinal and transverse attachments are hereinafter referred to as gusset and stiffener, respectively. Scallops are inserted into some specimens to avoid intersection of welds. In total, seven series of specimens are designed, TN50, TN100, TN200, TS100, TS200, HN200 and HS200. The numbers in the specimen names represent the length of the gusset in millimeters, and the letters *N* and *S* indicate non-scallop and scallop, respectively. The steel is SM490YA. Constant amplitude fatigue tests are carried out with an Amsler type fatigue-testing machine of 980kN in loading capacity. The frequency of cyclic loading is 4.45Hz. The minimum tensile stress is set at 27MPa through all tests. Dye marking and beach marking tests are also carried out to leave markings on fracture surfaces.



(a) TN and TS type b) HN and HS type

Fig.1 Fatigue test specimens

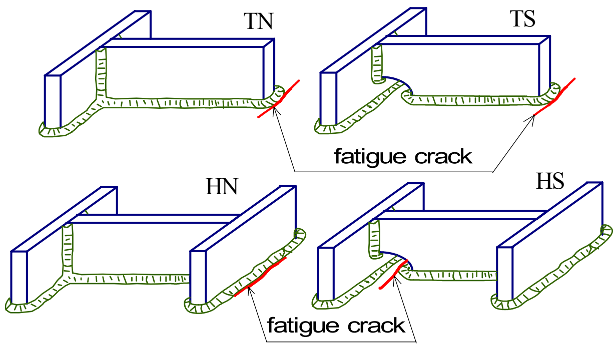


Fig.2 Location of fatigue cracks

3. Fatigue test results and comparison with test data of single attachment

The locations of fatigue cracks and typical fatigue crack surfaces are shown in Figs.2 and 3. Fatigue test results of T-type specimens are plotted in Fig.4. Solid lines indicate fatigue classes of JSSC [1]. It is seen from the test results that fatigue strengths of TN- and TS-specimens decrease with the increase of gusset length. In these specimens, fatigue cracks form at gusset end, where stress concentration is shown to increase with gusset length, as shown in Fig.5. Not much difference is shown between the fatigue strength of TS-100 and TN-100, nor between TS-200 and TN-200. HN200 and HS200 have similar strengths, as

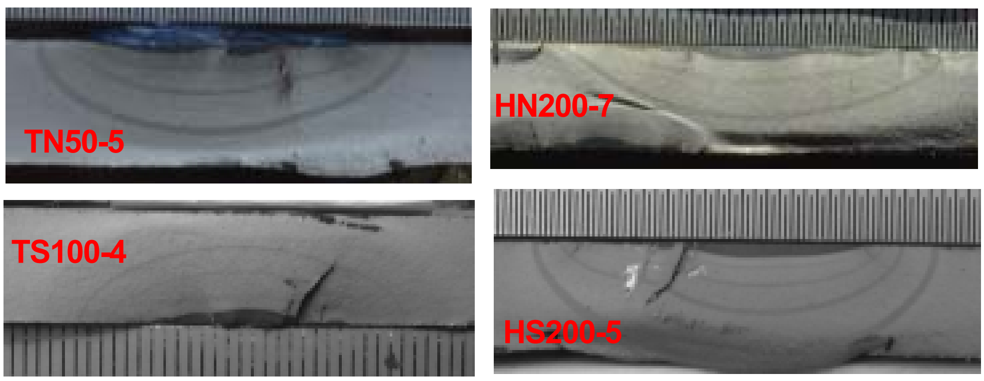


Fig.3 Typical fracture surfaces

Key Word: fatigue test, combined attachments, fillet weld, one-millimeter stress, gusset

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shown in Fig.6., though fatigue cracks in them form at different locations. Their fatigue strengths are much higher than that of TN200 and TS200.

For comparison, fatigue test data of 200 mm long out-of-plane gusset [2] are also plotted against those of TN200 and TS200 in Fig.7. Most of data points are distributed between JSSC-E and F, and no significant difference has shown between test data of those specimens. Fatigue test results of HN200, non-load-carrying cruciform joints [3] and 200 mm long out-of-plane gussets [2] are plotted in Fig.8 for comparison. Among them, test data of non-load-carrying cruciform joints are distributed in the top region, those of out-of-plane gussets in the bottom, and data of HN200 in between. The reason for the difference in fatigue strength is the difference in the severity of stress concentration at critical point.

Fatigue test results for all specimens are re-plotted in terms of one-millimeter stress in Fig.9. The one-millimeter stress is the normal stress at 1mm in crack path, where the local influence of weld bead vanishes. This stress is proved to be suitable for correlating fatigue life of weld toe cracked fillet welded joints with that of a non-load-carrying cruciform joint, i.e. the reference detail, by fatigue test results of several types of weld details, e.g. in-plane gussets and out-of-plane gussets [4]. Fig. 9 also shows the good correlation between combined attachments and the reference detail by one-millimeter stress.

4. Conclusions

In T-type specimens, fatigue cracks are initiated at the free end of gusset, and fatigue strength is sensitive to gusset length. Scallop does not have significant effects on fatigue strength. TN200 and TS200 specimens show similar fatigue strengths with 200 mm long out-of-plane gussets.

In HN200 fatigue cracks form at the central part of the free edge of transverse stiffener. The fatigue strengths of HN-specimens are in between those of out-of-plane gusset and non-load-carrying cruciform joints. In comparison with HN200, the scallops in HS200 results in shift of crack location from transverse stiffener edge to scallop edge, without significant change in fatigue strength.

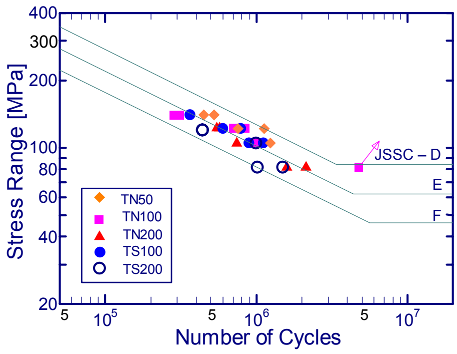

Fig.4 Fatigue test results of T-type specimens

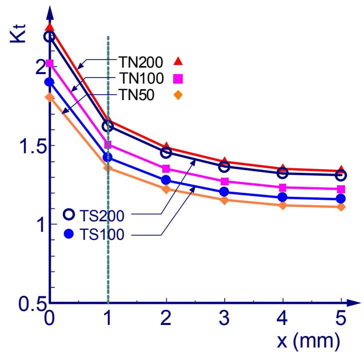

Fig.5 Stress distribution along thickness direction

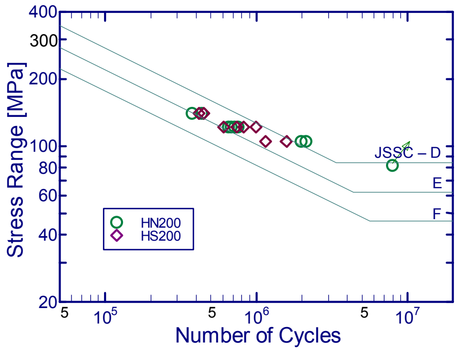

Fig.6 Fatigue test results of H-type specimens

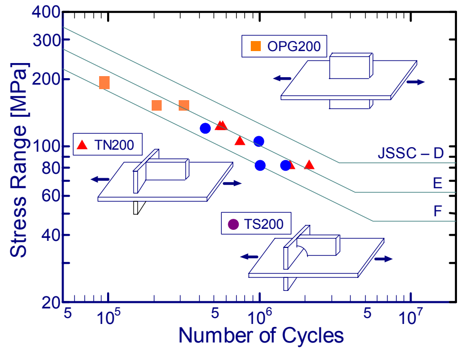

Fig.7 Comparison of fatigue test data of TN200 and TS200 with out-of-plane gussets

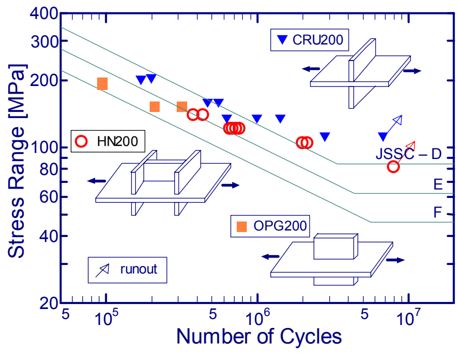

Fig.8 Comparison of fatigue test data of HN200 with cruciform joints and out-of-plane gussets

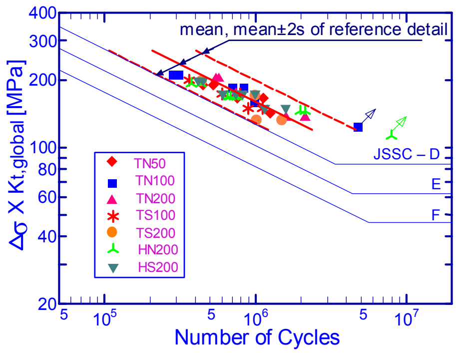

Fig.9 Fatigue test results in terms of 1 mm stress

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