CHARACTERISTICS OF ROLLED H SECTION STEEL WELDS JOINTED BY NEWLY DEVELOPED FLASH WELDING SYSTEM

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ABSTRACT

In the civil engineering and architecture fields, welding for large sectional members, such as I section steel and H section steel, are usually performed. A flash welding system, by which large I section steel or H section steel can be welded for a short time, was newly developed. In order to know the basic characteristics of welded joints, the specimens were cut out from flash welded joints, and tensile and fatigue experiments were carried out.

The joint efficiency of welded joints by flash welding is 100% for the specimens with reinforcements and 93% for without reinforcements. The fatigue strength of welded joints with reinforcements was about 50% of that of the base metal. Removing the reinforcement generated by flash welding, fatigue strength of flash welded joints became 75% of that of the base metal. In case of flash welded joints with reinforcements, after a couple of fatigue cracks had propagated, ductile fracture occurred at the toe. In flash welded joints without reinforcements, fracture occurred at the bond or at HAZ (Heat Affected Zone). In case of fracture at the bond, fracture was brittle, and in case fracture at HAZ, fracture was ductile.

KEYWORDS

Flash welded joints, Flash welding system, Mechanical properties, Welding of large section steel, Joining time

1. Introduction

Large sectional members such as I section steels, H section steels and large section steel pipes are very often welded in construction works. However, long execution time is required to connect these large sectional members by welding or high strength bolts. A small flash welding system for construction site welding was newly developed to shorten joining time of large sectional members [1].

By the way, if flash welding is performed in general, reinforcements (upset metals) are inevitably generated in the joints. The reinforcements become a source of stress concentration, and cause the adverse effects on mechanical properties of the joints. In general, reinforcements are removed. However, long time is spent to remove reinforcements.

Under such a background, influences of reinforcements on tensile strength and fatigue strength of the joints by newly developed flash welding system are investigated in order to use as the structural members without removing the reinforcements.

2. Experiment

2.1 Material and specimen

The H section steel used in the experiment is a rolled structural steel. The material is SS400 (A36 in USA). Figure 1 shows the dimensions of a rolled H section steel. Table 1 shows the flash welding conditions. The joining time of the rolled H section steel is about 5 mints.

Table 1 Flash welding conditions.

Electric power (w/mm^2)	Flash time (s)	Upset distance (mm)	Heat input (J/mm^2)
6.5	277.0	15.0	1800.0

The tensile specimens are cut out from the joints of the webs and flanges. The fatigue specimens are obtained from the joints of the webs. The welds located at the center of the specimens. Figure 2 shows the shapes of each specimen.

Specimens used in the experiments are as follows:

Base metal (web (with surface as forged)): BM
Welded joint with reinforcement (web): WJ-1W
Welded joint with reinforcement (flange): WJ-1F
Welded joint without reinforcement (web): WJ-2W
Welded joint without reinforcement (flange): WJ-2F

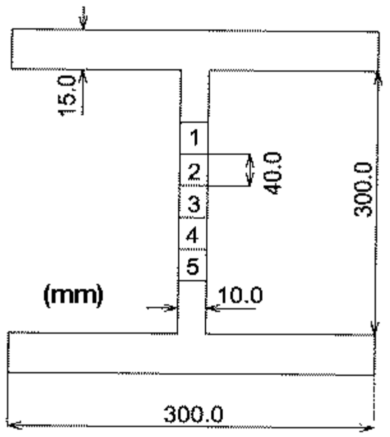


Fig.1 Dimensions of the H section steel.

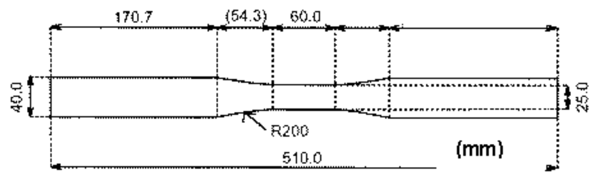
2.2 Tensile test

Specimens of welded joints are cut out from the web and the flange, and they are subjected to the tensile test. The gauge length is 50 mm, and the strain gauges are attached between gauge marks. The welds of the specimen are etched to specify the bond line. By the observation of the macrograph, the exact location of fractured point is determined

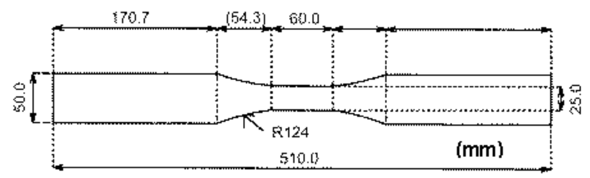
2.3 Fatigue test

The fatigue tests are carried out under the loading conditions of pulsating tension by using single axis fatigue test machine. The shape of waves is the sine wave and the frequency is 5-10 (Hz).

Specimens of welded joints are cut out from the web, and the fatigue tests are conducted by using them. By the way, some specimens of base metal are fractured at their gripped parts. Therefore, only for the base metal, specimens whose width is 10mm wider than that of WJ-series specimens in grip sections are used.



(a) Specimen for WJ (Welded joints).



(b) Specimen for base metal.

Fig.2 Specimens used by experiments.

3. Results and Discussions

3.1 Tensile characteristics

3.1.1 Comparison between base metals and flash welded joints

Figure 3 shows the relation between nominal stress and

Table 2 Results of tensile test.

Series	Yield stress (MPa)	Tensile strength (MPa)	Elongation (%)
BM	348.1	468.3	37.9
WJ-1W	341.3	476.6	28.8
WJ-2W	253.6	435.9	22.0

nominal strain. The tensile test results of BM, WJ-1W and WJ-2W are shown in Table 2. The results include yield stress, tensile strength and elongations, and 0.2% proof stress is used as the yield stress of WJ-2W.

WJ-1W specimens have broken ductile in the base metal. The yield stress and tensile strength of WJ-1W are the same level as those of the base metal, however the elongation at the maximum load and fractured load are smaller than those of the base metal. The reason why the elongation was smaller is that upset metals were thicker than the base metal. So, its upset metals are not deformed uniformly.

On the other hand, in the all specimens of WJ-2W, the brittle fractures occurred at the bond lines. The yield stress, tensile strength and elongation of WJ-2W are lower than those of the base metal. The joint efficiency is about 93% in this experiment. The fracture occurred at the base metals for flash welded specimens without reinforcements under tensile tests. Therefore, it is thought the joints should be used without removing reinforcements from the viewpoint of tensile strength.

3.1.2 Influences of cold-rolled on tensile strength

(1) Reinforced welded joints (WJ-1W, WJ-1F)

Figure 4 shows nominal stress and nominal strain. Table 3 indicates the yield stress, tensile strength and elongation of the tensile test specimen cut out from web (WJ-1W) and flange (WJ-1F) of the joints without upset metal. The yield stress of WJ-1W is higher than that of WJ-1F, but the tensile strength of each series specimen is almost same. The reason is considered that the web was strongly influenced by pre-strain generated in cold working during manufacturing rolled H-shaped steel.

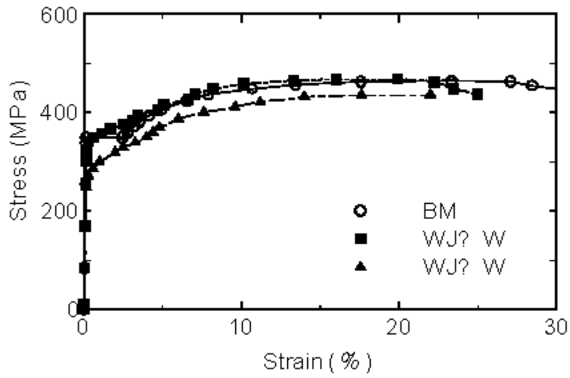


Fig.3 Stress - strain diagram.

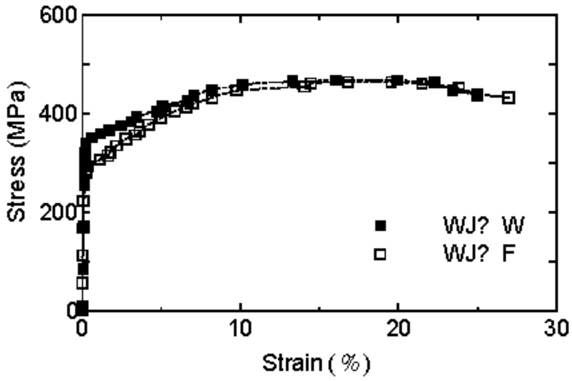


Fig.4 Stress - strain diagram (with reinforcement).

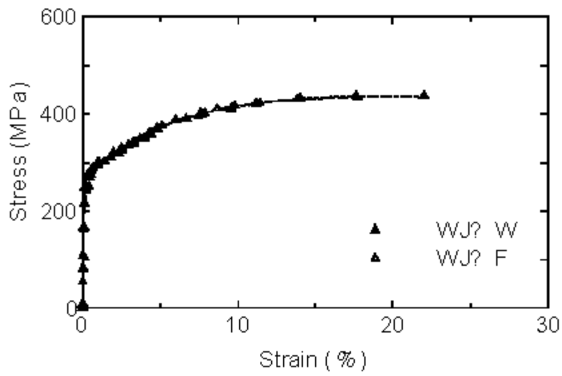


Fig.5 Stress – strain diagram (without reinforcement).

Table 3 Results of tensile test (With reinforcement).

Series	Yield stress (MPa)	Tensile strength (MPa)	Elongation (%)
WJ-1F	293.3	463.7	34.8
WJ-1W	341.3	476.6	28.8

Table 4 Results of tensile test (Without reinforcement).

Series	Yield stress (MPa)	Tensile strength (MPa)	Elongation (%)
WJ-2F	243.7	434.2	18.1
WJ-2W	253.6	435.9	22.0

(2) Welded joints without reinforcement (WJ-2W, WJ-2F)

Figure 5 shows nominal stress and nominal strain. Table 4 shows yield stress, tensile strength and elongation of the tensile test specimens cut out from web (WJ-2W) and flange (WJ-2F) of the joint without upset metal. Yield stress and tensile strength of WJ-2W and WJ-2F are in the same level. The reason is that influences of pre-strain due to cold working are vanished by the heating by flash welding.

The pre-strain due to cold-working influences on the yield stress of the specimens cut from the web, but it can be said that there is no difference in tensile strength. The influences due to cold working are relatively small from a viewpoint on tensile strength.

3.2 Fatigue properties

Figure 6 shows the fatigue test results of the base metal (BM), welded joints with reinforcement (WJ-1W) and welded joints without reinforcement (WJ-2W). S-N curves in the figure are obtained by linear regression of the experimental results by using the stress range (log Δ σ) as independent variables and using a subordination variable as fatigue life (log N). Fatigue strength of BM, WJ-1W and WJ-2W at 2,000,000 cycles is 366, 179 and 275 (MPa) respectively, and fatigue strength of WJ-1W is about 50% of that of BM and fatigue strength of WJ-2W is 75% of that of BM. It is natural that welded joint without reinforcement is more dominant than welded joint with reinforcement.

In WJ-1W specimens, after a couple of fatigue cracks have propagated, ductile fracture occurs at the toe of the reinforcement. The reason why the scattering of the experimental results is small is that the shapes of reinforcements are almost the same in flash welding. In WJ-2W specimens, fracture occurs at HAZ from 10 mm or less from the bond. In case that a couple of fatigue cracks propagate at the bond, fracture is brittle. In case that a couple of fatigue cracks propagate at HAZ, fracture is ductile. The reason why the scattering of the experimental results of WJ-2W is large is that the alignment of joints influences on the results of the fatigue test.

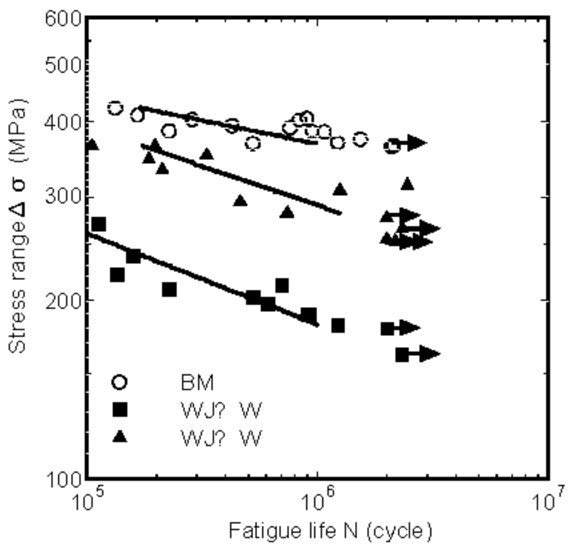


Fig.6 Results of fatigue test.

As generally known, fatigue strength of welded joints with reinforcement is greatly influenced by the shapes of reinforcement. Contrary to welded joints with reinforcement, fatigue strength is greatly influenced by the alignment in case of without reinforcement.

4. Conclusion

Welding by using newly developed flash welding system is performed to the rolled H section steels. The specimens are cut out from the flash welded joints, and a series of experiments are carried out.

The obtained main results are as follows:

(1) The welded joints with reinforcements have almost same of yield stress and tensile strength as the base metal. However, in case that reinforcement is removed, the yield stress and tensile strength of the joints decrease less than those of the base metal. Contrary to this, welded joints with reinforcement is more dominant than the welded joints without reinforcement from the viewpoint of tensile strength.

(2) The yield stress of the joints at the web is slightly higher compared with that of the welded joints at the flange due to cold working. However, tensile strength of the joints at the web is the same as that of the joints of the flange. Therefore, the influences of cold working on tensile strength are not strong.

(3) Fatigue strength of flash welded joints with reinforcement is about 50% of that of the base metal. Removing the reinforcement generated by flash welding, fatigue strength of flash welded joints become 75% of that of the base metal.

(4) After a couple of fatigue cracks have propagated, ductile fracture occurs at the toe of welded joints with reinforcement. On the other hand, in case of welded joint without reinforcement, fracture occurs at the bond or at HAZ. In case of fracture at the bond, it is brittle, and in case fracture at HAZ, it is ductile.

Reference

1) Welding News, Sanpou Publication, No.2426, and 2001/5/15 issues.