Bending Strength of Rolled H Section Steel Welds Jointed by Newly Developed Flash Welding System †

OKU Kentaro*, UMEKUNI Akira**, KIM You-Chul ***

Abstract

For joining large sectional members, such as I section or H section steesl, on site, a flash welding system was newly developed. When H section steel (600×300(mm)) was joined by using the newly developed flash welding system, the joining time was 1/10 compared with conventional arc welding. There is also an advantage that when this system is used, members are employed directly from gas cutting, without groove preparation. If flash welding is performed, weld reinforcements (called reinforcements hereinafter) are inevitably generated at the joints. Reinforcements are generally removed because they become the source of stress concentration and they may possibly have a bad influence on the mechanical properties of the joints. Therefore, bending tests were carried out on small specimens cut from the flanges of H section steels and on the welded member itself to evaluate bending strength of the joints as the structural members.

No cracks occurred in the welds of the small specimens in bending test at -40 ℃, -20 ℃ and at room temperature. Therefore, it was concluded that the un-welded zone on the upset metal did not lower the bending strength of the joints. The welded members had sufficient bending strength without fracture in the full plastic moment.

KEY WORDS: (Flash welding), (Bending strength), (Weld reinforcements), (Bending test), (H section steel)

1. Introduction

For joining large sectional members, such as I section or H section steels, on site, a flash welding system was newly developed to shorten the joining time for large sectional members[1]. When H section steel (600×300(mm)) is joined by using the flash welding system, it took 5 minutes, that was 1/10 comparing with conventional arc welding. There is also the advantage that when this system is used, members are used directly from gas cutting without groove preparation.

To investigate the basic mechanical characteristics of H section steel members joined by the flash welding system[2], a series of experiments have been carried out.

If flash welding is performed, upset metals (called reinforcements) are inevitably generated at the joints. Reinforcements are generally removed because they become the source of stress concentration and they may possibly have a bad influence on the mechanical properties of the joints. Tensile tests were carried out for the specimens with reinforcements cut from H section steel members jointed by flash welding. From the results, joints with reinforcements were not broken at the welds.

There is an un-welded zone at the upper part of reinforcements. This has the possibility of having a bad influence on the static strength. So, bending tests are carried out with cutting small specimens from the flanges of H section steels to investigate influences of the existence of the un-welded zone. At the same time, bending tests are carried out for the jointed members of H section steels to evaluate the bending strength of the joints as the structural members.

2. Experiments

2.1 Materials of specimens and welding condition

H section steels used in the experiments are SM490A(488×300×11×18 (mm)). **Table 1** shows the mechanical properties and the chemical compositions of a rolled H section steel SM490A.

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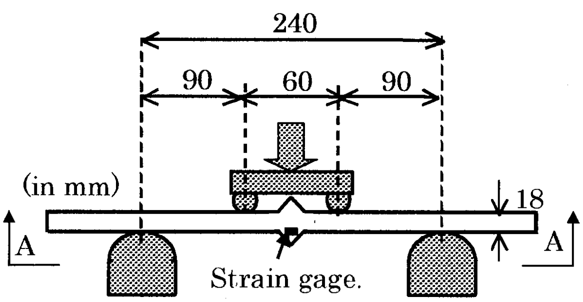
Table1 Mechanical properties and chemical compositions of SM490A.

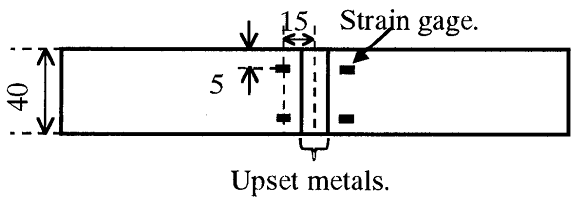
Mechanical properties			Chemical compositions (%)					
Y.P.	T.S.	EL.	C	Si	Mn	P	S	V
(MPa)	(MPa)	(%)	x100			x1000		x100
366	529	29	13	28	123	14	9	2

Table 2 Flash welding conditions.

Electric power (w/mm^2)	Flash time (s)	Heat input (J/mm^2)	Upset distance (mm)
6.5	277	1800	15



(a) Outline.



(b) Section A-A.

Fig.1 4-point bending test for small specimens.

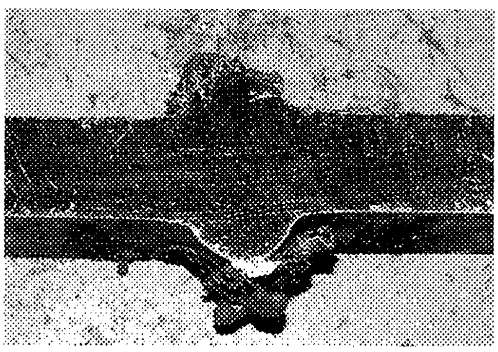
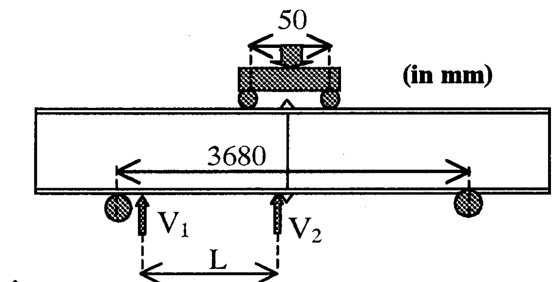
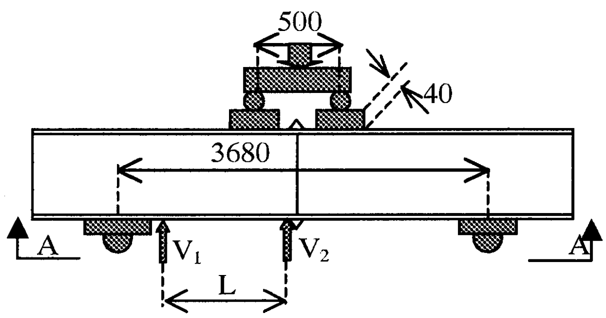


Fig.2 Configuration of flash welded joints.

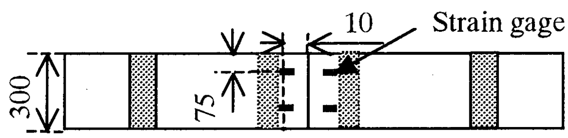


: Measuring position of vertical displacement

(a) Outline (not strengthened).



(b) Outline (strengthened for crippling).



(c) Section A-A.

Fig.3 4-point bending test for rolled H section welds.

The small size specimens for 4-points bending tests are cut from the flanges of H section steels. They are cut by avoiding the inside of 10mm from crossing positions of web and the inside of 18mm from edges of flange.

Table 2 shows the flash welding conditions.

2.2 Four-points bending tests

The 4-points bending tests are carried out for the small specimens cut from jointed members of rolled H section steels and for the jointed member itself. In the experiments, static monotonous loads are applied on specimens by a universal testing machine.

Figure 1 shows the outline of 4-point bending tests for the small specimens and the attached positions of strain gauges. Width of specimens is 40mm and thickness 18mm. Strain gauges are attached on reinforcements and the base metal 15mm away from the interface. The experiments are carried out at room temperature, -20°C and -40°C.

Figure 2 shows the cross section of welds of small specimens used in 4-point bending tests. In small size bending specimens, there is little difference in the cross sections of reinforcements. An un-welded zone, under 1mm, is observed at the top of reinforcements in most of the specimens.

Figure 3 shows the outline of 4-point bending tests for the jointed members of rolled H section steels and the attachment positions of strain gauges.

In the experiments, crippling occurred at the web of loaded points before the bending moment of welds reached full plastic moment M_p (**Fig.3**(a)). Then, applying plates for reinforcement to the loaded points and the supported points of the jointed members (**Fig.3**(b)), 4-point bending tests are carried out.

Vertical displacements V_1 and V_2 are measured at the bottom flange in the experiments. The relative angle of rotation θ in welds is calculated from Eq.(1) by using the measured V_1 and V_2.

$$\theta = (V_2 - V_1)/L \qquad (1)$$

3. Experimental Results and Consideration

3.1 Bending properties

3.1.1 Small specimens cut from jointed member

Table 3 shows the maximum load at each test temperature obtained by 4-point bending tests for small specimens and each bending angle of the specimen after the experiments. **Figure 4** shows a view of the specimen after the experiment as one example.

Table 3 Results of bending test for small specimens.

Temperature (°C)	Maximum load (kN)	Bending angle (degree)
14	45.6	130
15	50.0	128
8	46.6	122
7	48.1	126
-20	47.4	115
-20	47.1	117
-20	46.6	113
-20	47.0	115
-40	50.5	104
-40	48.0	108

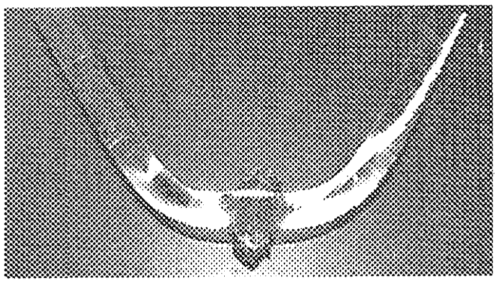


Fig.4 Appearance after bending tests.

In the experiments, pure bending is applied on the whole of the specimen including reinforcements. No fracture occurs at -20°C and -40°C as well as at room temperature. The bending angle exceeds 100° in all specimens. No fracture occurs at the joints (the interface) in the bending test, although larger local strain is generated comparing with that in the tensile tests.

It is considered that stress generated in the welds becomes relatively smaller than that in the base metal due to the increment of the cross section by reinforcements. Even if an un-welded zone exists at the upper part of reinforcements, an un-welded zone itself is small, and is considered the reason why no fracture occurs at reinforcements. Actually, it is confirmed that the base metal around reinforcement yields earlier than welds does and the specimen is deformed. As an example, **Figure 5** shows the relation between applied load (kN) and strain at weld metal and at the base metal 15mm away from the bond line.

3.1.2 Jointed members

Figure 6 shows the relation between the bending moment M and the relative angle of rotation θ obtained by 4-point bending tests for the jointed members. Full plastic moment M_P for the jointed member is 1131(kN · m) and elastic relative angle of rotation θ_P responding to full plastic moment is 0.0064(rad.).

In the experiment (**Fig.3**(a)), crippling occurred at web before the bending moment of welds reached full

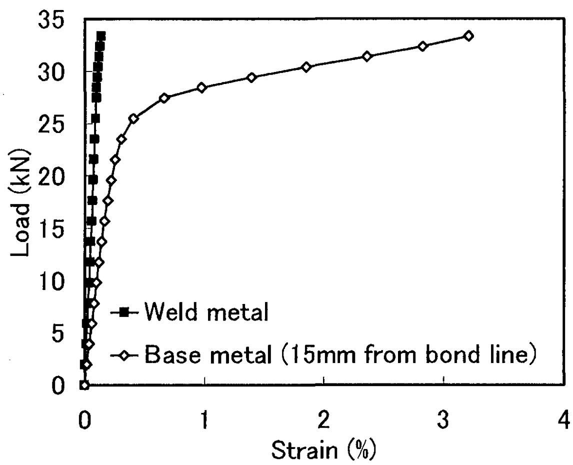


Fig.5 Load and strain diagram.

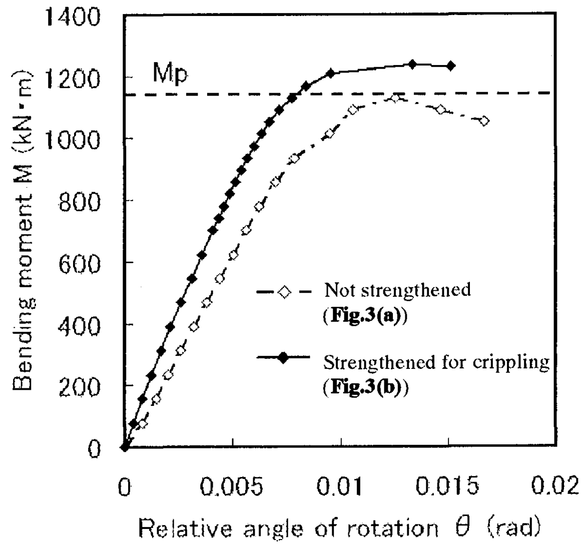


Fig.6 Bending moment M and relative angle of rotation θ diagram at welded zone.

plastic moment M_P. When crippling occurs at the web, strain under the bottom flange is about 2% and the relative angle of rotation θ of welds is about 0.017(rad.).

On the other hand, no fracture occurs even if they reach full plastic moment in the experiment (**Fig.3**(b)) for the reinforced jointed members. Strain under the bottom flange is about 2% and the relative angle of rotation θ of welds is about 0.018(rad.). The crippling occurs finally at the web of the supported points.

As no fracture occurred at the jointed members in both experiments (**Fig.3**(a), (b)), even when they reached full plastic moment, it is considered that they have sufficient bending strength to be suitable for practical use.

Then, as no fracture occurred at welds of the specimens used in both experiments (**Fig.3**(a), (b)), validity of the results on 4-point bending tests for small specimens was confirmed.

4. Conclusions

The 4-point bending tests were carried out for small specimens cut from jointed members of rolled H section steels and for the jointed member itself. The obtained results were as follows.

From the tests for small specimens cut from jointed members:

(1) No fracture occurred in welds at -20°C and -40°C as well as at room temperature.
(2) An un-welded zone at the upper part of reinforcements did not influence the bending strength.

From the tests for jointed members:

(3) No fracture occurred at the jointed members, even when they reached full plastic moment.
(4) Validity of the results on small specimens cut from jointed member was confirmed by comparing them with those of jointed members. They had sufficient bending strength to be suitable for practical use.

References

1) For example: Welding news No.2426(2001), pp.1 (in Japanese).
2) Kim Y.C., Oku K., Umekuni A. and Horikawa K.: Mechanical Properties of Rolled H Section Steel Jointed by Newly Developed Flash Welding System, Quarterly Journal of the Japanese Welding Society, 21-1(2003), pp.95-100 (in Japanese).