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Mechanical Properties of Plates Welded under Loading†

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It is reported that fatigue crack initiates in steel bridges and consequently load carrying capacity is lack in these bridges. When the steel bridges are repaired and/or strengthened by welding, the bridges are welded after stress is decreased by built up of staging and off limits of traffics. There are a few studies on welding under loading. TOKUZAWA et al. studied on the mechanical properties and the residual stress distributions of plates which were welded in parallel with applied tensile load.

In the former part of this paper, the mechanical properties of plates welded in parallel with applied compressive load are described.

Material of the specimen is the mild steel of 41 kg/mm^2 in the tensile strength (called SM41B in JIS G3101) with 6 mm thickness. Specimen configuration is shown in **Fig. 1**. Flanges with 30 mm width were welded to prevent from buckling. Stress relief treatment was performed after the welding. Types of specimens are the following.

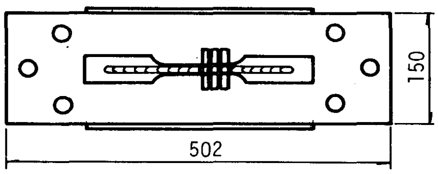

Fig. 1 Specimen configuration

I. Welding without stress.
II. Welding without stress, then applying compressive stress equal to the allowable stress.
III. Welding with compressive stress equal to the allowable stress.
IV. Welding without stress, then welding with compressive stress equal to the allowable stress.

Welding condition is 315 A, 33 V and 50 cm/min. Therefore, weld heat input is 12.5 kJ/cm. Edge preparation was 3 mm depth, 5 mm width and 250 mm length. Load was always kept constant during experiment. One tensile specimen and three sharpy sub-size (5 X 10) specimens with 2 mm V-notch were machined from every specimens as shown in Fig. 1.

The results are shown in **Fig. 2**. There is no difference in yield stress, tensile strength and elongation among four types. Sharpy absorbed energy of type IV is greater than the others. As welding with loading was performed on welding without loading, micro-structure of weld metal was become the fine-grained one. The toughness of weld metal was improved by this fine-grained structures. From these results, it is considered that mechanical properties of joint welded under compressive loading are not damaged as compared with them of joint welded under no loading.

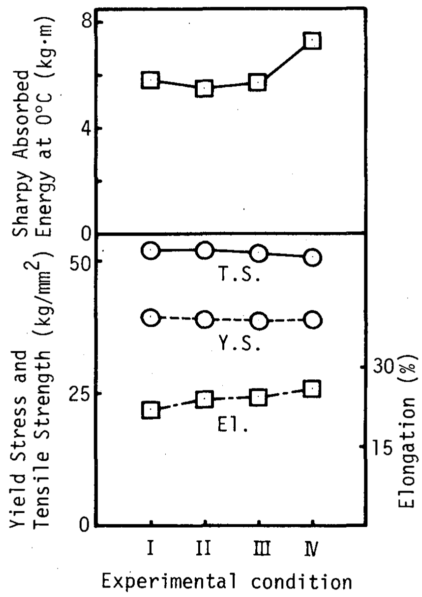

Fig. 2 Results of tensile and impact test

Theoretical consideration is made on the case of welding under tensile loading as well as compressive loading. **Figure 3** shows schematical stress histories on weld bead.

In case of no-loading, compressive stress increases according to temperature. And yield stress decreases. Therefore, compressive stress reaches yield stress at point A and maintains yield stress along AB. With beginning of cool-

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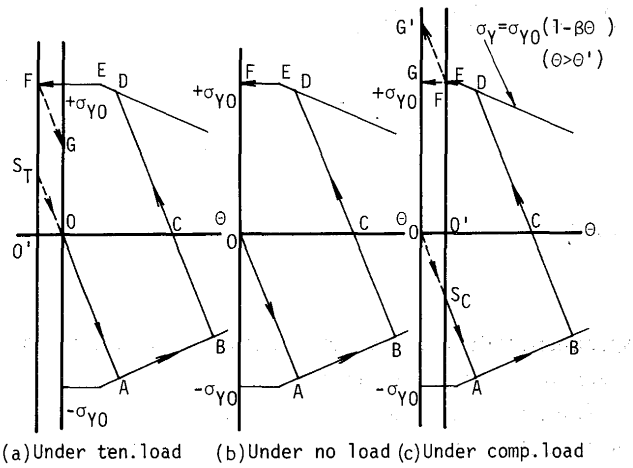

Fig. 3 Stress histories

ing, compressive stress decreases (B to C) and tensile stress occurs at a certain temperature (point C). This tensile stress increases with cooling and reaches tensile yield stress (point D). Tensile stress maintains yield stress after here (D to F). The residual stress on weld bead becomes tensile yield stress at room temperature (point F).

Tensile pre-loading can be shown as line OS_T in Fig. 3 (a). The stress history to room temperature is the same as the case of no-loading (S_T to F). When pre-load is unloaded, residual stress on weld bead decreases as the same as applied tensile stress (F to G).

In the case of under-compressive-loading, stress history goes from 0 to S_c and then the stress history to room temperature is the same as the others (S_C to F). Tensile residual stress might increase in elastic body by unloading (F to G'). However, tensile residual stress over yield stress disappears because of yielding in elasto-plastic body and tensile residual stress maintains yield stress (F to G).

Next, mechanical properties and residual stress distributions of plates welded transverse to tensile or compressive loading will be discussed.

Material of specimen is the mild steel of 41 kg/mm^2 in the tensile strength with 6 mm thickness. Specimen configuration is shown in **Fig. 4**. Types of specimens are as follows.

I. Welding with tensile stress equal to the allowable stress.

II. Welding without stress.

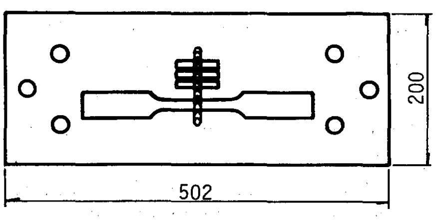

Fig. 4 Specimen configuration

III. Welding with compressive stress equal to the allowable stress.

Welding condition is the same as the previous experiment. But edge preparation was 2 mm depth, 5 mm width and 100 mm length. Load was always kept constant during experiment. In type III, two angle bars of 50 X 50 X 4 X 280 were attached by clamps to prevent from buckling. One tensile specimen and three sharpy sub-size specimens with 2 mm V-notch were machined from every specimens.

The results are shown in **Fig. 5**. There is no difference

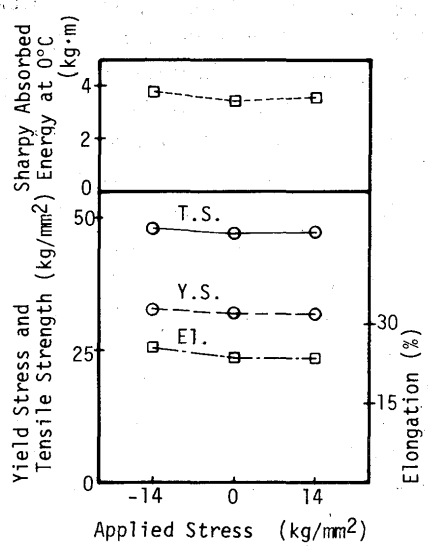

Fig. 5 Results of tensile and impact test

in yield stress, tensile strength, elongation and sharpy absorbed energy among three types. Tensile specimens fractured at base metal in all types. Therefore, even though welding transverse to applied stress was performed to the plates under loading, it is considered that their mechanical properties are not damaged as compared with them of joint welded under no loading.

The residual stress distributions are shown in **Fig. 6**. Bold and fine lines are the stress of parallel and transverse direction to applied stress, respectively. There is no difference in residual stress distributions of transverse direction to applied stress. On the other hand, there is considerable difference in residual stress distributions of parallel direction to applied stress. Tensile residual stress of joint welded under tensile loading is relieved the same quantities of applied stress and compressive residual stress also is relieved equivalent to the decrease in tensile residual stress. Tensile residual stress of joint welded under compressive loading is nearly equal to one under no loading and compressive residual stress is relieved about 10 kg/mm^2. These facts were the same as the results of previous consideration.

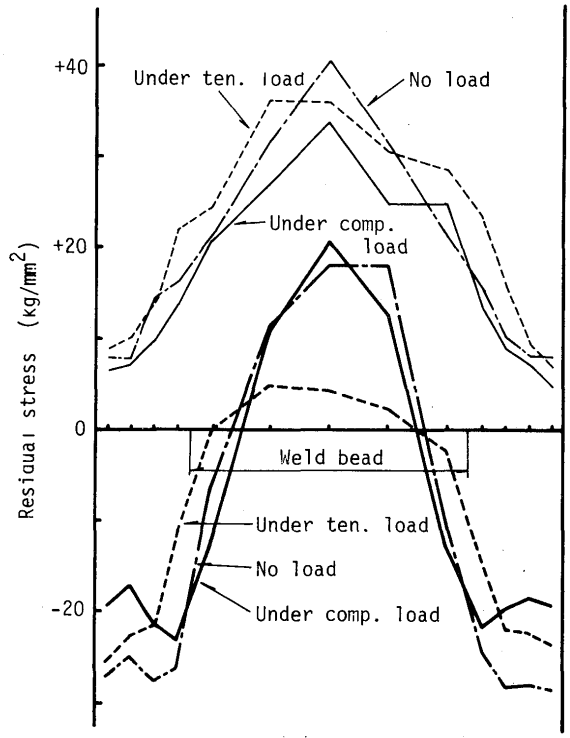

Fig. 6 Residual stress distributions (Bold line; parallel direction Fine line; transverse direction)

Results are summarized as follows.

(1) Yield stress, tensile strength, elongation and sharpy absorbed energy of joint welded under loading were not damaged as compared with them of joint welded under no loading regardless of weld direction.

(2) In residual stress distribution of joint welded transverse to applied stress, tensile residual stress in the direction of applied stress decreased in under-tension-loading as compared with no-loading and was nearly equal to no-loading in under-compression-loading.

References

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