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Autor: Konishi, Ichiro / Okumura, Toshie / Minami, Shunji

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Welding of High-Strength Steels

Soudage des aciers à haute résistance

Schweissen von hochfesten Stählen

ICHIRO KONISHI
Professor Emeritus
Kyoto University
Kyoto, Japan

TOSHIE OKUMURA
Professor
Saitama University
Tokyo, Japan

SHUNJI MINAMI
Adviser
Nissho-Iwai Co. Ltd.
Osaka, Japan

MATSUJI SASADO
Manager
Hanshin Expressway Public Corporation
Osaka, Japan

1. INTRODUCTION

It should be taken great pains with not only the characteristics of materials but also the welding methods from a viewpoint of risk of failure of long-span bridge made of high-strength steels. In the preliminary report, the outline of way to build-up of long-span truss bridge, i.e., design, materials, fabrication and erection were discussed. In this report, the conditions and methods of welding and the quality control of welding during the fabrication course may be presented.

2. CONDITIONS OF WELDING

As a procedure test to determine welding conditions of high-strength steels 70 kg/mm^2 and 80 kg/mm^2 classes, the following tests were conducted prior to fabrication;

(1) lamellar tear test,
(2) restrained cracking test,
(3) tests on the performance of corner weld joints,
(4) tests to check residual stresses due to welding, and
(5) tests to investigate the various characteristics of the actual members using full scale models.

The maximum heat input of less than 50 KJoule/cm during welding was preset based on the results of such tests to avoid "bond" embrittlement of weld joint. Welding conditions including minimum preheat temperature, maximum preheat temperature, interpass temperature, and preheat temperature for tack welds were determined from the condition mentioned above. (Table 1)

The three factors of kind of materials, restraining and hydrogen are said to be main ones causing weld cracking. The first was settled by employing the steels passing the new specification. The second was thought not to be serious problem because of no steel plate having great restraining with neighbour plate in the Osaka Port Bridge. Therefore, the final factor was remained as the most considerable one which brought so called transverse cracking, i.e., the cracking along weld line. The suitable control method with which hydrogen entry could be minimized as much as possible was settled for fabrication in order to avoid such possible cracking.

Table 1 Preheat Temperature

Minimum Preheat Temparature (°C)

High-Strength Steels of 70 kg/mm² and 80 kg/mm² Classes				
Welding Method / Thickness (mm) / Kind of Joint	Covered Arc Welding	M I G ※ Welding	Submerged Arc Welding	
	Butt , Fillet , Corner		Butt	Fillet
t ≦ 50	100	80	100	80
t > 50	120	100	150	100

※ M I G Welding...........Inert Gas Shielded Metal Arc Welding.

Maximum Preheat Temparature and Interpass Temparature

Thickness (mm)	Temparature
t ≦ 50	200°C and under
t > 50	230°C and under

3. WELDING METHOD

The automatic welding technique was made every effort to use in order to uniformalize the fabrication conditions. Among the automatic methods, two techniques of submerged arc welding and MIG welding were selected. The latter has an advantage to avoid the possible occurrence of cracking because of small heat input, but involves the serious problems of ill efficiency of work and of increased hardness in weld joint. Therefore, the first was used as the butt and fillet welding and the latter as the corner one. Also the following three types of preheating methods were used;

(1) electric preheating type with automatic control, (Photo 1)
(2) fixed burner type, and
(3) manual burner type.

The separate preheating method was specified for each type of weld joints. In welding major members, symmetrical preheating and symmetrical welding methods were employed to secure higher fabrication accuracy and minimize residual stresses. (Photo 2)

The preheating prior tack welding of small heat input and rapid cooling was carried out with careful concern, and its temperature was set higher by 20-40°C than that of primary weld.

4. QUALITY CONTROL OF WELDING

The close quality control system is necessary for the use of high-strength steels 70 kg/mm² and 80 kg/mm² classes to long span bridge. Although the detail explanation of such system is omitted in this report, the non-destructive inspections involves serious and many problems. Especially at the ultrasonic examination of corner joint shown in Fig.1, as the ultrasonic flaw detector possessed by the fabricators were different in the kind and the material and dimension of probe, the inspection was quite different each other, and the correlation between flaw and echo from discontinuity captured on the Braun tube could not be obtained. Therefore, the inspection standard was rechecked from the measurements with various test material.

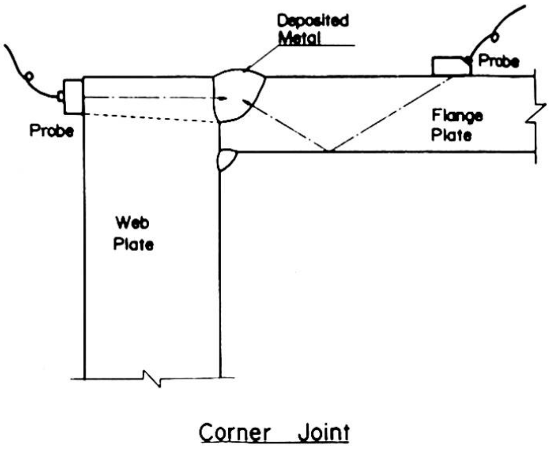

Fig. 1 Corner Joint

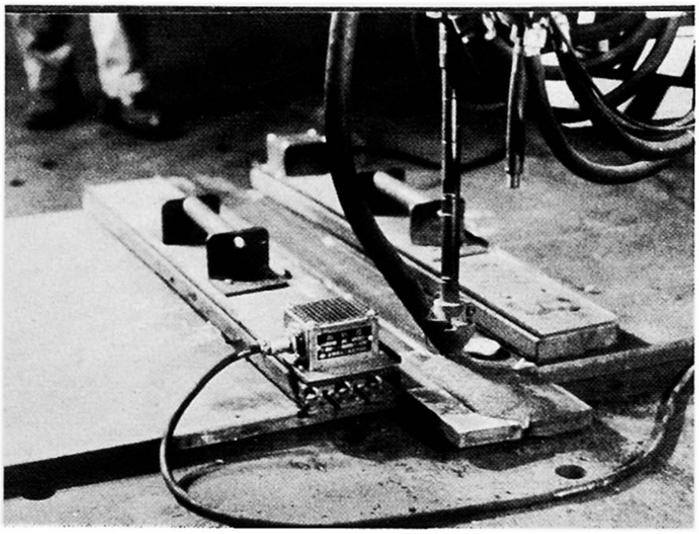

Photo 1

This photograph shows preheat performance with electric preheating equipments.

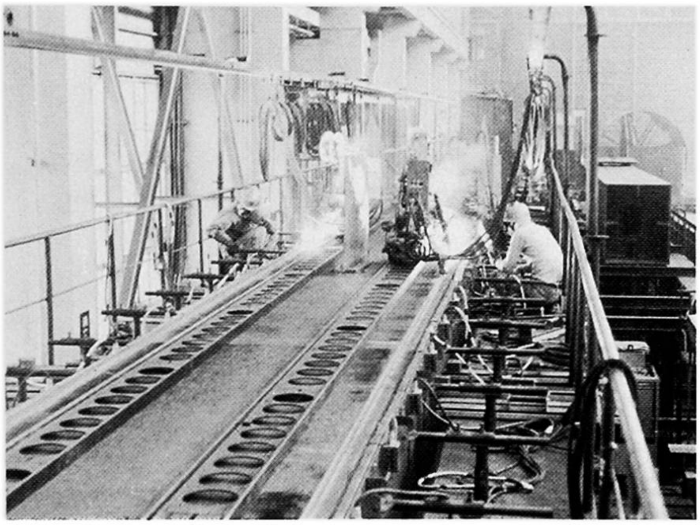

Photo 2

This photograph shows the appearance of symmetrical welding.

SUMMARY

Due attention was paid to the problem of cracking and embrittlement of weld joints of high-strength steels. The maximum heat input of less than 50 K Joule/cm during welding was preset and the preheat temperature was determined. The suitable control method with which hydrogen entry could be minimized was settled for fabrication. Among the automatic welding methods, two techniques of submerged arc welding and MIG welding were selected.

RESUME

On a prêté une attention particulière au problème des fissures et des ruptures fragiles dans les joints soudés en acier à haute résistance. L'apport de chaleur durant le soudage a été limité à 50 K Joule/cm et la température de préchauffage, déterminée. On a fixé la méthode de contrôle permettant de réduire au minimum la teneur en hydrogène. Parmi les méthodes de soudage automatiques, on a retenu le soudage sous flux et le procédé MIG.

ZUSAMMENFASSUNG

Der Vermeidung von Rissen und Sprödbrüchen in Schweissnähten an hochfesten Stählen wurde besondere Beachtung geschenkt. Das Wärmeeinbringen während der Schweissung wurde auf 50 K Joule/cm begrenzt und die Vorwärmetemperatur bestimmt. Man verwendete eine geeignete Kontrollmethode, um die Wasserstoffaufnahme möglichst niedrig zu halten. Unter den automatischen Schweissmethoden wurden das Unterpulverschweissen und das MIG-Verfahren ausgewählt.