Latest Trends and Lineup of Welding Consumables for Structural Steel

Takahiro YAMAMOTO*1 · Hang YU*2 · Yuto INOUE*3 · Masaharu KOMURA*4

*1 Welding Process Department, Technical Center, Welding Business (currently Thai Kobelco Welding Co., Ltd.)
*2 Welding Process Department, Technical Center, Welding Business (currently Quality Management Department, Welding Business)
*3 Welding Process Department, Technical Center, Welding Business
*4 Welding System Department, Technical Center, Welding Business

Abstract

This paper presents the latest trends in consumables for gas shielded arc welding, submerged arc welding, and electroslag welding, which are commonly used in the construction of structural steel. Also introduced is the lineup of welding consumables, which is tailored to the strength class of the steel.

Introduction

Construction demand grew in the Tokyo metropolitan area in particular in 2025. Activity in this region is being driven by projects such as the Mori JP Tower in Azabudai Hills – now Japan's tallest skyscraper, at 325 meters – and the TOKYO TORCH, a 385-meter skyscraper scheduled for completion in 2028. The trend in high-rise and commercial buildings in recent years has been to shift toward larger columns and wider spans between columns to maximize space and improve economic efficiency. This entails increased thicknesses and cross-sectional areas of steel frames, and the associated increased weight of these steel frames poses the challenge of higher costs for processing and freight. One way to overcome this challenge is to develop higher-strength steel. High-strength steels, such as those in tensile strength grades of 550 MPa and 590 MPa, have recently started seeing increased use. Steels with tensile strengths as high as 780 MPa are now starting to be used in skyscrapers.[1)]

These trends are increasing the demand for improved productivity and quality in welding, but there is a shortage of skilled welders for structural steel column fabrication. Automated welding using vertical articulated robots to weld cold-formed square steel pipe has gained widespread use in structural steel column fabrication. For welded box columns, however, high-heat input methods such as multi-electrode submerged arc welding (SAW) and electroslag welding (ESW) are commonly used.

Some of Kobe Steel's forthcoming developments will satisfy needs for further improvements in productivity and welding quality. For instance, we are developing a robot system and specialized welding wire for structural steel columns, as well as welding consumables compatible with steel materials of various strength classes, including steel with a tensile strength grade of 780 MPa. In this paper, we introduce our lineup of consumables for the gas-shielded arc welding, SAW, and ESW of structural steel columns. The steel strength class and latest trends applicable to each type of consumable are described.

1. Solid wires for CO_2 shielded arc welding

1.1 Lineup of welding consumables by steel strength class

Table 1 shows the lineup of solid wires for building structures broken down by steel strength class.

A common material used for structural steel columns is square steel pipe for building structures (hereafter, "columns"), which is made by cold-forming steel plates. The resulting columns are stronger than the steel plates they are made up of due to the work hardening that occurs as part of cold forming. As such, the welding consumables chosen must account for the effects of work hardening.[2)] For example, columns with a tensile strength of 590 MPa require TRUSTARC™ MG-70 and TRUSTARC™ MG-70R(N) [Note 1)], which are solid wires for the CO_2 shielded arc welding of 690 MPa-grade steel.

Welding robot systems with vertical articulated robots are widely used for column welding in steel column fabrication plants. Kobe Steel's welding robot systems for structural steel columns use the REGARC™ process [Note 2)], which achieves high efficiency and low spatter. The (N) series and (A) series are welding wires specially designed for this process, with the (N) series specifically being coordinated to the REGARC™ process, and the (A) series to the NEW REGARC™ process.

Note 1) TRUSTARC is a trademark of Kobe Steel, Ltd.
Note 2) REGARC is a trademark of Kobe Steel, Ltd.

Table 1 List of CO_2 solid wires for building structures

<table>
<tr><th colspan="2">Grade of steel plate</th><th rowspan="2">TS※1 400 MPa / YP※2 235 MPa</th><th rowspan="2">TS 490 MPa / YP 325 MPa</th><th rowspan="2">TS 520 MPa / YP 355 MPa</th><th rowspan="2">TS 550 MPa / YP 385 MPa</th><th rowspan="2">TS 590 MPa / YP 440 MPa</th><th rowspan="2">TS 780 MPa / YP 630 MPa</th></tr>
<tr><th>Welding joint</th><th>Column type</th></tr>
<tr><td rowspan="12">Column-Column (for robot welding)</td><td rowspan="6">Square pipe column</td><td>FAMILIARC™ MG-50R</td><td></td><td></td><td>TRUSTARC™ MG-60R</td><td>TRUSTARC™ MG-70</td><td></td></tr>
<tr><td>FAMILIARC™ MG-50R(N)</td><td></td><td></td><td>TRUSTARC™ MG-60R(N)</td><td>TRUSTARC™ MG-70R(N)</td><td></td></tr>
<tr><td>FAMILIARC™ MG-50R(A)</td><td></td><td></td><td>TRUSTARC™ MG-60R(A)</td><td></td><td></td></tr>
<tr><td colspan="2">FAMILIARC™ MG-56R</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">FAMILIARC™ MG-56R(N)</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">FAMILIARC™ MG-56R(A)</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="6">Circular pipe column</td><td colspan="2">FAMILIARC™ MG-50R</td><td colspan="3">TRUSTARC™ MG-60R</td><td>TRUSTARC™ MG-80</td></tr>
<tr><td colspan="2">FAMILIARC™ MG-50R(N)</td><td colspan="3">TRUSTARC™ MG-60R(N)</td><td>TRUSTARC™ MG-82</td></tr>
<tr><td colspan="2">FAMILIARC™ MG-50R(A)</td><td colspan="3">TRUSTARC™ MG-60R(A)</td><td></td></tr>
<tr><td></td><td colspan="3">FAMILIARC™ MG-56R</td><td></td><td></td></tr>
<tr><td></td><td colspan="3">FAMILIARC™ MG-56R(N)</td><td></td><td></td></tr>
<tr><td></td><td colspan="3">FAMILIARC™ MG-56R(A)</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="3">Column-Beam, Beam-Beam, Column-Column (for semi-auto welding)</td><td colspan="2">FAMILIARC™ MG-50</td><td></td><td></td><td></td><td>TRUSTARC™ MG-80</td></tr>
<tr><td></td><td colspan="3">FAMILIARC™ MG-56</td><td></td><td>TRUSTARC™ MG-82</td></tr>
<tr><td></td><td></td><td colspan="3">TRUSTARC™ MG-60</td><td></td></tr>
</table>

※1 TS ; Tensile Strength
※2 YP ; Yield Point

1.2 NEW REGARC™ solid wire for welding FAMILIARC™ MG-56R(A) [Note 3)]

Improvements of the NEW REGARC™ process over the original REGARC™ process include optimized waveform control, enhanced stability of droplet transfer in the globular mode, reduced spatter, an increase in the maximum wire feed speed from 16.4 m/min to 18.0 m/min, and an increase in the maximum welding current from 320 A to 340 A. However, with a higher wire feed speed, the inside of the feeding path exerts a higher reaction force on the wire. This makes the copper plating on the wire more likely to peel. The peeled plating accumulates in the feeding path on the inner tube, conduit liner, and tip, causing unstable wire feeding.[3)] This phenomenon drove us to develop a special type of welding wire for this process: the (A) series, which features a special surface treatment to ensure stable wire feeding and reduce clogging.

We compared the amount of contamination on the inner tube, conduit liner, and tip using the NEW REGARC™ process and two different solid wires – specifically, FAMILIARC™ MG-56R(N) as a benchmark and FAMILIARC™ MG-56R(A) of the improved (A) series. Welding was performed at a welding current of 350 A for 5 hours. **Fig. 1** shows an example of the amount of contamination clogging the feeding path per 10 kg of wire, and **Fig. 2** shows photos of the base of the contact tip. It can be surmised that the copper plating of FAMILIARC™ MG-56R(A) was less prone to peeling in the feeding

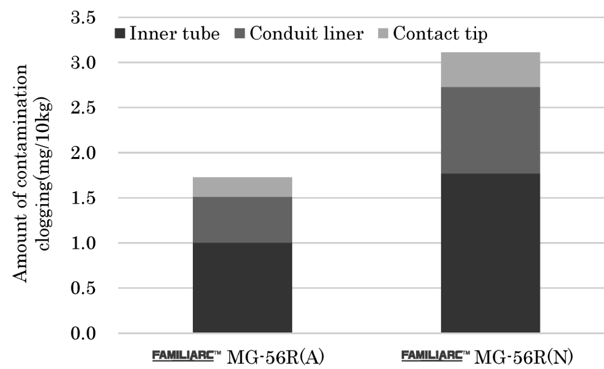


Fig. 1 Example about amount of contamination clogging wire feeding path parts

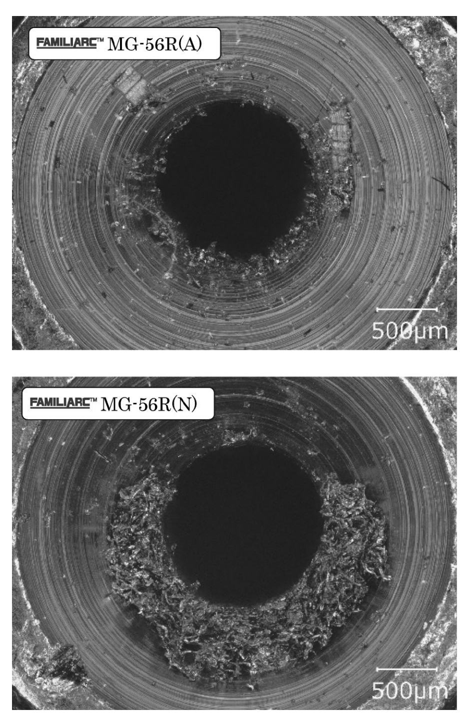


Fig. 2 Contamination clogging at base of the contact tip

Note 3) FAMILIARC is a trademark of Kobe Steel, Ltd.

path due to reduced sliding friction between the surface of the wire and the inner tube or conduit liner.

We evaluated the performance of the welding joints of a column (490 MPa grade, plate thickness 32 mm) and a through-diaphragm (JIS G 3136 SN490B, plate thickness 36 mm). We fabricated two joints with root gaps of 4 mm and 10 mm at a maximum heat input of 35 kJ/cm and a maximum interpass temperature of 250℃. **Fig. 3** shows the macroscopic cross-sections of the straight and corner sections as well as a depiction of the welding layers. **Table 2** shows the mechanical properties of the weld metal for the joint with a root gap of 10 mm. We collected Charpy impact specimens 7 mm from the top surface of the column, in the direction of the plate thickness. The macroscopic cross-section shows good penetration and good geometry of the surface of the bead. Furthermore, the strength of the weld metal and the absorbed energy upon Charpy impact testing meet the standards for structural steel.

1.3 TRUSTARC™ MG-82 solid wire for 780 MPa-grade steel

Both in-plant and on-site semi-automatic welding processes for structural steel columns must be highly efficient. Welding consumables must not only result in favorable mechanical properties of the weld metal, but also ensure weldability to streamline upstream and downstream processes. In particular, there is a demand for improvements in spatter control and wire feedability. Kobe Steel is developing technologies to address these needs, for instance through our surface treatment technology to improve wire feedability. We have pursued this avenue in developing solid wires for high-tensile strength steel, such as in our TRUSTARC™ MG-82 solid wire for 780 MPa-grade steel.

This line is an improved version over earlier TRUSTARC™ products in that it receives a surface treatment during production to achieve superior wire feedability and arc stability. We conducted testing to evaluate the feedability of the wire under adverse conditions. As shown in the conceptual diagram in **Fig. 4**, we used a 6-meter torch cable with a coil diameter of 300 mm in the feeding path and evaluated the welding current, arc voltage, and feed resistance during welding. **Fig. 5** shows the results of welding with a wire diameter of 1.2 mm at 300 A, 36 V, and 30 cm/min. Compared with the conventional product, the improved product exhibits less fluctuation in wire feed resistance and thus more consistent results. Fluctuations in wire feed

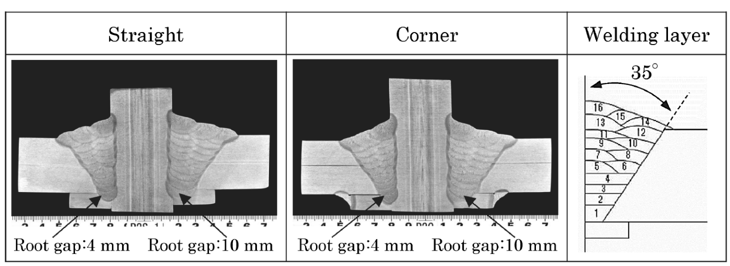


Fig. 3 Cross-sectional macro comparison [F] MG-56R(A) welded joint and welding layer

Table 2 Mechanical properties of weld metal by [F] MG-56R(A)

-		YP(MPa)	TS(MPa)	$vE_{0℃}$(J)
FAMILIARC™ MG-56R(A)	Straight	567	645	Avg. 108
	Corner	-	-	Avg. 124
Spec.(490 MPa Grade)		≧325	≧490	≧27

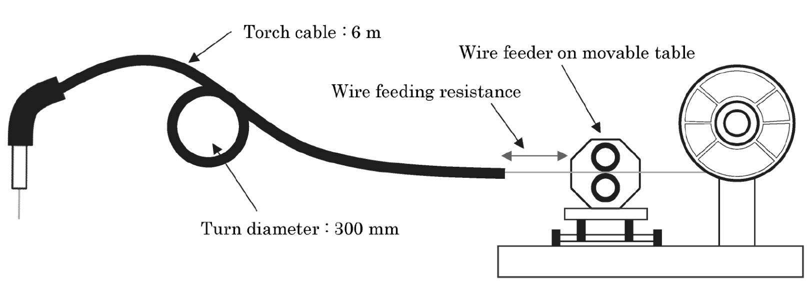


Fig. 4 Schematic illustration of wire feeding path

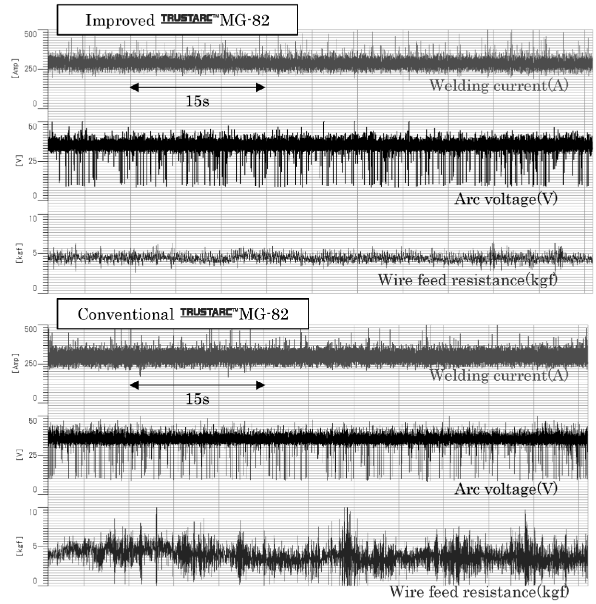


Fig. 5 Fluctuation of welding current, arc voltage and wire feed resistance of improved and conventional [T] MG-82

resistance affect arc stability and spatter generation. In semi-automatic welding, fluctuations also increase torch vibration. As such, the improved product is expected to not only ensure consistent welding performance, but also reduce operator fatigue.

2. Welding consumables for SAW

2.1 Lineup of welding consumables for corner joints of box columns

Fig. 6 shows a schematic diagram of a box column. Single-pass high-heat input SAW is commonly used for corner joints. **Table 3** shows the lineup of SAW consumables for the corner joints of box columns broken down by steel grade.

Recent developments include our welding consumables for 780-MPa grade steel and for two-layer, two-pass welding, which is necessary for high-strength, ultra-thick plates that cannot accommodate single-layer, single-pass welding. The subsections that follow introduce the performance characteristics of these consumables.

2.2 Welding consumables for two-pass welding of corner joints made of ultra-thick 550- and 590-MPa grade steels

Buildings today are taller and larger, meaning skin plates are becoming thicker. This has created a strong need for high-efficiency fabrication methods. Our SAW consumables for welding the corner joints of box columns are designed to

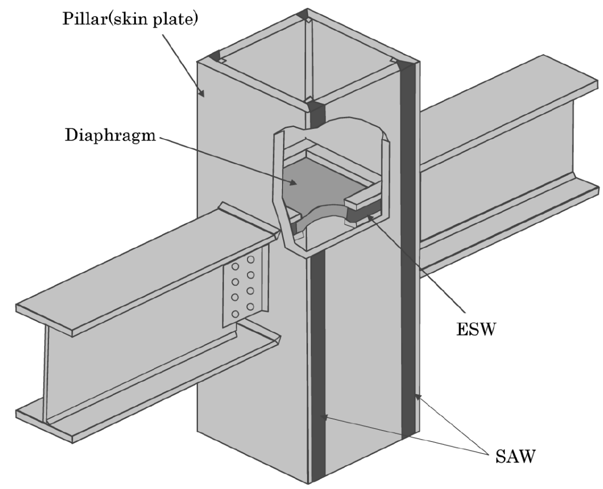


Fig. 6 Weld joints in box columns

ensure consistent weld quality even when used in high-heat input, single-layer, single-pass welding processes involving plate thicknesses of up to 60 mm. For plate thicknesses exceeding 60 mm, however, meeting the demand for high-efficiency construction of ultra-thick steel plate is challenging because it is difficult to ensure consistent bead shape and penetration. To address this challenge, research is underway to devise 3-layer, 4-pass and 2-layer, 3-pass welding methods employing relatively high heat input. However, experience has shown that weld metal subjected to two heat cycles is prone to microcracking. We surmised that a 2-layer, 2-pass process could provide both high efficiency and consistent weld quality since it involves just one heat cycle. This led us to develop a new flux, TRUSTARC™ PF-I60K, to be used specifically in combination with the conventional wire TRUSTARC™ US-49. The performance characteristics of TRUSTARC™ PF-I60K and TRUSTARC™ US-49 are described next.

For the skin plates, L-shaped test specimens simulating the corners of a box column were fabricated using KCL A385C (75 mm) and SA440C-ST (80 mm) steels. **Table 4** shows the welding conditions, **Table 5** shows the mechanical properties of the weld metal, and **Fig. 7** depicts the sampling locations.[4] The results satisfy the standards of the respective steels in terms of the tensile properties of the weld metal and in terms of the individual values and averages for the absorbed energy upon Charpy impact testing (≥ 27 J).

Performing multi-layer welding on ultra-thick steel plate introduces concerns regarding low-temperature cracking resistance. As such, we validated the preheating and interpass temperature conditions using a window-type restraint weld cracking test. **Fig. 8** depicts the specimen for said

Table 3 List of recommended SAW consumables for box columns

<table>
<tr><th>Grade of steel plate</th><th>TS 400 MPa / YP 235 MPa</th><th>TS 490 MPa / YP 325 MPa</th><th>TS 520 MPa / YP 355 MPa</th><th>TS 550 MPa / YP 385 MPa</th><th>TS 590 MPa / YP 440 MPa</th><th>TS 780 MPa / YP 630 MPa</th></tr>
<tr><td rowspan="4">1layer-1pass</td><td colspan="3">FAMILIARC™ PF-I53ES / FAMILIARC™ US-36L</td><td></td><td></td><td>TRUSTARC™ PF-I80ES ※1 / TRUSTARC™ US-80SP</td></tr>
<tr><td></td><td></td><td colspan="3">FAMILIARC™ PF-I53ES / TRUSTARC™ US-49</td><td></td></tr>
<tr><td></td><td colspan="4">FAMILIARC™ PF-I55ES / FAMILIARC™ US-36L</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">FAMILIARC™ PF-I55ES / TRUSTARC™ US-49</td><td></td></tr>
<tr><td>2layers-2 passes</td><td></td><td></td><td></td><td colspan="2">TRUSTARC™ PF-I60K ※1 / TRUSTARC™ US-49</td><td></td></tr>
</table>

※1 : New lineup

Table 4 Welding conditions

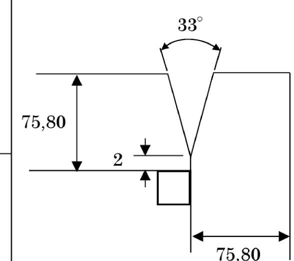
<table>
<tr><th>Pass</th><th>Electrode (6.4φ)</th><th>Welding current (A)</th><th>Arc voltage (V)</th><th>Welding speed (cm/min)</th><th>Heat input (kJ/cm)</th><th>Preheating・inter pass temperature (℃)</th><th>Groove shape</th></tr>
<tr><td rowspan="2">1</td><td>L</td><td>2250</td><td>38</td><td rowspan="2">16</td><td rowspan="2">618</td><td rowspan="2">RT.</td><td rowspan="4"></td></tr>
<tr><td>T</td><td>1650</td><td>48</td></tr>
<tr><td rowspan="2">2</td><td>L</td><td>2000</td><td>42</td><td rowspan="2">24</td><td rowspan="2">396</td><td rowspan="2">≦250</td></tr>
<tr><td>T</td><td>1550</td><td>48</td></tr>
</table>

Table 5 Mechanical properties of weld metal

Specification (thickness)	Specimen location	Tensile test※1			Charpy impact test※2
		YP (MPa)	TS (MPa)	El. (%)	$vE_{0℃}$(J)
KCL A385 (75 mm)	Face	459	626	26	106 111 100 Avg.106
	Back	533	654	26	97 121 142 Avg.120
Spec.		≧385	≧550		≧27
SA440C-ST (80 mm)	Face	471	641	24	120 97 123 Avg.113
	Back	506	648	25	143 121 144 Avg.136
Spec.		≧440	≧590		≧27

※1 Size of tensile specimen; Dia. = 12.5 mm, G.L. =50.0 mm
※2 10×10 mm,2 mm V notch

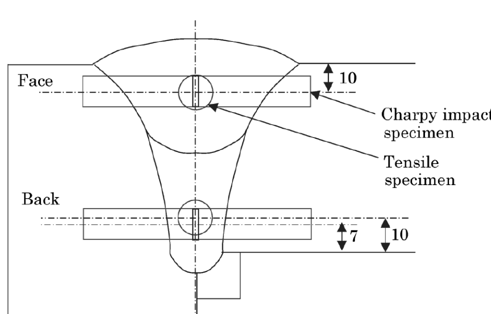


Fig. 7 Specimen location

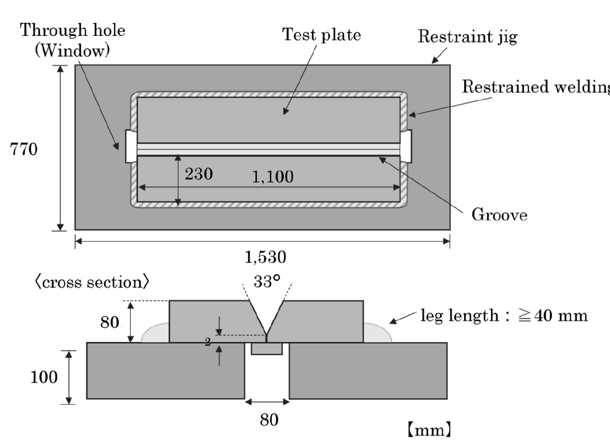


Fig. 8 Schematic illustration of layout of both restraint and test plate

test. We used JIS G 3106 SM490A for the test plate, as it has a relatively high Pcm, indicating a higher susceptibility to weld cracking. The welding conditions were as shown in Table 4, with no preheating for the first pass (approximately 15℃) and an interpass temperature of 150℃ for the second pass. After welding, the test plate was left at room temperature for 48 hours. We then removed it from the restraint jig to perform ultrasonic testing (UT) at reference sensitivity +10 dB with the transducer over the ground weld bead. Testing revealed no echoes above the detection threshold, confirming that there are no issues regarding low-temperature cracking resistance under the practical conditions of no preheating and an interpass temperature of 150℃ (specification ≤ 250℃).

Welding consumables used for building structures must correspond to the classifications for deposited metal in JIS Z 3183. Tensile testing, impact tests, and diffusible hydrogen content tests were conducted on the deposited metal created using the combination of TRUSTARC™ PF-I60K and TRUSTARC™ US-49. **Table 6** shows the results. The quality classification of the deposited metal is JIS Z 3183 S621-H4, confirming that it can be used for 590 MPa-grade high-tensile strength steel.

2.3 Welding consumables for single-pass welding of corner joints of box columns made of 780 MPa-grade steel

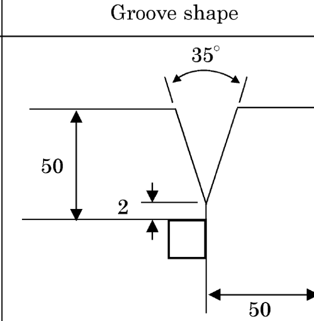
Recent years have seen a trend toward reducing skin plate thickness through the use of stronger steel, driving the increased use of 780 MPa-grade steel. The most common process used for the corner joints of box columns in steel grades up to 590 MPa is single-pass SAW. For 780 MPa-grade steel, however, the low-efficiency process of multi-pass welding with low heat input is mainstream. Preheating and interpass temperatures must be strictly controlled with this grade because its weld metal is highly susceptible to low-temperature cracking. Furthermore, low-heat input, multi-pass welding involves long arc-on times, which is operator-intensive. This section introduces the properties of SAW consumables that enable single-pass welding of the corner joints of box columns made of 780 MPa-grade steel: flux TRUSTARC™ PF-I80ES and wire TRUSTARC™ US-80SP.

The standards for these welding consumables are JIS Z 3351 YS-NM6 for the wire and JIS Z 3352 SACG-I1 for the flux. The quality classification of the weld metal per JIS Z 3183 is JIS Z 3183 S804-H4. We evaluated the performance of the welding joint using a skin plate made of 780 MPa-grade steel (thickness 50 mm) using a high-heat input process under the welding conditions in **Table 7**. **Fig. 9** shows the weld bead, and **Fig.10** shows the macroscopic cross-section. Weldability is comparable to that of welding consumables used with steel plate of 590 MPa grade or lower, and the penetration geometry is good. **Table 8** shows the mechanical properties of the weld metal. Tensile test specimens were taken from the center of the weld metal, 10 mm from the surface of the base metal. Charpy impact test specimens were taken 7 mm from the rear surface of the base metal.

Table 6 Mechanical properties of [T] PF-I60K / [T] US-49 deposit metal

Wire /Flux	Tensile test			Charpy impact test	Diffusible hydrogen content(ml/100g)
	YP (MPa)	TS (MPa)	El. (%)	$vE_{-5℃}$(J)	
TRUSTARC™ PF-I60K / TRUSTARC™ US-49	606	686	26	120, 105, 132 Avg.119	Avg. 4.4
JIS Z3183 S621-H4	≧500	≧610	≧17	≧27	≦8.5

Table 7 Welding conditions

Flux / Wire	Electrode (6.4φ)	Welding current (A)	Arc voltage (V)	Welding speed (cm/min)	Heat input (kJ/cm)	Groove shape
TRUSTARC™ PF-I80ES / TRUSTARC™ US-80SP	L	2050	40	20	462	
	T	1500	48			

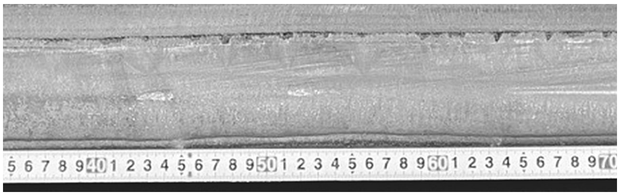


Fig. 9 Bead appearance of [T] PF-I80ES/ [T] US-80SP welded joint

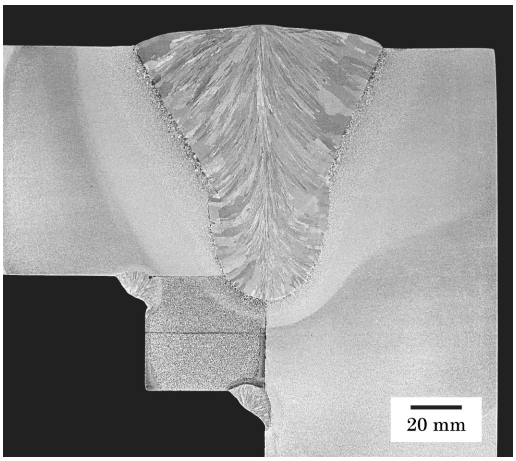


Fig.10 Cross-sectional macro comparison of [T] PF-I80ES / [T] US-80SP welded joint

Table 8 Mechanical properties of welded metals

Flux / Wire	Tensile test			Charpy impact test
	YP (MPa)	TS (MPa)	El. (%)	$vE_{0^\circ C}$(J)
TRUSTARC™ PF-I80ES/ TRUSTARC™ US-80SP	644	822	19	Avg. 79
Spec.(780MPa Grade)	≧630	≧780	-	≧27

The results confirm that the tensile properties of the weld metal satisfy the specifications for the base metal of the skin plate, and that the absorbed energy upon Charpy impact testing meets the standard of an average of ≥ 27 J.

3. Welding consumables for ESW

3.1 Lineup of welding consumables by steel strength class

ESW is a high-efficiency welding process primarily used for the vertical welding of thick plates. In this welding method, a wire is continuously fed into a pool of molten slag formed in a weld groove. Current flowing through the wire generates heat due to resistance, heating the molten slag and melting the wire and base metal.[5)] In the architectural steel frame sector, ESW is widely used to join the skin plates and inner diaphragms of box columns, as shown in Fig. 6. **Table 9** shows the product lineup broken down by steel strength

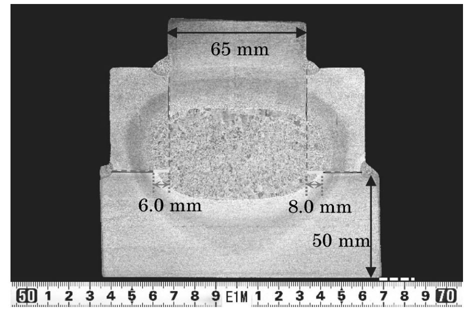


Fig.11 Example of ESW cross-section macro

class. **Fig.11** shows the macroscopic cross-section of a typical welding joint as well as the penetration depth, which confirms sufficient penetration.

ESW enables single-pass welding across a wide range of plate thicknesses, with minimal spatter generation and a welding efficiency near 100%. However, because it is a high-heat input process, guaranteeing welding joint performance is a major challenge. Kobe Steel is developing ESW wire for structural steel to overcome this challenge.

3.2 Flux-cored wires for 550-MPa- and 590-MPa-grade steels

The recent trend toward high-strength, thick-walled materials means that to ensure the performance of welding joints, the alloy content introduced via the welding wire must be increased to compensate for the higher heat input. However, solid wires may harden excessively, potentially introducing manufacturing challenges and adversely affecting wire feedability. This challenge served as our impetus for developing FAMILIARC™ EM-56ST and TRUSTARC™ EM-60ST for use with 550-MPa- and 590-MPa-grade steels. The design of these products is based on flux-cored wires to facilitate alloy composition design. FAMILIARC™ EM-56ST is classified as JIS Z 3353 YES560-M, and TRUSTARC™ EM-60ST is classified as JIS Z 3353 YES600-M.

Table 10 shows a sample of the results of testing the mechanical properties of the weld metal per JIS Z 3353. Both wires had a diameter of 1.6 mm and were used in combination with FAMILIARC™ EF-38 flux.

We used diaphragms and skin plates with dimensions of 60 mm × 40 mm and 65 mm × 45 mm to evaluate weld joint performance in the plate thicknesses and high heat inputs frequently encountered in actual structures. Simple T-joints were constructed to simulate the conditions of a diaphragm in a box column. **Table 11** shows the combinations of steel materials and consumables, and **Table 12** shows the welding conditions and the groove shape.

Table 9 List of Electroslag Welding Materials for building structures

<table>
<tr><th>Grade of steel plate</th><th>TS 400 MPa
/
YP 235 MPa</th><th>TS 490 MPa
/
YP 325 MPa</th><th>TS 520 MPa
/
YP 355 MPa</th><th>TS 550 MPa
/
YP 385 MPa</th><th>TS 590 MPa
/
YP 440 MPa</th></tr>
<tr><td rowspan="3">Solid wire
(Flux / Wire)</td><td colspan="2">FAMILIARC™ EF-38 / FAMILIARC™ ES-55</td><td></td><td colspan="2">FAMILIARC™ EF-38 / TRUSTARC™ ES-60ST</td></tr>
<tr><td></td><td colspan="2">FAMILIARC™ EF-38 / FAMILIARC™ ES-55ST</td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">FAMILIARC™ EF-38 / FAMILIARC™ ES-56ST</td><td></td></tr>
<tr><td>Flux cored wire
(Flux / Wire)</td><td></td><td colspan="3">FAMILIARC™ EF-38 / FAMILIARC™ EM-56ST ※1</td><td>FAMILIARC™ EF-38 /
TRUSTARC™ EM-60ST ※1</td></tr>
</table>

※1 : New lineup

Table10 Mechanical properties of the weld metal in compliance with JIS Z 3353

Grade of steel (thickness)	Flux	Wire	Tensile test (center)			Charpy impact test (center)	
			YP(MPa)	TS(MPa)	El.(%)	$vE_{-5℃}$(J)	$vE_{0℃}$(J)
550 MPa (25 mm)	FAMILIARC™ EF-38	FAMILIARC™ EM-56ST	483	657	26	–	51, 73, 57 Avg.60
JIS Z 3353 YES560-M			≧400	≧550	≧20	–	–
590 MPa (25 mm)	FAMILIARC™ EF-38	TRUSTARC™ EM-60ST	556	737	23	126, 111, 115 Avg.117	–
JIS Z 3353 YES600-M			≧450	≧590	≧20	–	–

※SESNET® Note 4), GAP:23 mm, DCEP, 1 layer-1 pass , 380 A-48 V

Table11 Welding consumables and steel plate

No.	Flux	Wire	Skin plate	Diaphragm	Backing bar
1	FAMILIARC™ EF-38	FAMILIARC™ EM-56ST	KCL A385C-ST (t: 40 mm)	KCL A385C (t: 60 mm)	JIS G 3136 SN490B
2		TRUSTARC™ EM-60ST	KCL A440C-ST (t: 45 mm)	KCL A440B (t: 65 mm)	

Table12 Welding conditions and groove shape

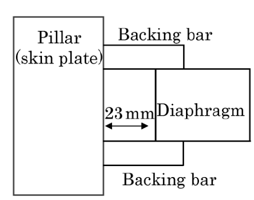
No.	Welding conditions		Groove shape
1	380A-50V Wire feed speed:9 m/min	H.I. : 861 kJ/cm	
2		H.I. : 964 kJ/cm	

Table13 Mechanical properties of the weld metal

No.	Tensile test (center)				Charpy impact test $vE_{0℃}$(J)		
	YP (MPa)	TS (MPa)	El. (%)	RA (%)	Weld metal (Bond-1 mm)	Skin plate side: Bond	Skin plate side: HAZ (Bond+1 mm)
1	460	659	26	70	119, 84, 128 Avg.110	141, 122, 83 Avg.115	117, 120, 127 Avg.121
Spec.	≧385	≧550	–	–	≧27J		
2	481	700	25	70	167, 114, 166 Avg. 149	115, 68, 109 Avg.97	124, 111, 108 Avg.114
Spec.	≧440	≧590	–	–	≧27J		

Note 4) SESNET is a trademark of Nippon Steel Welding & Engineering Co., Ltd.

Table 13 shows the mechanical properties of the welding joints, which confirm that the tensile properties and Charpy impact properties of all welding joints satisfy the requirements of the applicable specifications. The Charpy impact properties fully meet specifications not only in the weld metal, but also in the base metal as required in the weld zone of the ESW – specifically, the bond and the HAZ (heat-affected zone, bond + 1 mm).

Conclusions

The construction industry today has a clear need for thicker and higher-strength plates for structural steel columns as well as increased efficiency in the construction of such columns. As such, we are actively pursuing technological developments in welding consumables and welding processes to meet these requirements. We will continue these development efforts to solve our customers' challenges and ultimately contribute to safe and secure community development and manufacturing.

References

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