which are high ef f ciency high heat input welding methods. Because the microstructure of the heat affected zone (HAZ) and the weld metal (WM) coarsens in this type of high heat input welding, reduced toughness had been unavoidable with conventional steels.

JFE Steel carried out research and development of steel plates and welding consumables which make it possible to improve toughness in welded joints, even in this type of high heat input welding[5,6], and has now developed a new high performance 590 N/mm^2 steel for archi

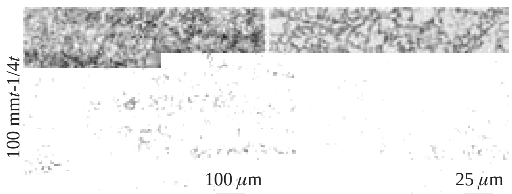
C_{eq} would be approximately 0.35% in order to achieve an F + P microstructure in HAZ, and in HBL385 and SA440, the alloy design secured C_{eq} of 0.40% or less to hold F + B microstructure in HAZ, considering welded joint strength.

Furthermore, when necessary, the intra-granular

Photo 3 shows the microstructures of welded joints with ESW welding at a heat input of 100 kJ/mm using the newly developed high-B welding consumable. The material is HBL325-E with C_{eq} = 0.34 mass% and a plate thickness of 60 mm. When the developed welding consumable is used, it can be understood that CGHAZ microstructure in the narrow region around the FL is also refined by diffusion of B from the WM. No similar refinement can be observed with the conventional welding consumables.

4. High Toughness Technology for Weld Metal

With high heat input SAW and ESW, coarsening of the microstructure also occurs in the WM, and as a result, reduced toughness becomes a problem. High toughness in to Ws can% re ! ec prved% s co l я l . x



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alloy design and reheating and quenching treatment in the $\gamma+\alpha$ dual-phase region, the base material microstructure achieved a dual-phase structure consisting of a soft phase of ferrite and a hard phase of tempered martensite. As a result, both high strength and a low yield ratio of 80% or less are realized even with a plate thickness of 100 mm. Toughness, ductility, and reduction of area in the plate thickness direction also amply satisf ed the targets.

5.3 Welded Joint Performance

To investigate the welded joint toughness improvement effect, corner welds and inner diaphragm welded joints were produced by SAW and ESW, respectively, using developed plates 60 mm in thickness and the developed welding consumables.

5.3.1 Welding conditions and microstructure

Table 4 shows the groove shape and welding conditions. High heat input welding was performed in SAW with tandem electrodes ((2 electrodes)/(1 run)) at a heat input of 63 kJ/mm. The heat input in ESW was 100 kJ/mm. The welding consumables for SAW and ESW were described in the previous chapter. Welding wire and f ux were used considering also the effect of base material dilution during welding on the WM and microstructure control of the FL.

Photo 5 shows the macrostructure of the welded joints and the microstructure of the WM. The bead shape is satisfactory and adequately penetrates the base mate-

Welding method	Electrode (Diameter)								
	KW-55 (*ϕ*6.4 mm)	KB-55I AD	2 300 1 800	40 53	180	63	1	Y shape	60
	KW-60 AD (*ϕ*1.6 mm)	KF-100 AD	380						

corresponding welding consumables are presented in **Tables 7** and **8**, respectively. Finally, a list of JFE Steel's steel plates for architectural construction by standard is shown in **Table 9**.

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