Introduction of Shape Steel Products in JFE Steel

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Abstract:

JFE Steel has developed and manufactures shape steel products to meet various social needs. This paper introduces shaped steel products manufactured by JFE Steel.

1. Introduction

JFE Steel has been actively engaged in product development of steel products and has produced a large number of products to meet diversifying and sophisticated social needs. In shaped steel, we have a lineup of products that contribute to the development of social infrastructure, including those for the fields of construction, civil engineering, and shipbuilding. This paper introduces the outline of JFE Steel's shape steel products.

2. H-Shapes[1)]

In September 1961, JFE Steel began manufacturing and marketing H-shapes produced by Japan's first universal mill. Since that time, the company has accumulated a wealth of experience and an extensive sales record, and has earned an outstanding reputation with its customers.

During this period, the company has manufactured products with excellent reliability and economy, including fixed outer dimension H-shapes "Super HISLEND^{TM}-H" with an abundant size repertoire, TMCP (Thermo-Mechanical Control Process) H-shapes "HBL^{TM}-JH325 and HBL^{TM}-"JH355" with excellent weldability and high strength, fire resistant steel for building structures "JFE-FR," "Welded light Gauge H-shapes," and H-shapes for bridge piers "Stripe H"[1)]. The JFE Group's H-shapes are widely used in structures from houses to skyscrapers and large span structures.

2.1 Fixed Outer Dimension H-Shapes "Super HISLEND^{TM}-H"

Fixed outer dimension H-Shapes "Super HISLEND^{TM}-H", which JFE Steel began manufacturing in 1989, have the performance required for building materials such as beams, and the web depth and flange width dimensions are fixed even when the web or flange thickness changes. This series also has high dimensional accuracy. As shown in **Table 1**, "Super HISLEND^{TM}-H" has a maximum web height of 1 000 mm and an abundant range of cross-sections including 42 series and 400 sizes. We also offer the steels "HBL-H355B" and "HBL-H355C," which were Japan's first 520 N/mm^2 TMCP H-shapes for building structures.

2.2 Fire Resistant Steel "JFE-FR"[2)]

JFE-FR has improved performance at high temperatures compared to general steel materials and has a guaranteed yield strength of 2/3 or more of the F value at 600 ˚C. In addition, because the steel material characteristics at room temperature conform to JIS standard materials or minister-approved standard materials, structural design similar to that when using general building steel materials is possible. Fireproof design using JFE-FR, as shown in **Photo 1**, makes it possible to reduce or omit the fireproof coating material (material that protects steel from the heat of a fire) required in conventional buildings, resulting in improved design creativity, shortening of the construction period, and reduced costs.

When applying JFE-FR to self-propelled parking facilities, fireproof coating of the steel materials can be realized by simple fireproof performance verification by performing a fireproof design approved by the Minister of Land, Infrastructure, Transport and Tourism. Since self-propelled parking facilities often do not have a ceiling finish, non-fireproof coating of the steel materials greatly improves the design of the building, as shown in Photo 1. The aim of most inquiries con-

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Table 1 Super HISLEND™-H section table

Web	Flange t	200						250									300								350						400					
		12	16	19	22	25	28	12	16	19	22	25	28	32	36	40	16	19	22	25	28	32	36	40	22	25	28	32	36	40	22	25	28	32	36	40
400	9	●	●	●	●																															
	12		●	●	●																															
450	9	●	●	●	●			●	●	●	●																									
	12		●	●	●	●			●	●	●	●	●																							
500	9	●	●	●	●			●	●	●	●						●	●																		
	12		●	●	●	●			●	●	●	●	●				●	●	●	●	●															
	14																	●	●	●	●															
	16																	●	●	●	●	●														
550	9	●	●	●	●			●	●	●	●						●	●																		
	12		●	●	●	●			●	●	●	●	●				●	●	●	●	●															
	14																	●	●	●	●															
	16																		●	●	●															
600	9	●	●	●	●				●	●								●																		
	12		●	●	●	●	●		●	●	●	●	●				●	●	●	●	●															
	14										●	●	●					●	●	●	●	●															
	16											●	●	●					●	●	●	●															
650	9	●	●	●	●				●																											
	12		●	●	●	●	●		●	●	●	●	●				●	●	●	●																
	14									●	●	●	●					●	●	●	●																
	16										●	●	●	●					●	●	●	●															
700	9	●	●	●	●				●	●																										
	12		●	●	●	●	●		●	●	●	●						●	●	●	●				●	●										
	14									●	●	●	●					●	●	●	●	●			●	●	●	●								
	16																		●	●	●	●	●			●	●	●	●							
750	12								●	●	●	●																								
	14									●	●	●	●					●	●	●	●				●	●	●	●								
	16																		●	●	●	●				●	●	●	●							
800	14										●	●	●						●	●	●	●				●	●					●	●			
	16										●	●	●	●					●	●	●	●	●			●	●	●	●			●	●	●	●	
	19																									●	●	●	●	●			●	●	●	●
850	14										●	●	●						●	●	●															
	16										●	●	●	●					●	●	●	●				●	●	●				●	●	●		
	19																										●	●	●	●			●	●	●	●
900	14									●	●	●							●	●																
	16									●	●	●	●					●	●	●	●	●				●	●	●				●	●	●		
	19																		●	●	●	●	●				●	●	●	●				●	●	●
950	16										●	●	●	●					●	●	●	●				●	●	●				●	●	●		
	19											●	●	●	●	●				●	●	●	●	●			●	●	●	●	●			●	●	●
1000	16										●	●	●	●					●	●	●	●				●	●	●				●	●	●		
	19											●	●	●	●	●				●	●	●	●	●			●	●	●	●	●			●	●	●

Photo 1 Comparison of beams when using general steel (left) and beams when using JFE-FR (right)

cerning JFE-FR is fireproof coatings for self-propelled parking facilities using this certification.

2.3 Welded Light Gauge H-shapes[3)]

"Welded Light Gauge H-shapes" are produced by slitting a hot-rolled steel strip and forming an H-shaped cross section by electric resistance welding. These products used as structural members for houses, low-rise buildings, greenhouses, and the like.

SWH400 under JIS G 3353, which is the product standard, is a designated structural steel member as provided in public notice No. 1446, based on Article 37 of the Building Standards Act. Because this product has excellent dimensional accuracy, beginning with thickness, fabrication is easy and it is also an optimum material for automated processing lines. In comparison with hot-rolled H-shapes, the surface properties of the product are attractive, and products possess excellent coatability and plating properties.

2.4 H-Section for Bridge Pier "Stripe H"[4)]

Stripe H (**Photo 2**) is a product in which high adhesive performance with concrete is achieved in ordinary H-shapes by forming stripe-pattern ribs in the flange width direction on the outer surfaces of the flanges of H-shapes in the hot rolling process. These H-shapes demonstrate excellent performance in steel-concrete composite structures.

Utilizing this advantage, JFE Steel and Maeda Corporation jointly developed the REED construction method™ (Rapid Earthquake Environment Durability: rapid construction method for high seismic resistance bridge piers), which enables labor saving in site work

Photo 2 Striped -H

and shortens the construction period, by combining JFE's Stripe H product and the SEED Form™ (high durability precast concrete form) construction method.

The "RI-Bridge Construction Method™" (Rapid Integrated Bridge Construction Method)[5] is a further development of the REED construction method™ for rationalization of bridge construction work and improvement of aseismic capacity. This is a rapid construction method for ramen (rigid frame) type integrated superstructure-pier bridges, in which the steel girder and steel-concrete piers (REED construction method™) are integrated in a rigid connection structure. Rational bridge construction, as this method has the merits of safety against bridge collapse and reduction of the bending moment of the beams and pier base parts, while providing a higher aseismic capacity, because the bridge behaves as a total system of the piers and beams.

2.5 Lateral Buckling Restrained Steel Beam Method

In the lateral buckling restrained steel beam method, lateral buckling of a steel beam is restrained by connecting a floor slab and a steel beam with an H-shaped cross section with a stud with a head and anticipating the restraining effect of the upper flange by the floor slab[6]. As shown in **Fig. 1**, this method can reduce the amount of lateral buckling stiffeners, knee braces, joint members, etc., and thus can save labor in design and construction work and steel frame processing.

Experimental and analytical studies have confirmed that sufficient beam bending strength in the applicable range can be obtained by this method, and the allowable bending stress, fb, specified in Notification No. 1024 No. 1 and 2 of the Ministry of Land, Infrastructure, Transport and Tourism 2001 can be treated as equivalent to the allowable tensile stress degree, ft. It has also been confirmed that this method does not cause a sudden decrease in yield strength due to lateral buckling and has sufficient plastic deformation capacity, and the beam can be treated as a stiffened beam.

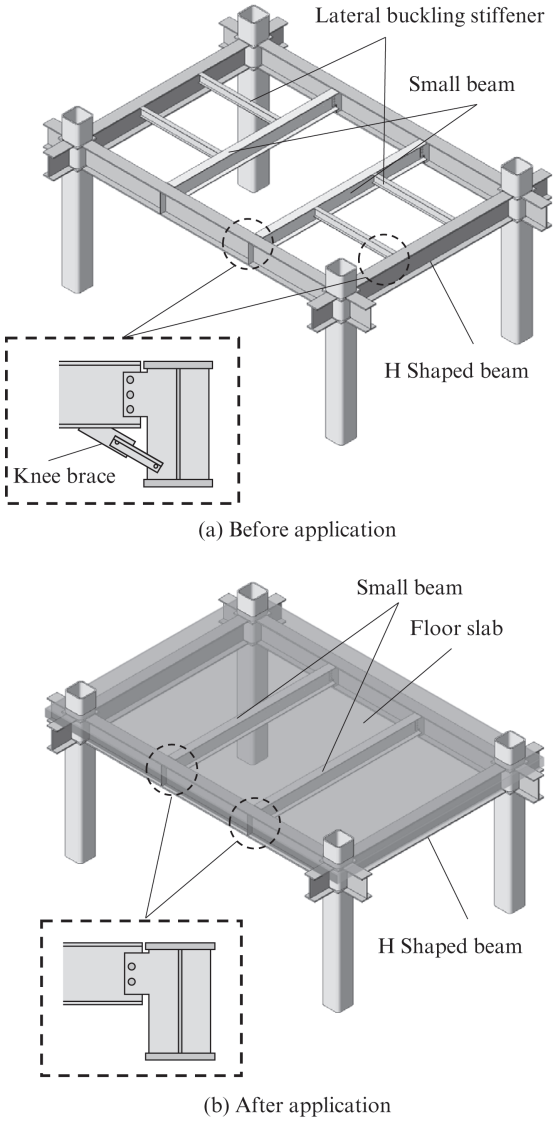

Fig. 1 Method for lateral buckling restrained steel beam

In June 2017, JFE Steel obtained building technology performance certification for this method from the Japan Building Research Institute. In March 2019, this certification was revised to expand the scope of application of the construction method to improve convenience, and it is now widely used in office buildings and hotels, and particularly in distribution warehouses.

3. Steel Sheet Piles[8]

Steel sheet piles are widely used in the construction of river embankments, port quay walls, cut-off walls, earthquake strengthening structures, and many other types of construction work, and are becoming increasingly important.

JFE Steel takes full advantage of the state-of-the-

art rolling mills at its West Japan Works to produce three types of steel sheet piles (hat-shaped, U-shaped, and straight-shaped piles) conforming to JIS A 5523 or JIS A 5528. We also manufacture corner steel sheet piles by combined rolling and forming processing and heavy corrosion protection steel sheet piles (JFE Marine Coat™) for marine environments.

3.1 Hat-shaped 900 Width Steel Sheet Pile

The hat-shaped 900 width steel sheet pile shown in **Photo 3** was developed in 2004 as a steel sheet pile that exhibits higher performance than conventional wide-width steel sheet piles in terms of construction efficiency, structural reliability, and economy. This is the world's widest (900 mm) steel sheet pile as a single rolled material.

3.2 Steel Sheet Pile with Grooved Joints for Cut-off Wall "J-Pocket Pile™"[9]

As shown in **Photo 4**, J-Pocket Pile™ (JPP) has rolled pockets (about φ10 mm) on the bottom surface of conventional steel sheet pile joints, where a water-shielding material or filler or monitoring pipes can be installed. This is a new vertical impermeable steel wall that is used in controlled waste final disposal sites.

3.3 New Straight-shaped Steel Sheet Piles "J-Flat Pile"[10]

As shown in **Photo 5**, J-Flat pile is a new straight-shaped steel sheet pile that dramatically reduces the weight of steel materials by downsizing the joints. It is the lightest straight-shaped steel sheet pile in Japan, and excellent economy can be expected.

Straight-shaped steel sheet piles are mainly used as steel shell materials for steel sheet pile cells because of their high tensile strength at the joints. Straight-shaped steel sheet piles are also used as high stiffness steel elements for the retaining wall, J-domer™, in combination with H-shapes.

3.4 High Performance Composite Wall "J-WALL™ II"[11]

J-WALL™ II is a technology for constructing a main composite wall by using the steel sheet pile for retaining walls Beetle pile shown in **Fig. 2** as a temporary retaining wall, and integrating the wall with post-cast concrete after excavation to construct a composite underground wall.

The J-WALL™ II method was developed through joint research by JFE Steel, Obayashi Corporation, and GECOSS. The examination certificate (Technical Examination Certificate No. 40) of the Construction Technology Examination Certification Project (General Civil Engineering Method) of the Japan Institute of Country-ology and Engineering (JICE) has been obtained, and this technology is registered in the New Technology Information System (NETIS) of the Ministry of Land, Infrastructure, Transport and Tourism. (NETIS number: KT-190018-A, new technology name: J-WALL™ II method).

Photo 3 Hat-shaped steel sheet pile

Photo 4 J-Pocket pile™ (Steel sheet pile)

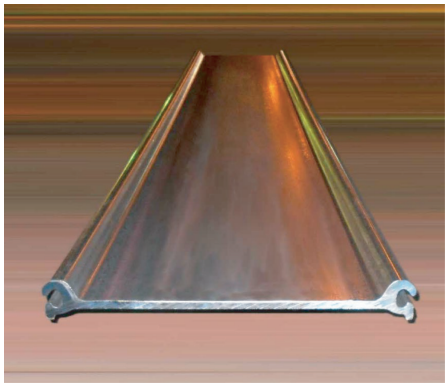

Photo 5 J-Flat pile (Steel sheet pile)

3.5 High Stiffness Steel Element for Retaining Wall "J-domer™"[12]

As shown in **Fig. 3**, J-domer™ is a high-rigidity steel earth-retaining member made by welding and assembling straight-shaped steel sheet piles and H-shapes. It has fitting joints at both ends of the flange, and a continuous steel wall made with high water resistance can be constructed by fitting the joints together while driving the piles.

Compared to soil cement walls and steel pipe sheet

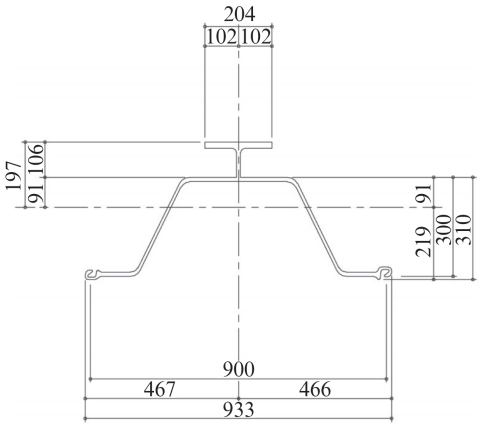

Fig. 2 Sectional shapes of Beetle pile™

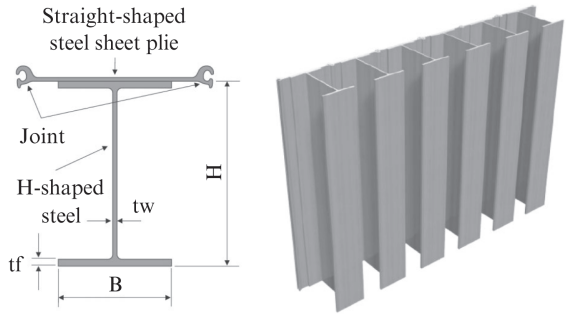

Fig. 3 Cross section shapes and image of steel wall

piles, a thinner wall and compact construction are possible, enabling effective use of limited land and space.

4. Steel Sections for Shipbuilding[13)]

Steel sections for shipbuilding are used to increase the rigidity of steel plates by welding the sections to steel plates. JFE Steel offers a wide variety and sizes, including unequal leg and thickness angles and bulb plates. We have also acquired certification under a wide range of ship classification society standards, including standards for low-temperature steel, to meet customer needs.

4.1 Application of TMCP[14)]

In order to ensure high toughness of low-temperature steels, etc., Cooling facilities were installed on the front and rear sides of intermediate rolling mills as dedicated facilities for asymmetrical-shaped unequal leg and thickness angles and bulb plates, and OLACTM (On-Line Accelerated Cooling) equipment on the rear side of the finishing rolling mills. The TMCP type low carbon equivalent, high toughness and high tension steel sections shown in **Table 2** are manufactured by implementing appropriate temperature

Table 2 Available grade by TMCP

Type	Rolling process	YP (kgf/mm^2)	Grade	*Ceq* (LRS)
NCL-Type A	CR	32,36	A,D	≦0.36
NCT-Type A	CR	32,36	A,D	≦0.36
NCT-Type B	CR OLAC®	32,36,40	A,D,E	≦0.36

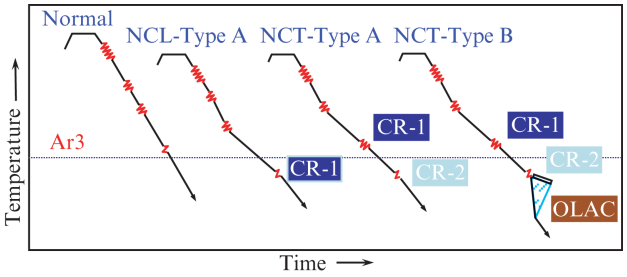

Fig. 4 Models of rolling process for shapes

Photo 6 Flange shape of unequal leg and thickness angle for compatible with PSPC

control as shown in **Fig. 4** according to each standard.

4.2 Steel Sections for Shipbuilding Supporting PSPC

IMO resolution MSC.215 (82) adopted in December 2006 stipulated the application of a new coating standard (PSPC: Performance Standard for Protective Coatings) to dedicated seawater ballast tanks for all vessels with a gross tonnages of 500 tons or more and the double side hull structure of bulk cargo ships with lengths of 150 m or more. JFE Steel improved the steel section

rolling conditions and rolling guides to satisfy the performance required by PSPC, and supplies steel sections for shipbuilding with PSPC-compliant edge treatment, as shown in **Photo 6**.

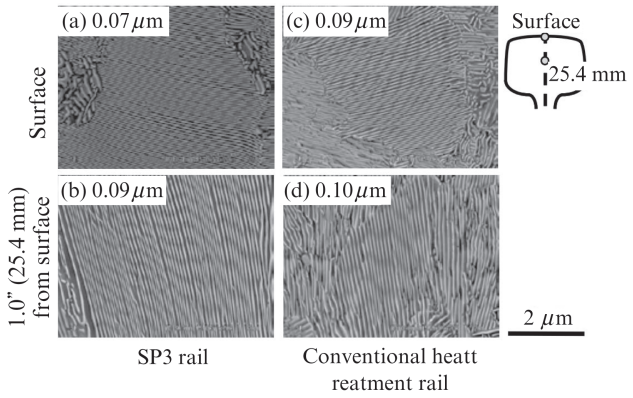

Photo 7 Perlite lamellar structures of surface and 1.0" (25.4 mm) from surface ((a),(b): SP3 rail and (c),(d): conventional heat treatment rail)

5. Rails[15)]

JFE Steel started manufacturing rails in 1972 and now manufactures heavy rails for the domestic and overseas markets. The company manufacture 37 kg to 60 kg rails for domestic railways and supports the overseas standards AREMA (US), IRS (India), EN (Europe), and AS (Australia) for other countries. We manufacture rails of various standards, including ordinary rails, end head hardened rails, head hardened rails, and conductive rails.

5.1 High Wear Resistance and Rolling Contact Fatigue Resistance for Heavy Haul Railways "SP Rail Series"

In many other countries, high-hardness rails with excellent wear resistance and damage resistance are required for heavy haul freight railways, represented by mine railways. To meet this demand, JFE Steel developed a super pearlite rail using TMCP with optimized air cooling conditions after rolling and the optimum composition design.

As shown in **Photo 7**, the highest-class SP3 rail[16)] has a surface hardness of HB420 points or more and a 1-inch (25.4 mm) depth hardness of HB370 or more, which is achieved by narrowing and refining the pearlite lamellar spacing to the utmost limit. At the same time, high elongation is also obtained. As a result, a laboratory test and a rail performance evaluation test by actual laying confirmed that wear resistance was improved by 10 % or more compared to the HB390 class conventional heat-treated rail. Furthermore, good fatigue damage resistance was obtained, as no flaking or shelling was observed on the rail head surface.

6. Conclusion

This report has introduced the outline of typical shape steel products of JFE Steel. We will continue to provide a wide variety of products and develop new products that meet the needs of our customers to merit their continuing patronage of JFE Steel's shape steel products.

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