Fixed Outer Dimension H-Shapes, 1000 and 950 mm Series*


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Synopsis:

With the recent trend toward higher and larger sizes in height and width of buildings, H-shapes for structures have been desired to have higher strength and toughness quality, and to have a larger variety of sizes. Kawasaki Steel developed Super HISLEND H 1000 mm series in April 1999. Additionally, in May 2000, Super HISLEND H 950 mm series were developed and the size variety of 1000 mm series was expanded. Hot-rolled fixed outer dimension H-shapes (Super HISLEND H) are once-in-a-decade hit products which greatly simplify the structural designs and the execution of construction work, provide superior dimensional accuracy and offer far better economy than welded H-shapes. Produced by using a revolutionary new flexible manufacturing system, the fixed outer dimension H-shapes outperform both conventional fixed inner dimension H-shapes and built-up H-shapes.

1 Introduction

It has been a trend in recent years to construct new buildings that are ever higher and more spacious, therefore, structural steels are desired to have higher strength and larger sections and to offer better economy as well. In the course of improving the strength of hot-rolled H-shapes, Kawasaki Steel achieved a tensile strength of up to 590 MPa by developing new TMCP heavy wide flange shapes, RIVER TOUGH.[1] As for their effort for larger sections, the company developed large section heavy wide flange shapes, H 700 × 500 series, with a superior section efficiency as H-shapes for columns.[2,3]

With respect to H-shapes for beams, on the other hand, the company started marketing fixed outer dimension H-shapes, Super HISLEND H (SH), in November 1989. Since then, by expanding the production range over and over again, the company developed fixed outer dimension H-shapes with the company's original section sizes in June, 1993. These H-shapes have a flange width of 350 or 400 mm and a web depth of 700, 750, 800, 850 or 900 mm. As a result, a full line of H-shapes with a large variety of sizes was completed and the company has been responding to the need for larger sections.

Compared with conventional fixed inner dimension H-shapes, Super HISLEND H are superior in section efficiency as well as in dimensional accuracy and are leading the trend toward larger sections, therefore, in the ten years since they were put on the market, they have steadily penetrated into a wide range of markets including high-rise buildings. However, in order to respond to the customers' request for H-shapes with still larger sections, the company was the first in Japan to develop fixed outer dimension hot-rolled H-shapes with a web depth of 1 000 mm and started marketing them in April 1999.

Production of H-shapes with a web depth of 1 000 mm was attained by increasing the capacity of the roughing universal mill through a refreshment project in the company's wide flange beam mill at Mizushima Works (June 1996) and through advancement in the method of grooved rolling in the break down mill.

Furthermore, in May 2000, the size variety was expanded by enlarging the size variety of SH 1000 series and by adding the SH 950 series and as a result, the company established its hot-rolled H-shape supply structure which makes it possible to respond to the wider requirements of customers by supplying fixed outer dimension H-shapes in a large variety of sizes. This report describes the development of large section fixed

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outer dimension H-shapes , the Super HISLEND H 1000 and 950 series.

2 Need for Hot-Rolled Large Section H-Shapes

The need to enlarge sections of steel materials for structures was rapidly increased with the trend toward higher and larger buildings. Accordingly, in the field of construction of super high-rise buildings, etc., economically more advantageous methods by enlarging sections of steel materials, including H-shapes, had consistantly become desirable.

On the other hand, H-shapes producible by hot-rolling were limited to 900 mm in web depth in Japan and when requiring H-shapes with a web depth greater than 900 mm, so-called built-up H-shapes made by welding thick steel plates were used. However, built-up H-shapes require cutting and welding processes, thereby making economical construction work difficult.

With such a background, requests to produce economically superior hot-rolled large section H-shapes were raised from the customers' side. In order to respond to these requirements, Kawasaki Steel developed very large fixed outer dimension H-shapes, the Super HISLEND H 1000 mm series. Furthermore, the SH 950 mm series was added and the company established the production structure for fixed outer dimension H-shapes consisting of 39 series and 270 sizes with a maximum size of H 1 000 × 400 mm.

3 Production Process and Rolling Mills for Large Section H-shapes

Mizushima Works is capable of producing almost all kinds of steel products. Production of large section H-shapes was possible at Mizushima Works because large section continuously cast slabs and a high power blooming mill were available.

The manufacturing process is shown in **Fig. 1** and the layout of the rolling line in the wide flange beam mill is shown in **Fig. 2**. Beamblanks received at the wide flange beam mill are groove rolled by the breakdown mill after being reheated and then rolled to the final product size through the roughing universal mill and finishing universal mill.

3.1 Reinforcement of Roughing Universal Mill

The roughing universal mill was renewed in June 1996 and made suitable for production of large section H-shapes by increasing the maximum rolling load. At the same time, mechanical clearances and gaps were minimized. Additionally, a hydraulic roll-screw-down mechanism and automatic gauge control (AGC) were introduced to the horizontal and vertical rolls. As a result of these changes, the mill was made more rigid and the dimensional accuracy was improved.[4] A comparison of the principal specifications of the new mill and previous mill is shown in **Table 1**. The new mill is capable of rolling products ranging from 300 mm to 1 000 mm in web depth.

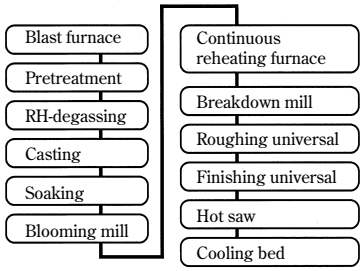

Fig. 1 Manufacturing process of SH 1000 mm series

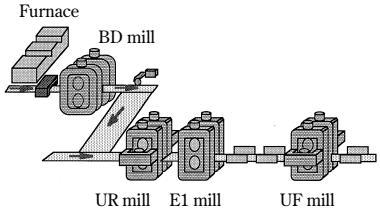

Fig. 2 Layout of wide flange beam mill

Table 1 Principal specifications of the new mill and the previous one

Items		New mill	Previous mill
Maximum load (kN)	Horizontal roll	15 000	11 800
	Vertical roll	10 000	5 700
Mill modulus (kN/mm)	Horizontal roll	3 000	2 300
	Vertical roll	3 000	2 000
Roll-screw-down mechanism		Hydraulic	Electric
Roll-change method		Roll-change (On-line)	Stand-change (Off-line)

In producing large section H-shapes from continuously cast slabs, in particular, size fluctuation in the rolling direction is apt to become large, therefore, control over the whole length is important. Examples of hydraulic AGC application are shown in **Figs. 3** and **4**. Furthermore, the above-described measures taken for reinforcement of the roughing universal mill also expanded the control ranges for production conditions and rolling temperature, thus contributing to the improvement of the material qualities, such as strength and toughness.

3.2 Grooved Rolling Method

First of all, continuously cast slabs with a section size of 310 × 1 800 mm are formed to intermediate beamblanks by the blooming mill. The section size of the intermediate beamblanks was made the same as that of the conventional H-shapes of H 900 × 400 series shown in **Fig. 5**.

Then, H-shapes are formed by the breakdown mill in the wide flange beam mill through a combined process

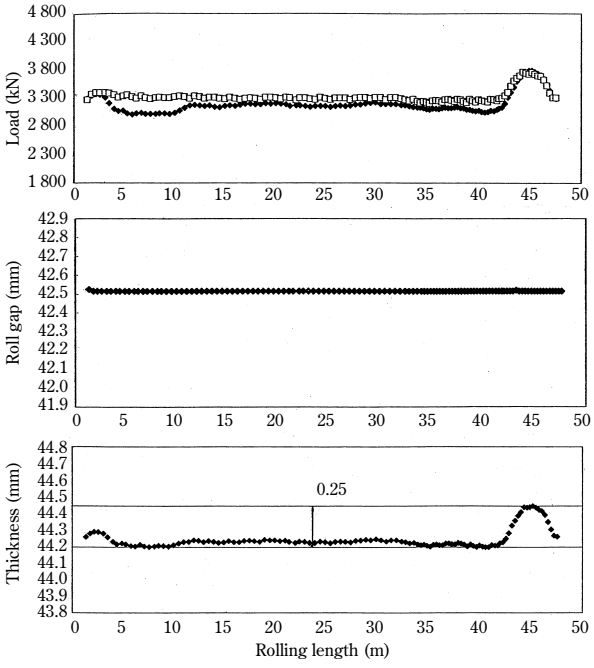

Fig. 3 Example of flange thickness without AGC system (H 1000 × 400 × 19 × 40)

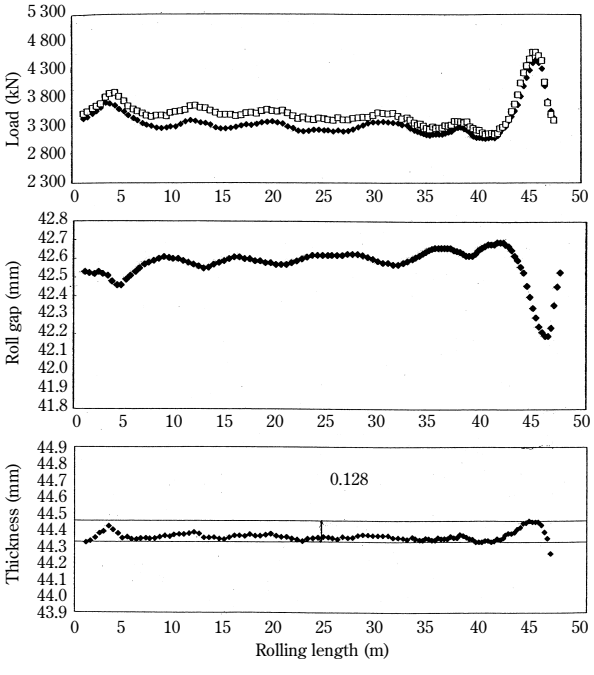

Fig. 4 Example of flange thickness with hydraulic AGC system (H 1000 × 400 × 19 × 40)

of rolling for enlargement and reduction of web depth and rolling for reduction of flange width using various kinds of grooves. Through this process, it was made possible to form 8 series of H-shapes consisting of web depths of 950 mm and 1 000 mm and flange widths of 250, 300, 350 and 400 mm. With respect to web depth, in particular, a special feature is that the dimensional

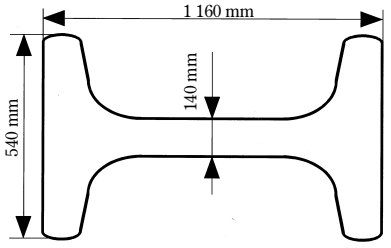

Fig. 5 Beamblank for SH 900, 950, 1000 mm series

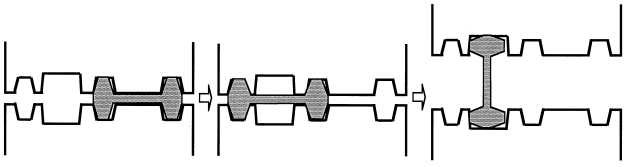

Fig. 6 Rolling method of breakdown mill

accuracy was improved by adding a web depth reducing pass after the materials being expanded by groove rolling to a degree greater than in conventional methods. An example of the groove rolling methods is shown in **Fig. 6**.

4 Size Variety

The size variety of fixed outer dimension H-shapes of Kawasaki Steel, Super HISLEND H, is shown in **Fig. 7**. As a result of adding 8 series with web depths of 1 000 mm and 950 mm, there are 39 series of Super HISLEND H with 270 different sizes at present. As shown in **Table 2**, the performance of the products satisfies many standards including JIS G 3136: SN Standard, Rolled Steels for Building Structures. As in the case of conventional Super HISLEND H with smaller web depths, the new series also have with a tolerance in shape and dimensions of ±2.0 mm for major items including depth, width and web off-center and are of a quality fully satisfying JASS6: Japanese Architectural Standard Specification.

The relationships between sectional area and moment of inertia for each size are shown in **Fig. 8**. Compared with conventional sizes, the newly developed SH 1000 and SH 950 series have larger moments of inertia even

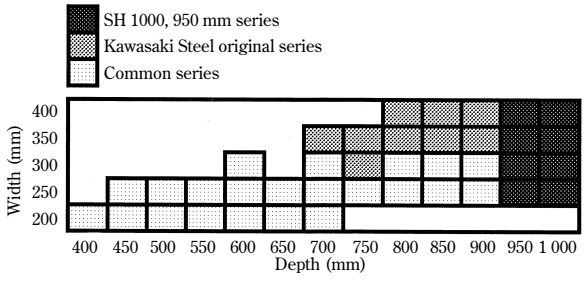

Fig. 7 Size variety of Super HISLEND H in Kawasaki Steel

Table 2 Corresponding standards

Specifications	JIS
JIS G 3136	SN400A, B, C SN490B, C
JIS G 3106	SM400A, B, C SM490A, B, C SM490YA, YB SM520B, C
JIS G 3101	SS400
JIS G 3114	SMA400AW, AP SMA400BW, BP SMA490AW, AP SMA490BW, BP
Kawasaki Steel specifications	SN400A-FR, B-FR, C-FR SM400A-FR, B-FR, C-FR SN490B-FR, C-FR SM490A-FR, B-FR, C-FR

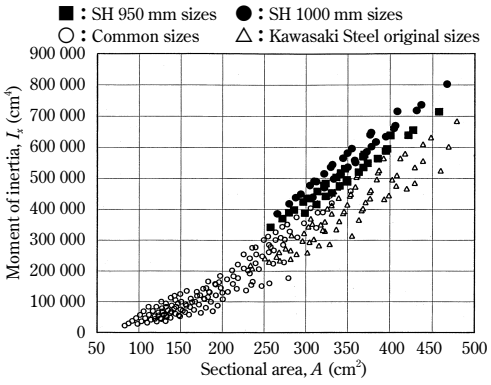

Fig. 8 Section properties

with nearly the same sectional area clearly showing that the section efficiency is high. As an example, **Table 3** shows a comparison of section properties of H 900 × 400, H 950 × 400 and H 1000 × 400. For example, H 900 × 400 × 19 × 40 has a sectional area of 478.6 cm^2 and a moment of inertia of 684 000 cm^4, whereas H 950 × 400 × 19 × 36 has a sectional area of 457.6 cm^2 and a moment of inertia of 714 000 cm^4 and H 1000 × 400 × 19 × 32 has a sectional area of 436.6 cm^2 and a moment of inertia of 736 000 cm^4. In other words, in order to secure a moment of inertia greater than that of H 900 × 400 × 19 × 40, a flange thickness of 36 mm is sufficient with the H 950 × 400 series and 32 mm is needed in the case of H 1000 × 400 series. With the new series, the sectional area decreases accordingly and the weight is reduced by 4.4% and 8.8%, respectively. Therefore, rational and economical structure design and steel selection become possible.

5 Conclusion

Kawasaki Steel has developed new products which lead the trend toward higher and more spacious building construction.

(1) Hot-rolled fixed outer dimension H-shapes with a web depth of 1 000 mm, the largest class in Japan, were developed.

(2) By increasing the web depth, the section properties have been dramatically improved and rational and economical structure design and steel selection have been made possible.

An example of the products is shown in **Photo 1**.

Among the new series, H 1000 × 300 and H 1000 × 350 series were put on the market in April 1999, and the other six series in May 2000 and the application of these new series to various structures including super high-rise buildings in the future is expected.

Table 3 Sizes and section properties

Nominal size	Section dimensions (mm)					Sectional area (cm^2)	Unit mass (kg/m)	Moment of inertia (cm^4)		Radius of gyration (cm)		Modulus of section (cm^3)	
	H	B	t_1	t_2	r			I_x	I_y	i_x	i_y	Z_x	Z_y
900 × 400	900	400	16	25	18	338.8	266	470 000	26 700	37.2	8.88	10 400	1 340
	900	400	16	28	18	361.8	284	511 000	29 900	37.6	9.09	11 400	1 490
	900	400	16	32	18	392.5	308	565 000	34 200	37.9	9.33	12 600	1 710
	900	400	19	28	18	387.1	304	526 000	29 900	36.9	8.79	11 700	1 500
	900	400	19	32	18	417.6	328	580 000	34 200	37.3	9.05	12 900	1 710
	900	400	19	36	18	448.1	352	632 000	38 500	37.6	9.26	14 100	1 920
	900	400	19	40	18	478.6	376	684 000	42 700	37.8	9.45	15 200	2 140
950 × 400	950	400	16	22	18	323.7	254	484 000	23 500	38.7	8.52	10 200	1 180
	950	400	16	25	18	346.8	272	531 000	26 700	39.1	8.77	11 200	1 340
	950	400	16	28	18	369.8	290	577 000	29 900	39.5	8.99	12 100	1 500
	950	400	16	32	18	400.5	314	638 000	34 200	39.9	9.24	13 400	1 710
	950	400	19	25	18	373.8	293	549 000	26 700	38.3	8.46	11 600	1 340
	950	400	19	28	18	396.6	311	595 000	29 900	38.7	8.69	12 500	1 500
	950	400	19	32	18	427.1	335	655 000	34 200	39.2	8.95	13 800	1 710
	950	400	19	36	18	457.6	359	714 000	38 500	39.5	9.17	15 000	1 920
1 000 × 400	1 000	400	16	22	18	331.7	260	544 000	23 500	40.5	8.42	10 900	1 180
	1 000	400	16	25	18	354.8	279	596 000	26 700	41.0	8.68	11 900	1 340
	1 000	400	16	28	18	377.8	297	647 000	29 900	41.4	8.90	12 900	1 500
	1 000	400	16	32	18	408.5	321	715 000	34 200	41.8	9.15	14 300	1 710
	1 000	400	19	25	18	383.3	301	617 000	26 700	40.1	8.35	12 300	1 340
	1 000	400	19	28	18	406.1	319	669 000	29 900	40.6	8.58	13 400	1 500
	1 000	400	19	32	18	436.6	343	736 000	34 200	41.0	8.85	14 700	1 710
	1 000	400	19	36	18	467.1	367	802 000	38 500	41.4	9.07	16 000	1 920

Photo 1 SH 1000 series

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