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One Approach for Developing a Construction Steel Market Outside of Japan

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Abstract

One approach for developing an overseas market for construction steel products such as steel sheet pile, steel pipe pile and H section steel will be shown in this article. There are two categories for realizing this objective. One is related to Japanese ODA scheme, the other relates to civil and architectural markets mostly in developed countries such as Taiwan, Singapore and Middle East Asia. Among ODA projects, three typical projects using Japanese governmental feasibility study funds are introduced. As for civil and architectural markets in the countries mentioned above, the competitiveness of construction products themselves is most important. Among many construction steel products, steel straight sheet pile and extra-heavy [giant] H shape steel will be described in this paper.

1. Nippon Steel's Response to Recent Trends in Overseas Construction Materials Markets

In the decade from 1995 to 2005, domestic consumption of steel pipe piles and steel sheet piles, which account for the majority of construction materials used in Japan, has decreased markedly, from 800,000 tons to 500,000 tons for steel pipe piles and from 1,000,000 tons to 500,000 tons for steel sheet piles. On the other hand, in the period from 1996 to 2000, the amount of Japanese sales in the field of construction all over the world grew 5.5%. From about five years ago, Japan's major construction companies have been expanding their overseas offices and increasing their overseas workforce in hopes of boosting their sales abroad.

In order to cope with the declining domestic demand for construction materials and explore the possibilities for development of steel construction markets overseas, in July, 1999 Nippon Steel established its "Overseas Construction & Engineering Service Department" in the Construction & Architectural Materials Development & Engineering Service Div. For some time, the newly created department focused its activities on projects relating to Japan's overseas development aid (ODA). Recently, it has finally started to develop steel construction markets for general construction materials (i.e., construction materials unrelated to ODA projects). **Table 1** shows a history of the department's activities.

In this paper, the relevant technical activities the company has conducted so far are described and future endeavors are outlined.

2. Activities Relating to Japan's ODA

2.1 Activities under the Special Yen Loan System[1)]

Nippon Steel's activities in overseas construction materials markets began with the technical guidance the company provided in October, 1998 for the cut-off work concerning steel sheet piles on the Yangtze river. After that, in response to the "Special Yen Loan" announced by the Japanese government in December, 1998, the Overseas Construction & Engineering Service Department that the company established in July, 1999 launched technical proposal activities

*[1] Construction & Architectural Materials Development & Engineering Service Div.
*[2] Structurals Sales Div.
*[3] Project Development Div.

Table 1 Activities of overseas construction technical sector

	1st stage			2nd stage			3rd stage			4th stage
	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008
ODA	Special Yen Lone projects			STEP Yen Lone projects				New STEP Yen projects		
	July 1/ Overseas Construction & Engineering Service Dept. established.					Overseas base activity in Manila				Linking general construction materials to ODA
	JETRO FS projects	Garbage disposal in Manila, Philippines	Prevention of salt damage in Mekong Delta; prevention of floods in Panay	Construction of Guzar railway	Expansion of Panama Canal, erosion control	Rehabilitation of road bridge in Sri Lanka	(Pakistan N-70 mountain road)	(Elevated Hanoi Station)		
General construction materials			Market surveys	(Steel sheet piles in Southeast Asia)	(Bridges in China)	(Rivers in China)				
					Nippon Steel received orders for project execution	Taiwan/Singapore				
						Development of internationally competitive products, design tools and organization for making proposals				
Japan Iron and Steel Federation			Overseas Projects Committee established in fiscal 2002; "Steel Seminar for Southeast Asian Countries" of former Steel Export Association reorganized.	Steel construction seminar for Southeast Asian countries held at 10 times in five years (4 in Hanoi, 2 in Manila, 2 in Jakarta and 2 in Kuala Lumpur)				Seminar reorganized into Southeast Asia Steel Construction Conference (tentative name) (4 countries to be invited)		
					China-Japan Architectural Seminar (ended after 3rd meeting held in fiscal 2003)				Technical interchange meeting	
				Publication of steel construction technology magazine (quarterly) for both civil engineers and architects						

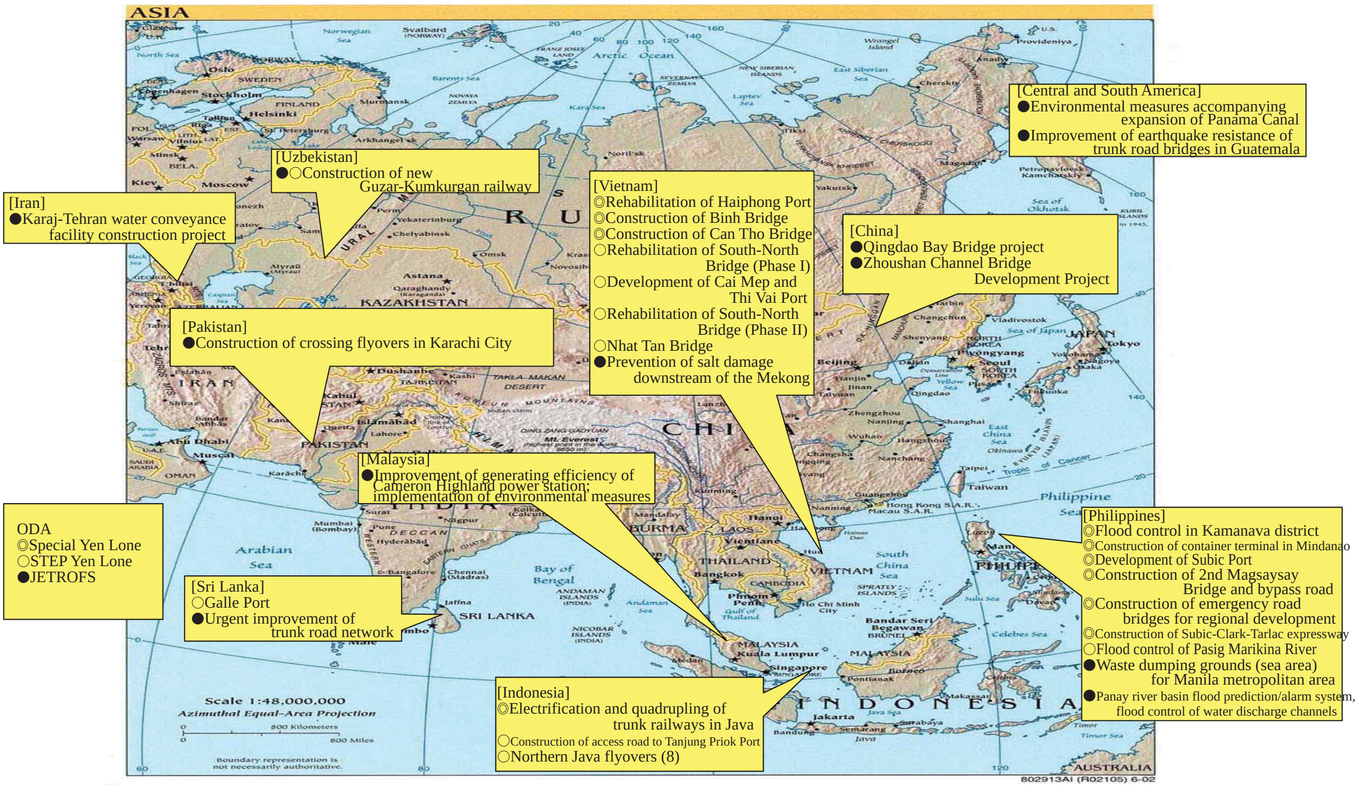


Fig. 1 Japanese ODA projects in which Nippon Steel is involved

in earnest. The Special Yen Loan was established to assist with infrastructural development and suchlike in Asian countries, specifically to improve logistical efficiency, reinforce manufacturing bases and prevent the occurrence of major disasters. It was intended specially for projects which would help revitalize business and promote employment so as to promote the early recovery of the Asian economy from the financial crisis of 1998.

The major role of steel construction engineers from Japanese steelmakers in the projects planned under the Special Yen Loan system was to help engineers of the recipient countries understand the advantages of Japan's steel construction technology. The Special Yen Loan (total value: ¥600 billion), which was in force for three years, was applied to 21 projects worth some ¥500 billion in Japan. With regard to the steel construction projects in which Nippon Steel is involved, those shown in **Fig. 1** have been completed, or are underway or planned.

The technical issue that the company pays utmost attention to in those projects is to disseminate to the recipient countries the steel construction technology the company has developed in Japan, which is an earthquake-ridden country with weak subsoil yet which has developed its social infrastructure rapidly and admirably. In the recipient countries, as in Japan, steel constructions are widely used for river, port and bridge projects. Nippon Steel has submitted a number of technical proposals, with the major emphasis on the points shown in **Table 2**. Generally speaking, it takes four to five years for a Japanese ODA project to be completed after the government grants the loan to the recipient country. Of the projects shown in Fig. 1, some have yet to be started. **Photos 1** through **5** show examples of projects that have progressed smoothly.

2.2 Activities with yen loan under the STEP system[2)]

In 2002, in place of the Special Yen Loan, the Japanese government introduced the Special Term for Economic Partnership

Table 2 Technical proposal points in Japanese ODA projects

Field	Flood control/irrigation	Need for earthquake-resistant ports	Construction work under unfavorable site conditions
Technical proposal to recipient country	From restoration to disaster prevention Prevention of river flooding in urban areas		Thick layer of poor subsoil, etc. Urban civil engineering
Technical points (1)	High water cut-off reliability Space-saving structure Easy fieldwork execution	Rich experience of earthquake-ridden Japan Reliable work execution Steel pipe pile piers	Experience in construction on poor subsoil in Japan Large, deep foundation consolidation Reliable field work execution Steel pipe sheet pile foundation
Technical points (2) (proposed product/method)	Steel sheet pile revetments Vibro-hammer method Press in steel pipe pile method Ports	Heavy corrosion prevention technology (NS-PAC) Underwater strut beam method Bridges & foundations	Weathering steel Eco-pile method

Photo 1 Two main steel girders on Subic-Clark Tarlac expressway construction in Philippine

Photo 2 Revetment using 600mm wide steel sheet pile in Kamanava area of Metro Manila in Philippines

Photo 3 Driving steel pipe pile on construction of Subic Bay Port Development in Philippines

Photo 4 Construction of steel pipe sheet pile foundation for the second Magsaysay Bridge of Mindanao island in Philippines

Photo 5 Steel box girder construction of Second Magsaysay Bridge

(STEP)—a tied yen loan system—with the aim of promoting "visible aid" to developing countries by transferring advanced Japanese technology and know-how to them. Even though the total amount of Japan's ODA has been gradually decreasing in recent years, the amount of yen loans granted during fiscal 2005 totaled some ¥569.8 billion, about 10% of which accounts for the STEP loan granted during the same fiscal year. Thus, the chance of Japanese technology playing an important role on the world stage is positively increasing.

The technical issue that Nippon Steel concentrates on under the STEP system is to submit proposals appropriate to the spirit of STEP. Fortunately, in Japan, in which the maximum annual consumption of steel pipe piles and steel sheet piles, respectively, once reached 1,000,000 tons at the height of its prosperity, many improvements have been made not only to steel products itself but also to steel structures and steel construction methods, so that Japan's steel construction technology has been utilized very effectively. Of the STEP projects that have been granted to the recipient countries since fiscal 2002, those which have adopted Japan's steel construction technology are shown in Fig. 1 as yen loans under STEP. Although there are no projects underway as of September 2007, it is anticipated that they will materialize sooner or later depending on conditions in the recipient countries.

2.3 Activities under the system for International Atmospheric and Environmental Research Development.

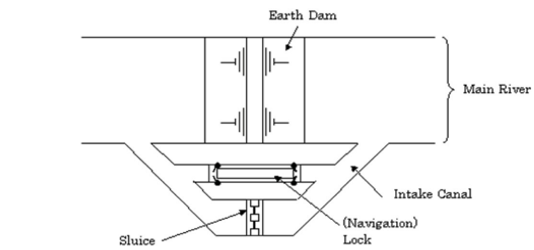
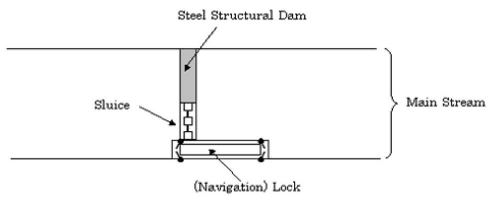
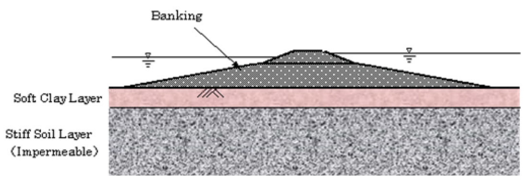
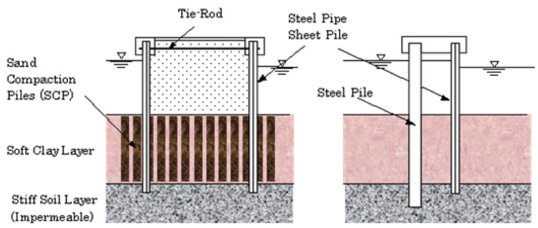
In 1998, a system for surveying "International Atmospheric and Environmental Research Development" was established in the Ministry of Economy, Trade and Industry (surveys to be implemented by an independent administrative corporation—Japan External Trade Organization: JETRO) in order for Japan to identify new projects that are eligible for Special Yen Loan or the current STEP. Since then, 20 to 30 feasibility studies have been carried out annually. Nippon Steel also utilizes this system in the hope of identifying as many potential projects as possible. The company has conducted 14 feasibility studies so far. Of the 14 FS projects, those which involved the Overseas Construction & Engineering Service Department are shown as JETROFS in Fig. 1. Three representative examples of those projects are described below.

2.3.1 Study of project to prevent salt damage in the Mekong Delta, Vietnam (FS carried out in fiscal 2001)[3)]

Farmers along the Mekong Delta in the southern part of Vietnam have been suffering a shortage of irrigation water caused by seawater flowing upstream in the rivers during the dry season. Since the Mekong is an international river, it was considered difficult for Vietnam to unilaterally dam the river to solve the problem. Therefore, the country planned to improve the rice yields in the northern part of Ben Tre province along the lower reaches of the Mekong by reinforcing the river embankments/revetments and constructing a movable sluice with locks, intake dam, etc. there. Nippon Steel conducted a feasibility study in terms of both software and hardware. In the software FS, the company analyzed the hydraulics in the lower reaches of the Mekong and confirmed that it would be possible to obtain freshwater as planned by adopting the embankments method. In the hardware FS, the company proposed steel structures. The proposal points for steel construction are shown in **Table 3**. In Vietnam, when it comes to constructing a dam, it is common practice to shift the channel of the stream as long as there is adequate time and space. However, the company proposed a system using steel pipe piles and steel sheet piles to permit installing the sluice and lock in the channel within a short time without diverting the stream.

As a result, Vietnam asked the Japanese government to carry out

Table 3 Alternative layouts and structures of dam, sluice and lock

<table>
<tr><th>Types of construction</th><th>Earth dam, lock in intake canal
(original plan)</th><th>Sheet pile dam, lock in river
(proposed plan)</th></tr>
<tr><td>Layout plan of dam and navigation lock</td><td>
</td><td>
</td></tr>
<tr><td>Section of dam structure (ex. An Hoa Dam)</td><td>
</td><td>

Type A: double wall cofferdam Type B: sheet piles with steel piles</td></tr>
<tr><td>Structural members</td><td>Soil mound (using excavated soil for intake canal)</td><td>Type A: steel pipe sheet pile, tie-rod, back-fill, concrete, sand compaction pile (if necessary)
Type B: steel pipe sheet pile, steel pile, concrete</td></tr>
<tr><td>Construction flow</td><td>Start: excavation of intake canal
↓
Start: banking execution of earth dam (using excavated soil)
↓
Start: construction of sluice & lock
↓
Completion: earth dam, sluice and lock
↓
Excavation of connecting point between main stream and intake</td><td>Start: construction of sheet pile dam, sluice and lock
↓
Completion: sluice and lock
↓
Completion: sheet pile dam (steel structural dam)</td></tr>
</table>

the project. Regrettably, however, the project has not materialized under the yen loan scheme because Vietnam could not wait for the yen loan to be granted, and because other dam construction projects, etc. in the central region had higher priority. Even so, it seems that the project under consideration is being implemented, though at a slow pace, with the country's own funds in the way Nippon Steel recommended.

The company's FS accelerated the Vietnamese engineering activity, which has been progressing rapidly these days.

2.3.2 Construction of new Guzar-Kumkurgan railway in Uzbekistan[4) (FS carried out in fiscal 2001)

This project was implemented by Japan Transportation Consults (JTC), Inc. who have rich experience in overseas railway construction projects as the main consultant. As experts in the field of steel construction, Nippon Steel provided JTC with technical advice. The railway network of the Republic of Uzbekistan in which Nippon Steel carried out the FS has been built without regard to the present national border that extends to the former Soviet Union. Because of this, after the disintegration of the Soviet Union, the railway network was disconnected here and there. As a typical example, traveling from Samarkand—the center of the country's economy—to southeastern Surxondaryo Province, which covers a wide area and is rich in minerals, freshwater and labor, requires passing through the neighboring country of Turkmenistan. Accordingly, construction of a new railway connecting the two places directly was called for. Therefore, Nippon Steel studied the feasibility of a mountain railway running through a mountainous area having the peak height of 4,127 m.

In the project area, there were five sections whose natural features were so severe that it was considered extremely difficult to lay rails using a crane or carry massive concrete girders on trailers. Nippon Steel proposed that a steel bridge be constructed in each of those sections (**Fig. 2**).

The government of Uzbekistan highly evaluated the company's technologies for manufacturing wear-resistant rails suitable for railways constructed in steep mountainous areas, such as the project area, and for designing and constructing sturdy bridges with excellent earthquake resistance. The Japanese government granted yen loan to the project under the STEP system in 2004 and construction work began in 2007.

2.3.3 Environmental measures accompanying expansion of the Panama Canal in the Republic of Panama[5) (FS carried out in fiscal 2003)

The Panama Canal Authority announced that it would carry out a Panama Canal Expansion Project in order to cope with the steady increase in the volume of cargo transported through the canal. The goal of this project is to construct at each of the Pacific and Caribbean sides of the Canal a (third) lock to allow for the passage of 150,000-ton-class vessels. It was expected, however, that the project would entail the excavation of massive volumes of soil—50 to 70 million cubic meters—from construction of the new locks, etc. The Authority, therefore, was having great difficulty working out suitable environmental measures to take.

Under that condition, Nippon Steel and Nippon Koei jointly came up with the idea of utilizing the surplus excavated soil to construct a man-made island for use as a container terminal. To construct an artificial island by means of land reclamation, a proposal was submitted based on the use of Japan's steel construction technology. When it comes to constructing man-made islands in Japan, it is common practice to enclose the construction site with revetments before land reclamation so as to prevent the seawater from being polluted with soil (**Photo 6**). With this in mind, the prefabricated steel sheet pile cell method (**Photo 7**) that was developed in Japan was proposed and that has been used in many land reclamation projects, from the standpoint of minimizing seawater pollution, shortening the construction period and cutting construction costs.

In October, 2006, a national referendum about the propriety of the canal expansion was held. Nearly 80% of the votes were in favor. So the Authority launched the canal expansion project with completion set for 2014. The construction of a container terminal, however,

Photo 6 Revetment using straight steel sheet pile of man-made island of Tokyo Trans Bay Highway

Photo 7 Transportation of cell in prefabricated steel sheet pile cell structure method

Fig. 2 Image of railway bridge in mountain area of Uzbekistan

was excluded from the canal expansion project as it was decided that it should be carried out by the Ministry of Transport (Panama). Concerning the disposal of surplus excavated soil, after some meandering, the Authority seems to have finally decided to dump the surplus soil onto a former firing ground of the U.S. Army—one of the plans that had been discussed initially. So, regrettably, the idea of constructing a man-made island to utilize the excavated soil has not materialized yet. Nevertheless, the technical study into the steel sheet pile cell method that was made at that time has paved the way for Nippon Steel's current activities to promote this option to the general construction materials market.

3. Nippon Steel's Activities to Penetrate the General Construction Materials Market

At the end of the day, it is a product's competitiveness that matters most when attempting to penetrate general construction materials markets overseas. Needless to say, some products that are competitive in Japan are not always competitive in foreign countries which differ from Japan in terms of their political, cultural and economic conditions. At present, Nippon Steel is investigating whether or not its steel sheet piles, steel pipe piles, prefabricated civil engineering products and high-performance structural steel materials are competitive enough in various foreign countries. The following sections will describe several of the general construction materials that the company has successfully introduced to certain foreign countries since it started developing overseas markets in earnest.

3.1 Straight steel sheet piles

3.1.1 Prefabricated steel sheet pile cells

The straight steel sheet piles (**Table 4**) used in steel sheet pile cells were first manufactured in Japan in 1953. At first, the width of straight steel sheet piles was 400 mm. Today, straight steel sheet piles are wider (500 mm) and hence more economical to use. In the case of cell structures using straight steel sheet piles, if the piles are driven in one by one, they remain in a critically unstable condition for a considerable period of time until the packing sand is put into the cell because of their limited flexural stiffness lengthways. The prefabricated steel sheet pile cell method was developed to eradicate such problems. Nippon Steel proposed that the method be used to construct a man-made island as one of the environmental measures that need to be provided for expansion of the Panama Canal, as described earlier.

The prefabricated steel sheet pile cell method, in which straight steel sheet piles as originally developed overseas are used more effectively, was worked out in Japan, and contributed to the speedy development of port facilities in Japan during the period of its rapid economic growth. Because this method requires not only a large floating crane and many vibrating pile drivers but also sophisticated construction technologies, such as a synchronizer for the pile-driving operation, it cannot always be used easily and efficiently everywhere around the world. However, there is still room for adaptation of the method to the actual conditions in individual countries. It is expected that in the future, the method will be positively employed in projects which need to be carried out in a comparatively short period of time.

3.1.2 Example of application of straight steel sheet piles in overseas project

When we carefully follow up projects carried out in any country, not only the concepts of the design firms and design standards, but also the specific conditions of that country gradually become apparent to us. A typical example of this is a steel sheet pile cell construction project in Taiwan. Apparently, the method employed in the project was economically justified because the local construction company could obtain large volumes of packing sand at low cost and had dredgers of its own. Namely, as shown in **Photos 8 and 9**, the site on which to construct a berth was first filled with sand using a pump dredger and then, straight steel sheet piles were driven into the sand one by one using small-sized construction equipment, such as a backhoe. Although this method is the very opposite of the prefabricated steel sheet pile cell method, it may be said that it can be applied economically when there is sufficient time for construction and the sand required for land reclamation can be obtained easily.

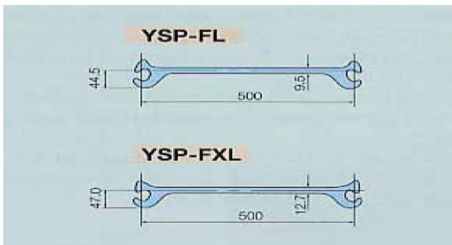
At the construction site, not only were steel sheet piles made by Nippon Steel used, but also those of other makers were used at the same time. Nippon Steel's piles were evaluated as being easier to use than the other makers' piles because of the superior fit accuracy of the interlocking joints and better fit straightness.

3.1.3 Compatibility with global standards for cell joints

Ordinarily, a steel sheet pipe cell structure consists of the main members in the form of cylinders and arcs jointing adjoining main members (**Fig. 3**). In steel sheet pile cell structures constructed in Japan, the joint between the cylinder and the arc forms a T-shape in which the arc meets at right angles to the cylinder. Formerly, a backing rivet joint welded construction provided with fillet-welded reinforcement was used to joint the cylinder and arc. In around 1980, a backing plug welded joint construction (**Fig. 4**) began to be used.

Table 4 Specification of straight steel sheet pile

Pile type	FL, FXL
Material	SYW290, SYW390
Yield stress	290 MPa, 390 MPa
Maximum length	38 m
Appearance of fitted part	
Fit accuracy	10 °
Tensile strength	3 920, 5 880 kN/m



Both constructions, however, were very costly because they required complicated work and strict quality control.

In foreign countries, not only the aforementioned T-joints, but also y-joints at which the arc connects obliquely to the cylinder, have been widely used and joint constructions obtained by welding alone are most common.

In view of those situations, Nippon Steel carried out a test to confirm the strength of welded joint constructions of its straight steel sheet piles YSP-FL and YSP-FXL (material: SYW295). As a result, it was found that the welded joint constructions had sufficient yield strength (**Fig. 5**, **Table 5** and **Photo 10**). Thus, it has been confirmed

Photo 8 One by one construction method using straight steel sheet pile in Taiwan (1)

Photo 9 One by one construction method using straight steel sheet pile in Taiwan (2)

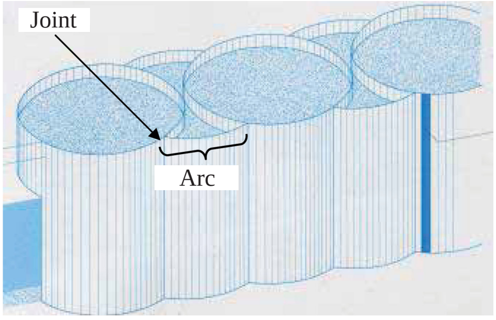


Fig. 3 Schematic view of straight steel sheet pile cell

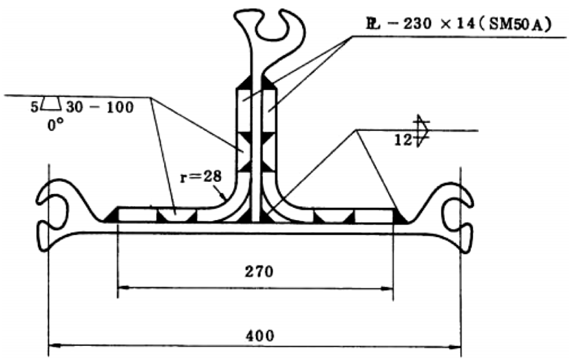


Fig. 4 T-junction steel pile using backing plug welding

Table 5 Specification of y-junction steel sheet pile and test results of y-junction test case and strength of test result

Item		Specifications	
Specimen width		50 mm	
Welding		Full penetration phase, etc.	
Steel material		SYW295	
Test cases and strengths			
		YSP-FXL	YSP-FL
Angle between members	35 °	5 811, 6 019 kN/m	4 218, 4 324 kN/m
	45 °	5 686, 5 536 kN/m	4 302, 4 254 kN/m
Required strength (reference)		2 620 kN/m	3 503 kN/m

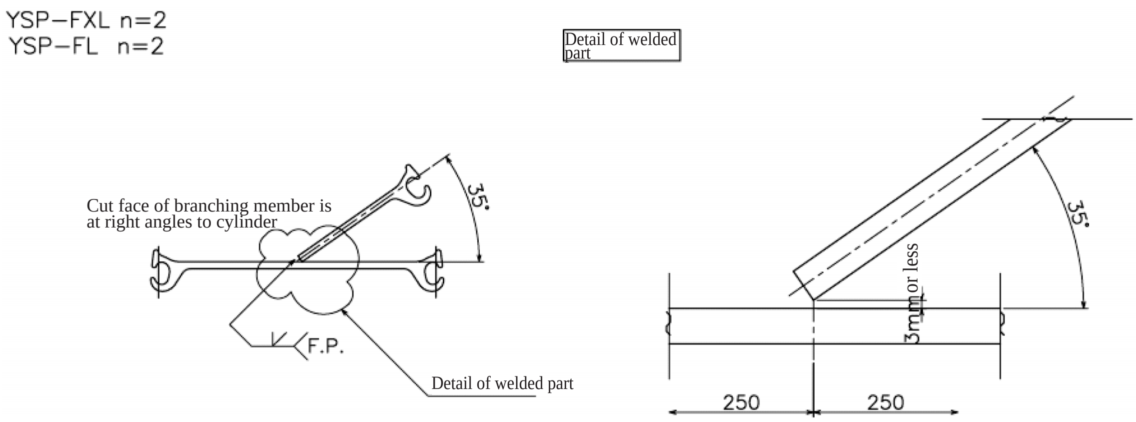


Fig. 5 Specification of y-junction

Photo 10 One of the test results in junction of steel sheet pile cell

that the company's steel sheet pile cell structure can safely be applied to overseas projects in the future.

3.2 High-performance, extra-heavy H-shaped beam for architectural structures

The extra-heavy H-shaped beam, which is widely used in columns for high-rise buildings overseas, was first manufactured in Japan in 1964. At first, the maximum flange thickness of extra-heavy H-shaped beams manufactured in Japan was 48 mm. In 1967, it became possible to manufacture extra-heavy H-shaped beams with a maximum flange thickness of 125 mm—the largest flange thickness in the world. Since then, this steel product has been used in many high-rise buildings all over the world, including the World Trade Center in the United States. In Japan, extra-heavy H-shaped beams were used for the first time in the Kasumigaseki Building in Tokyo. In around 1994, it began to be used as a high-performance material (maximum flange thickness: 80 mm) for the columns of tall buildings. In recent years, the demand for high-performance, extra-heavy H-shaped beam has been increasing again as a result of the boom in construction of high-rise buildings and long-span structures in the United States, the Middle East and China. In around 2005, Nippon Steel developed a high-performance, extra-heavy H-shaped beam (maximum flange thickness: 125 mm) (**Photo 11**), which is compatible with the current overseas standards and began promoting sales of the newly developed product. At present, only a few steelmakers, including Nippon Steel, can manufacture extra-heavy H-shaped beams with a maximum flange thickness of 125 mm. Because of this and its excellent dimensional accuracy, strict delivery management and the superior internal properties of the steel products of Nippon Steel, the high-performance, extra-heavy H-shaped beam developed by the company was adopted for the world's tallest building (**Photo 12**)[6].

Photo 11 High performance extra-heavy [giant] H shape

Photo 12 Burj Dubai Tower using extra-heavy [giant] H shape

4. Future Tasks

In retrospect, Nippon Steel began its activities to develop overseas construction materials markets by proposing steel constructions based on Japan's advanced steel construction technology to ODA-related projects to improve rivers and construct ports and bridges. Through these projects, the company gained a variety of experience in overseas markets. It then started to develop general construction materials markets. In concluding this paper, a brief description will be provided of the endeavors the company needs to take on to press ahead with the development of overseas construction materials markets in the future.

4.1 Development of internationally competitive products

Formerly, steel pipe piles, steel sheet piles and H-shaped beams used in the Japanese construction market were pitted against concrete-based materials, and the major properties required of them were earthquake resistance, environmental friendliness and applicability to construction in urban areas. Under those conditions, when it comes to using them in construction, the primary emphasis was placed on improving their load-bearing capacity, yield strength and earthquake resistance by introducing advanced new application technology. In the development of overseas markets, however, the product itself is required to be internationally competitive because it is generally targeting more than one country or territory. Consider steel sheet piles as an example. In Japan, special importance has been attached to the workability and durability of this steel product since it is often applied repeatedly in the construction of temporary structures. Because of this, steel sheet piles manufactured in Japan are somewhat inferior in sectional performance per steel weight to those made in foreign countries. Thus, in order for Nippon Steel to penetrate overseas construction materials markets in earnest in the future, it is considered necessary to secure sufficient international competitiveness of its products.

4.2 Development of suitable tools and organization

The existing Japanese design standards and design tools in Japanese alone are not enough. In order to make inroads into foreign markets, it is necessary for Nippon Steel to propose designs that are compatible with EUROCODE, AASHTO or other applicable design standards. To that end, it is important to pick up products which are internationally competitive and prepare documents in English providing the technical details of those products. Depending on circumstances, it will become necessary to improve and maintain the software, such as preparing design and calculation tools in English.

It is considered that both internationally competitive products and tools to develop new markets are indispensable to push through international market strategies in the field of construction materials.

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