Abridged version

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Establishment of All-Weather Berth Network

Tanemitsu Yasuda, Seiji Ueda, Koji Tatsu

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Kawasaki Steel estblished an integrated network comprising a total of six all-weather berths for loading and unloading at its Mizushima Works, Chiba Works, Chita Works and Osaka Service Center to improve transportation efficiency by the domestic vessels on which the company depends for approximately 70% of its steel product transportation. The Osaka Service Center, because it is located on a public wharf, has adopted the retractable vessel housing method for the first time in Japan. With a fixed shed eqipped with both a ceiling crane and a movable shed which moves on an overhanging guard, the facility can be used in the shut down condition, and is possible to operate in both good and inclement weather. In addition, a multipurpose semi-automatic crane was adopted to improve loading and unloading efficiency. Kawasaki Steel consequently realized a basic transportation improvement by achieving labor saving, improvement in the labor environment, and a 90% all-weather berth work ratio.

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1 Introduction

About 70% of the company's domestic steel transportation depends on coastal service ships. When the ship-loading work stops due to rainy weather, not only the delivery to customers is delayed but also the shipping cost is increased, the delivery plan disturbed, and the operation load increases due to plan changes. Recently, the sophistication of customer needs came to boost the quantity of products that are incompatible with rain water. Coupled with this problem is an anticipation of future labor shortage, causing an urgent requirement for working environment improvement. Against these backdrops, the company reinforced all-weather berths at Mizushima and Chiba, built new ones at Chita and Osaka Service Centers, thus setting up all-weather berth network covering both loading and unloading points establishing a physical distribution system unaffected by weather conditions and capable of time-reduced product loading and unloading work.

The foremost features of this construction are, first, the adoption in Osaka SC of the retractable vessel housing which is different from the conventional fixed-type berth and, secondly, the adoption at the main berth of Mizushima Works of the multipurpose semiautomatic crane, which has been introduced to improve ship-loading capacity and to save labor.

The present paper reports an outline of the all-weather berth network centering on the berth at Osaka SC and the multipurpose semiautomatic crane.

2 Outline of All-Weather Berth Network

In constructing all-weather berths, the company aimed at:

(1) securing 90% for all-weather berth efficiency ratio (probability of cargo-handling not hampered by rainfalls and/or wind), and

(2) structuring of all-weather berth network covering from loading point to unloading point to attain the full advantage of the berth network with cargo-handling smoothly underway both at loading point and unloading point with no interruption by rainfalls.

With the above in mind, a new unit of all-weather berth was installed at Mizushima, Chiba, Chita, and Osaka SC each, totaling 4 units, aside from the existing ones (each 1 at Mizushima and Chiba), totaling two units, thus bringing the total

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Table 1 Specifications of Kawasaki Steel all-weather berths

	Newly constructed berths				Existing berths	
Name	Osaka SC	Mizushima No.2	Chiba	Chiba	Mizushima No.1	Chiba
Data of operation start	Oct. 1991	Feb. 1992	Feb. 1991	Apr. 1991	—	—
Location	Adjacent to Bldg. J	Takahashi River Wharf	OD Berth	7-gochi	Takahashi River Wharf	Samugawa Wharf
Type	Retractable vessel housing	Fixed overwater overhanging housing			Fixed overwater overhanging housing	
Capacity (t/month)	38 000	100 000	68 000	59 000	105 000	8 000
Corresponding vessel (DWT)	1 600	2 100	2 100	2 100	3 000	700
Water depth (m)	−5.0	−6.0	−10.5	−6.0	−6.0	−5.0
Building						
Sea side L (m) × W (m)	48.9×23.8	80.0×20.0	90.0×20.0	80.0×22.0	105.0×20.0	70.0×16.0
Land side L (m) × W (m)	52.8×29.0	80.0×23.0	90.0×23.0	48.0×51.0	105.0×21.5	70.0×17.0
Ceiling rail (m)	GL+23.2	GL+21.5	GL+22.0	GL+22.0	GL+21.0	GL+20.0
Gate	Sheet-shutter	Net-shutter	Net-shutter	Net-shutter	—	
Crane						
Type	OHC	OHC	OHC	OHC	OHC	OHC
Capacity	20 t×2	20 t×2	20 t×2	20 t×2	30 t	10 t
Span (m)	47.5	40.0	40.0	45.0	39.0	30.4
Connection with warehouse	Shed is directly connected with warehouse	Pallet with hood			Truck or pallet with hood	Pallet with hood

units of the network into six altogether.

As for berth functions, Mizushima berth handles only the delivery from the plant and has only a ship-loading function, Chiba and Chita berths, having a service center each in the yard, carry out both ship-loading function of delivered goods and the unloading function (service center function), and the berth at Osaka SC has only the cargo-unloading function.

The main facility specifications of these all-weather berths are shown in **Table 1**.

The existing berths were of the conventional fixed type, and the newly constructed berths have the following features:

(1) Except the Osaka SC berth of the retractable vessel housing type, all the berths are of the conventional overwater overhanging fixed housing type, and are aimed at a maximum 2 100 DWT class.

(2) Crane capacity has been unified at 40 t, taking into consideration the need of coping with the consistent unit transportation in the future.

(3) Aiming at berth loading capacity improvement and labor saving, a semiautomatic crane was installed at the main berth of Mizushima Works.

(4) Except Osaka SC, where the carrier system is not introduced, product transportation between the berth and the warehouse is connected by the pallet with hood (coping with rainy weather). At Osaka SC, the berth and the warehouse are connected by the lower shed installed to shelter from the rain.

3 All-Weather Berth at Osaka Service Center

The all-weather berth[1] installed at Osaka SC of Kawatetsu Warehouse Co., Ltd. in October 1991 has its function and construction exceedingly different from the type of all-weather berths which have been operated in Japan. It permits construction of all-weather berths to quays and sea-lanes which are under legal restrictions. It not only facilitates ship maneuvering, but also greatly improves the operating environment irrespective of rain, burning sun and cold wind.

The conventional type all-weather berths are mostly of the fixed type of ocean pile driving, which installs piles and the shed on the sea (overwater overhanging fixed housing type) as shown in **Fig. 1**, and only rarely an excavation-type can be seen. The conventional type poses the following problems: (1) The ocean pile-driving type constructs fixed facilities on the sea and occupies the sea area; hence this type cannot be constructed at the public quays, over the river and sea-lane which are

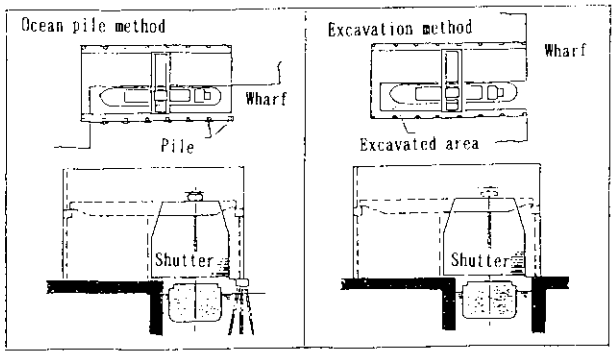

Fig. 1 Conventional all-weather berth type

governed with restrictions, and consequently, the quays to be constructed are limited, (2) the excavation-type needs huge construction costs, because it requires cutting of quays, and (3) ship maneuvering when the ship comes alongside or is leaving the berth is more difficult than at general quays, demanding more care than in the case of ordinary quays.

In order to avoid these problems at the all-weather berth of Osaka SC, the "retractable vessel housing type," in which the facilities overhang only at the time of cargo-loading or unloading operation, was introduced, and this type is the coastal cargo-loading and unloading facilities adopted for the first time in Japan, with facilities covering the entire surface of the vessel, namely, the facilities cover the top, front/rear and both sides of vessel, thereby making cargo-loading and unloading possible during the rain.

3.1 Location of Osaka Service Center

Osaka SC is located at the South Port District of Osaka Port. At the opposite shore of Osaka SC, there is a largesized ferry wharf, and ferries destined for Kyushu, Shikoku, Shanghai and Taiwan are frequently departing and arriving in the morning and evening, and at the front of the quay, ordinary ships, wood-carrying ships, barges and tug boats are briskly coming in and going out, and this place is the second busiest in the marine traffic in the Osaka Bay.

Osaka SC is the largest service center of the company. It handles, as the distribution center of the Kansai District, many products such as coils, wires, rods, plates, shapes, steel pipes, etc., and in its distribution quantity, it has a monthly capacity of about 70 000 t on the unloading basis.

The scale of Osaka SC as follows:

Site area: 162 800 m^2

Berth specifications: water depth, 5.1 m; total length, 500 m; and maximum vessel type, 2 000 DWT class (The berth is a public one with 5-m width from berth normal line to the land side)

Stroage warehouses: 13 buildings (warehouse area, 45 000 m^2)

3.2 Construction Problems and Countermeasures

The construction problems of the all-weather berth at Osaka SC arose from the fact that the 5-m width part on the land side from the berth normal line was the public berth of Osaka City, and that the South-Port Inner Port in front of the berth was the navigation lane with a heavy traffic volume of ships, and the Osaka Port and Harbor Bureau do not approve the installation of fixed facilities (piles and buildings) on the seaside including the width of 5 m of the public berth. As a result, it was necessary to construct a unloading facility having a crane girder and a covering structure that was able to be overhung over the sea during cargo-handling operation in rainy weather so as to cover the ship and that was able to be stored on land side from the public berth at the

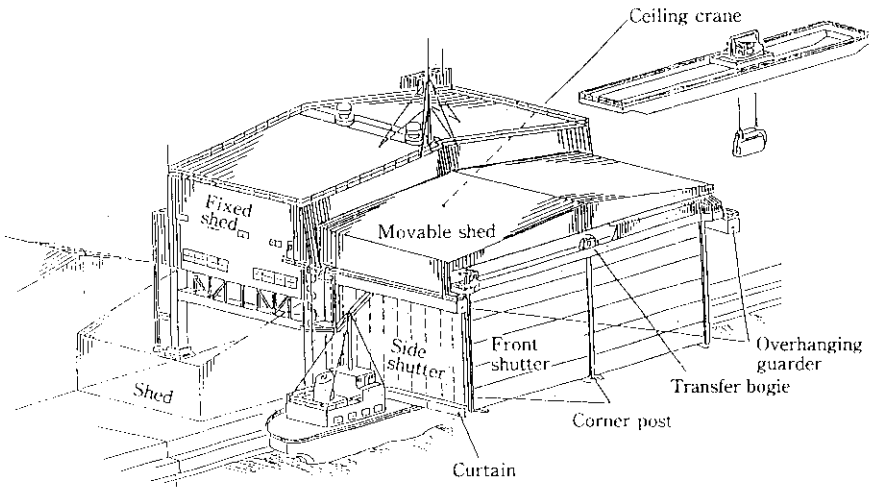

Fig. 2 Overview of all-weather berth

time of completing the cargo handling.

In order to meet this condition, we examined various types of unloading facilities and shed types and made tests using a model machine. Finally, we introduced for the first time a retractable vessel housing type shown in **Fig. 2**, and constructed the all-weather berth equipped with the "ship-periphery surrounding device," which permitted cargo-handling in rainy weather.

Major approvals obtained up to the time of construction were as follows:

(1) Public berth conditions (Strength investigation)—Osaka Port and Harbor Bureau
(2) Building Standard Law approval by the Minister of Construction—Osaka City Planning Bureau (Construction Ministry)
(3) Operating method of all-weather berth—Osaka-City Marine Safety Control Dept.

3.3 Outline of Facilities

The entire present facilities are shown in Fig. 2, and the major specifications of the facilities are shown in **Table 2**.

Table 2 Main Specification of equipment of Osaka Service Center

Fixed shed	(m)	52.8 W ×29 D ×36.6 H[a]
Movable shed	(m)	48.9 W ×23.8 D ×33 H[a]
Overhanging guarder		BOX type (2.5 mm/time)
Size	(m)	2.4 L ×2 W ×2.5 H
Transfer bogie		Self propelled type (8.2 min/time)
Span	(m)	47.5
Function on-board		① Front shutter, ② Corner post, ③ Side shutter
Front shutter		Folding steel panel method
Size	(m)	3.8 W ×20.6 L ×6 pieces×2 set
Lifting equipment		Wire rope coiling drum
Corner post		3 pieces (box type)
Side shutter		Sheet coiling drum method
Sheet		Polyester+Vinyl chloride
Size	(m)	24.6 W ×21.4 L
Ceiling crane		Rotating type
Capacity	(t)	40 (20 t×2)
Crane span	(m)	47.5
Speed	(m/min)	30 (lifting) ×50 (lateral) ×80 (running)
Set up time		
Good weather		15 min for set-up, 15 min for shut-dows
Inclement weather		26 min for set-up, 26 min for shut-down
Corresponding wessel		499 G/T (loading capacity 1 600 t)
Size	(m)	75 L ×12 W ×6.3 D
Hatch dimension	(m)	9.5×40
Wind resistivity	(m/sec)	16 (regardless of meather)

[a] Top height

The present facilities are of the retractable vessel housing type,[2] and main structures are constructed by broadly the following four blocks:

(1) A fixed shed, which is to be used as a cargo-sorting shed, movable vehicle and overhanging girder during the stopping of cargo-handling operation.
(2) The overhanging girder and movable buggy come out over the sea water only during cargo-handling operation.
(3) Ship-periphery covering mechanisms such as the movable shed, front shutter and side shutters function during cargo-handling in rainy weather, a hot day or a cold windy day.
(4) Ceiling crane for cargo-handling.

Photo 1 shows the working condition of the facilities. Setup patterns will be three, namely, "shut down," "good-weather cargo-handling," and "inclement weather

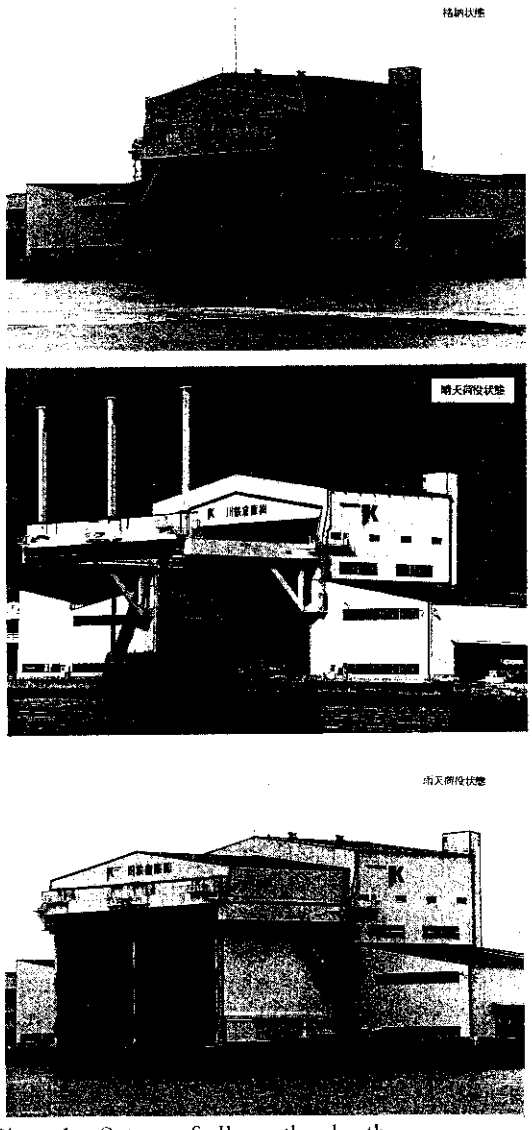

Photo 1 Set up of all-weather berth

cargo-handling."

3.3.1 Fixed shed

The fixed shed covers the steel-frame structure containing the fixed runway girder made of a roof and walls. It stores the movable shed, which travels on the fixed girder, overhanging girder, ceiling crane and transfer bogie. At the front of the fixed shed, a front shutter is provided, which closes and opens immediately below the transfer bogie, and this shutter functions as the end wall of the shed at the time of shut down.

3.3.2 Overhanging girder

The overhanging girder is installed at the right and left pillars on the sea-side, and rotates by the pushing and pulling of the hydraulic cylinder. On the girder, rails for the transfer bogie and ceiling crane are constructed, and the tip of the girder is fixed to the transfer bogie by a connecting pin, thereby maintaining the linearity of the girder and the directionality of the rail span.

3.3.3 Transfer bogie

The transfer bogie[3] self-travels on the overhanging girder, and is equipped with the front shutter, side shutters and guide-post which are to be used for covering the ship during cargo-handling in inclement weather. Further, the transfer bogie travels to the tip of the overhanging girder, and securely fixes it to the overhanging girder using a connecting pin, and it also has the function of hauling the movable shed.

3.3.4 Movable shed

The movable shed is stored in the fixed shed during the stopping of cargo-handling work and during cargo-handling in a fine day. Only during cargo-handling work on a rainy day, it completely covers the overwater overhanging part. The legs of the moving shed are supported by wheels, and the moving shed is connected to the movable shed by being connected to it using a drawing pin, and moves on the girder along with the travelling of the transfer bogie.

3.3.5 Front shutter

The front shutter[4,5] is composed of 12 folding steel panels fitted to the bottom side of the movable vehicle, and the opening and closing of the shutter is carried out by the rise and fall of the panels due to the elevation of the guide post.

At the time of shut down, the front panel functions as the wall at the end surface of the shed, and during the cargo-handling on a rainy day, the front panel is lowered to the sea level alongside the ship, thereby preventing the rain from blowing into the ship.

3.3.6 Side shutter

The side shutter[6,7] is installed at the lower side surface of the transfer bogie, and its perpendicular motion mechanism is of the sheet winding drum type. The side shutter is lowered directly below the overhanging girder to prevent the rain from blowing in by way of the front and rear surfaces of the hatches of the ship. At the bottom end of the side shutter, a drop-curtain device is provided to be used additionally depending upon the construction of the ship, and has a function of setting the curtain freely.

3.3.7 Ceiling crane

The ceiling crane is of the club rotation type, and its operation scope covers the entire span of the total length of the ship. In order to shorten the cycle time of cargo-handling operation and widen the visual field from the crane operating room, an individual moving device of the operation room is provided, and the rank-up of the winding speed of the crane is carried out.

3.3.8 Prevention of rain from blowing into ship

Figure 3 shows the condition of the periphery covering state of the ship, and the covering is composed of the following three types:

(1) Prevention of Blowing-in from Upper Part of Ship (Movable Shed)

(2) Prevention of Blowing-in from the Side of Ship (Front Shutter)
Blowintg-in of rain from the gap between the ship and the shutter (A of Fig. 3) into the hatch of the ship was considered, and from the rain blowing distance shown in **Table 3** (3.2 m, when light rain fell and wind velocity was 16 m/s), the rain blowing-in distance was set up to be 5 m or above.

(3) Prevention of Rain Blowing-in from Front and Rear Surfaces of Hatches of Ship (Side Shutters)
As shown in **Table 4**, the ship generates vertical displacement quantity of 3.5 to 4.5 m due to the tidal level, ship load variation, etc. Further, a sheet winding type mechanism has been adopted, which can arbitrarily make vertical adjustment of the shutter including the interference tie-in measures of the bridge, mast, etc., of the ship. As countermeasures to the protruding parts of the ship, a gap between the berth and the ship, etc., that are foreseen to be insufficient in covering by the side shutter alone, a drop curtain device is provided, which is divided into three parts and is movable vertically, in order to adopt sophisticated rain countermeasures. At the current condition, this drop curtain device is not used, and only by the side shutter, sufficient rainy weather cargo-handling is being carried out.

3.4 Features of All-Weather Berth of Osaka SC

The features of the present facilities are as follows:

(1) The present berth facilities are ordinarily stored at the land side, and only at the time of cargo-handling, they are hung over the sea; hence the facilities can be constructed on the sea surface as well as on

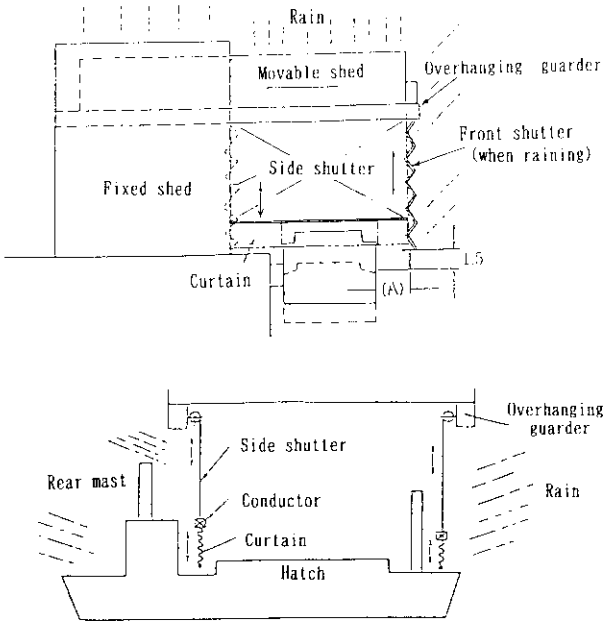

Fig. 3 Condition of movable shed

Table 3 Distance affected by rain (m)

Max. instantaneous wind velocity (m/s) / Rainning speed (m/s) / Rain-drop (mm)			6	12	16
Light rain	—	4	1.2	2.4	3.2
Light rain	1	6.5	0.8	1.5	2
Heavy rain	2	8.8	0.6	1.1	1.4
Squall	2.9	9.2	0.5	1	1.3

Note(1) When gate is raised to height of one meter.

Table 4 Change of vessel level (m)

	Bow	Stern
Range of tide	1.65	1.65
Draft	2.3	1.35
Swell	0.5	0.5
Total	4.5	3.5

the public berth and the river which are governed by strict regulations.

(2) Since there is ordinarily no protruding structure from the berth, maneuvering of the ship at coming alongside or leaving the berth is easy, and the facilities will not interfere with ships under navigation.

(3) As a countermeasure for the ship in rainy weather, the facilities have a covering mechanism selective according to the structure of the ship, its vertical fluctuations and the blowing directions of the rain and wind. Further, these covering mechanisms prevent not only the bad effect of the rainy weather, but also heat in the summer and cold in the winter and have realized selective use of indoor and outdoor operations, thereby achieving tremendous improvement in operational environment.

3.5 Working Condition

Since the completion of the network in October 1991, when the berth had some factors left for further development, the problematic points of the berth facilities were cleared by correcting a few initial troubles in the electrical system, and after the smooth start-up, the facilities have been working smoothly without any trouble, thereby achieving technically satisfying results.

4 Multipurpose Semiautomatic Crane

Simultaneous with the introduction of all-weather berth in Osaka SC, a part of crane operation was automated (semiautomated) as a pilot operation at the main berth of Mizushima Works in cargo-handling operations (multipurpose) of sheet coils and plates with the aims of improving the cargo-handling capacity and relieving the operation load of operators by the labor saving of the land-side operation members and by reducing the crane cargo-handling load. In the following, an outlines of the motion and control of the multipurpose semiautomatic crane are reported.

4.1 Outline of Crane Operation

As for an outline of crane operation, the cargo-loading operation step and unloading steps and the range of automation are shown in **Fig. 4** and **Table 5**. The semi-automatic operation procedure of the crane is carried out as follows:

(1) At the Time of Sheet Coil Cargo-Handling
To the coil on the pallet, which has been transported beforehand into the berth, at Fig. 4 (a) ①, select the coil to be cargo-handled on the terminal of the operator guidance, and push the button "commencement of automatic operation," and operation steps of ① to ⑩ will be automatically operated. In step ⑪, however, since automatic loading is difficult owing to the oscillation of the ship, manual operation is carried out.

(2) At the Time of Plate Cargo-Handling
At Fig. 4 (b) ①, select the plate to be cargo-handled on the terminal of the operator guidance, in the same way as with the sheet coil, and push the button of "automatic operation commencement," and the operation steps ① to ③ will become automatic operation. After manually operating steps ④ to ⑥, because these steps are difficult to be automated, press "automation resumption" in step ⑦, and steps ⑦ and ⑧ will become automatic operation. The operation of step ⑨ is not executed owing to the large size of the plate. Steps ⑩ and ⑪ are manually operated as in the case of the sheet coil.

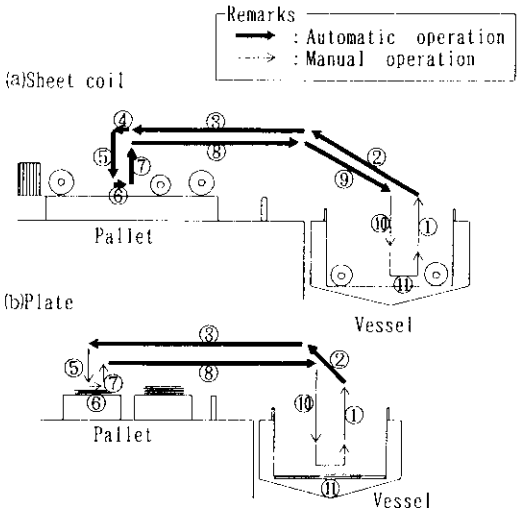

Fig. 4 Loading and unloading steps

Table 5 Range of automatic operation for loading and unloading

Operating steps	Sheet coil	Plate
① Lifting on vessel	Manual/Auto	Manual/Auto
② Simultaneous lifting and lateral movement	Auto	Auto
③ Lateral movement to pallet		
④ Shape recognition and centering		—
⑤ Lowering on pallet		Manual
⑥ Coil (plate) grasping		
⑦ Lifting on pallet		Manual/Auto
⑧ Lateral movement to vessel		Auto
⑨ Simultaneous lowering and lateral movement		
⑩ Lowering on vessel	Manual/Auto	Manual
⑪ Loading	Manual	

4.2 Crane Automatic Operation Control

Main control operations, which compose the crane automatic operation, are "steady-rest speed control" and "coil shape-recognition technique." The coil shape-recognition technique automatically detects the coil position and automatically controls the crane, thereby permitting the labor saving of land-side operations. The features of these control operations will be explained below.

4.2.1 Steady-rest speed control

(1) Steady-Rest Speed Control of Traversing Motion
A speed control pattren, which will nullify residual vibration of the suspended load and hoisting accerssory at the time of stopping the traversing operation of the crane, has been obtained by simulation, and the pattern is memorized in the crane sequencer as a table, and speed is controlled by setting a speed control pattern by the parameter matched with operating conditions (moving distance, rope length, etc.), thereby carrying out speed control.

(2) Micro-Vibration Stopping Control
When residual vibration exceeding the allowed value is remaining after stopping at the target location, the residual vibration is detected by the accelerrationmeter, the speed control pattern is calculated from the magnitude of vibration width and the vibration period, and the residual vibration is stopped without changing the location (by going forward and coming back by the same distance).

4.2.2 Coil shape-recognition technique

An outline of the coil shape-recognition equipment is shown in **Fig. 5**. The equipment is composed of a laser light source irradiating on the coil surface, two units of two-dimensional cameras that take photographs of the laser light in the whidth and diameter directions, and the calculation control equipment that carries out image processing from these pictures, calculates the coil position, and gives instructions to the crane control

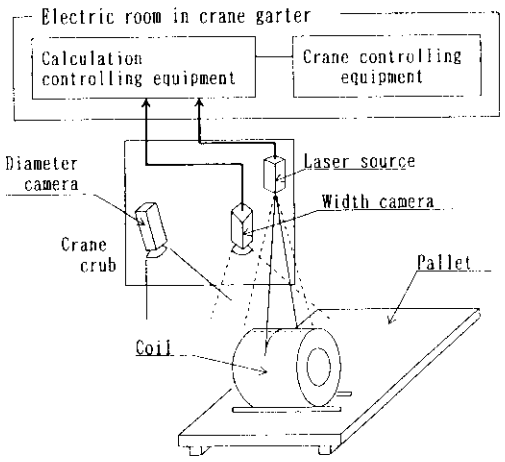

Fig. 5 Outline of shape recognition equipment

equipment. Using these devices, the automatic centering operation of the crane is carried out. Time required by shape-recognition is about 7 s, and the detection accuracy is +20 mm.

5 Effectiveness by All-Weather Berth Network Construction

In all-weather berth construction, three berths were first constructed at Chibe Works, Chita Works and Osaka SC, and a year later, one was constructed at Mizushima Works. All four units produced no significant troubles after construction, smooth operations are being carried out and the effectiveness expected at the initial plan is being obtained.

The main outcome of the network is as follows:

(1) The all-weather berth covering ratio (probability of not stopping cargo-handling due to rain or wind) achieved is 90%.
(2) Delivery as promised has become possible.
(3) Normalization of operation has been achieved.
(4) At the steel mill, planned delivery has become possible, and by aiming at the direct delivery by various product factories to the all-weather berth, process omission and "handling-less" effect have been achieved.
(5) Ship arrangement plan has become easier.
(6) Since the roof is provided, a great effect was caused to the labor environment improvement.
(7) Trouble with rain-wetting has disappeared.
(8) Material distribution costs such as the shipping cost and cargo-handling cost have been widely relieved.

6 Conclusions

The authors have introduced an outline of the all-weather berth of Osaka SC and the six all-weather berth networks, which consistently cover the loading location and unloading one, centering around the multipurpose semiautomatic crane at Mizushima Works. The results are as follows:

(1) Through the construction of the all-weather berth network, the all-weather berth covering ratio of 90% was acheved.
(2) Since Osaka SC was the public berth, the first-in-Japan retractable vessel housing type was adopted. In the fixed shed, a movable shed and overhead travelling crane are stored, which can move on the overhanging girder, thereby making it possible to operate by three patterns of storing, fine-day cargo-handling, and rainy-day cargo handling. Excepting the above, the berths have adopted the conventional-type over-water overhanging fixed shed type.
(3) At Mizushima Works of the main berth, a multipurpose semiautomatic crane was introduced, thereby achieving energy saving and improvement in cargo-loading effeciency.

In the future, meterial distribution operation in and out of the berth will be improved by fully utilizing the all-weather berth ability.

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