

**KAWASAKI STEEL TECHNICAL REPORT**

No.37 ( October 1997 )

*Rolling Technology and Modernization of Chiba Works*

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Overview of the Modernization of Chiba Works

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Based on a study of the future of Chiba Works, Kawasaki Steel undertook a major modernization program under which the site's main production equipment will be concentrated at the West Plant. The upstream process was revamped between 1991 and 1995, centering on the construction of a new steelmaking shop and hot strip mill in the West Plant. These new facilities incorporate advanced technologies such as the smelting reduction of Cr ore in the stainless steel refining process and the revolutionary endless hot strip rolling process, both of which are world's firsts. In deciding the layout of the new facilities, the future image of the West Plant was studied in consideration of the various possibilities of space, landscape, logistics, environmental influence and new production processes. Following the start-up of the new facilities, No. 1 steelmaking shop, No. 1 and No. 2 HSM, and their pickling lines were shut down at East Plant, completing the modernization of the upstream process.

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# Overview of the Modernization of Chiba Works\*



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## 1 Introduction

Construction work in the Chiba Works modernization project was conducted over a period of approximately five years, from the start of construction at No. 4 steelmaking shop to the start of operation at No. 3 hot strip mill, and has now been completed. This report presents an overview of the Chiba Works modernization, describing the chronology of this major project, the significance and basic concepts of the modernization plan, the overall layout plan, considering projections for the future of West Plant, and the concept of the urban steel works and related countermeasures.

## 2 Chronology

With the start of the rapid appreciation of the yen following the Plaza Agreement in September 1985, a decision was made to shift production to Mizushima Works. This move accompanied the shutdown of No. 2 steelmaking shop and the plate mill at Chiba Works. However, it was also considered necessary to clarify the future image of Chiba Works, based on a study of the production system at Kawasaki Steel over the mid- to long-term conducted between the end of 1987 and middle of 1988, and various cases were studied. The main study cases were proposals to maximize efficiency with the existing production system or to concentrate production at West Plant of Chiba Works, and a proposal to

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concentrate the upstream process at Mizushima Works. Based on the long-term forecast of steel demand, capacity shortages were expected to be a problem with the proposal to concentrate at Mizushima Works. The study therefore focused on proposals to strengthen Chiba Works, which enjoys a geographical advantage, being near major markets in Tokyo, and particularly on the proposal to concentrate production at Chiba Works West Plant. Investment in the East Plant had also been proposed, but it was concluded that only limited improvement could be expected with the old equipment. Moreover, it was not expected to be possible to secure adequate competitiveness without improving the existing layout, in which equipment was divided between the East Plant and West Plant.

Based on these results, concrete study began in July 1988, and construction started in April 1991. The aims of concentrating production at the West Plant were to maintain the world's strongest cost competitiveness into the future, expand and strengthen the base of the company's steel business in the Tokyo metropolitan area, secure upward flexibility in volume, including stainless steel, improve Chiba Works' capability to respond to the

\* Originally published in *Kawasaki Steel Giho*, 28(1996)4, 199-205

quality requirements of hot-rolled products, and guarantee latent competitiveness by lightening the burden of future wage increases, which was achieved maximizing labor productivity.

### 3 Fundamental Concept of Chiba Works Modernization

Figure 1 shows schematically the fundamental concepts of this modernization project. Estimates of future steel output indicated that Chiba must be a medium-scale steel works with an annual capacity of 3.5 to 4 million tons, and should have the strongest possible competitiveness. Although Chiba Works enjoys a superior location near markets in the Tokyo metropolitan region, the negative side of this advantage is rapid urbanization of the area surrounding the site, which means that Chiba Works must also be able to coexist with an urban environment.

Given these conditions, the following three points were proposed as the "identity" of Kawasaki Steel's Chiba Works.

- (1) High-profitability works specializing in flat-rolled products as a core unit of the company's steel business.
- (2) Customer-oriented works located in the Tokyo metropolitan area.
- (3) Attractive, community-friendly works coexisting with the urban environment and contributing posi-

tively to Kawasaki Steel's image.

As means of achieving cost competitiveness, a three-fold speed-up of the integrated manufacturing time was suggested in addition to equipment concentration and the adoption of advanced technology, and shorter lead times and reduced inventories were emphasized. These measures will make Chiba Works competitive in the 21st century in both customer response and cost. The plan also included ideas such as the "urban steel works" and "community-friendly steel works" which are not part of the conventional concept of an integrated steel mill. These goals were adopted not only because the company was conscious of the development of the region surrounding the steel works, but also because of their importance to the company's image and to securing human resources. In this sense, as with cost competitiveness, they were considered essential conditions for a next-generation steel works.

Specifically, the fundamental concept of this project was "modernization aimed at becoming the world's strongest medium-scale urban steel works producing high-grade products." In the overall plan for the future of Chiba Works, it was concluded that the construction of the new steelmaking and hot rolling facilities should have first priority, based on the stainless steel production capacity of the steelmaking shop, the quality response capability of No. 2 hot strip mill, and the deterioration of equipment at No. 1 hot strip mill.

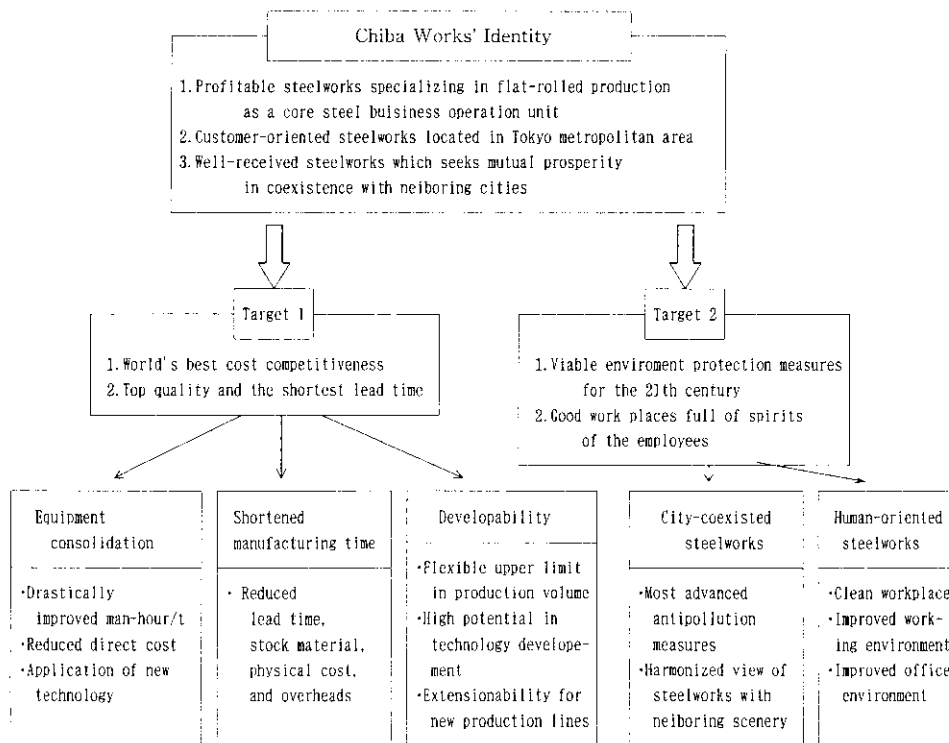


Fig. 1 Basic concept for the Chiba Works' overall modernization

#### 4 Fundamental Concept of Concentration at West Plant

As shown in Fig. 2, Chiba Works comprises three areas, the East Plant, West Plant, and Oihamia Area. In 1990, the main facilities in operation at Chiba Works East Plant were No. 5 blast furnace, the coke ovens, No. 1 steelmaking shop, No. 1 hot strip mill, No. 2 hot strip mill, No. 1 cold strip mill, and about half of the energy-related facilities. On the other hand, stopped equipment included No. 2-4 blast furnaces, No. 2 steelmaking shop, and the plate mill. Because a decision had been made to concentrate the raw material yards at the West Plant material yards, stopped facilities comprised a substantial area in the southern part of East Plant. The facilities in the Oihamia Area included Kawasaki Steel's No. 2 cold strip mill, stainless cold rolling mill, and iron powder plant, and plants belonging to Kawatetsu Galvanizing Co., Ltd., Kawatetsu Steel Tube Co., Ltd., and other Kawasaki Steel group companies. In the West Plant, the operating facilities included Chiba Works' main ironmaking and steelmaking processes, namely, No. 6 blast furnace and No. 3 steelmaking shop, main energy facilities such as the power and oxygen plants, the slag yard, the UO pipe plant, the export berth, and other facilities. The overall layout of Chiba Works made

it necessary to transport most slabs from No. 3 steel-making shop at the West Plant to No. 1 or No. 2 hot strip mill at the East Plant, and then to transport cold-rolled products for export back to the West Plant from the East Plant or Oihamia Area, which was a weak point in terms of logistics and production control.

As initial objects of the modernization, the layout study included the construction of new steelmaking and hot strip mill facilities in the West Plant. These new plants were intended to replace No. 1 steelmaking shop, with the aim of increasing the volume and improving the competitiveness of stainless steel production, and No. 1 and No. 2 hot strip mill, which were having increasing difficulty in meeting quality requirements. Moreover, it was also difficult to improve the competitiveness of No. 1 and 2 hot strip mills due to the division of production into two lines.

The layout was studied from every angle because the arrangement selected would restrict the overall shape of Chiba Works in the future. In particular, although it was clear that the entire southern part of the East Plant would be shut down in the near term, even greater changes were expected in the more distant future, when the entire area of the East Plant would be converted to purposes other than manufacturing. This point was included in the layout study.

The main issues were as follows.

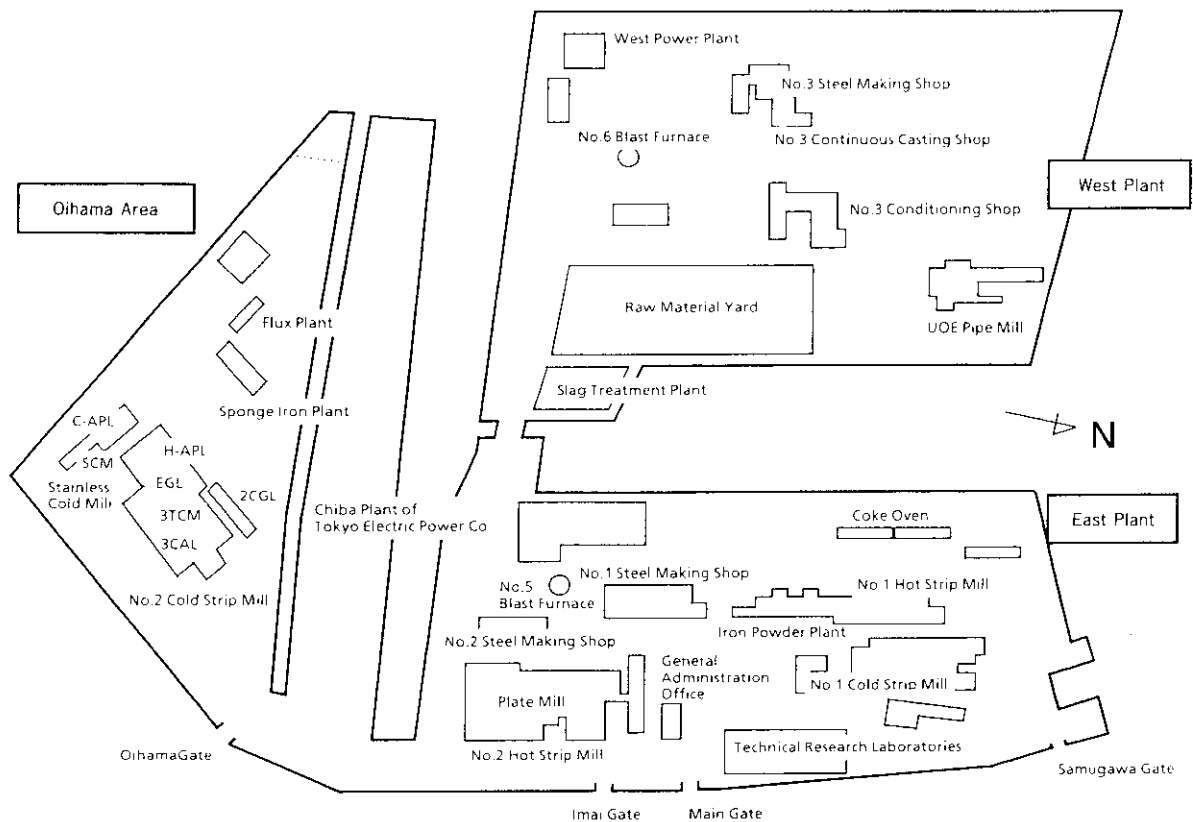


Fig. 2 Layout of Chiba Works

- (1) How should the necessary equipment for environmental countermeasures at the West Plant be arranged after the East Plant becomes an urbanized area? What advance consideration should be given to the arrangement of and environmental countermeasures for raw material yards and the method and arrangement of slag treatment?
- (2) What should the direction and position of the hot strip mill be? What is the optimum proposal for improving the layout of the hot strip mill based on various studies of both the layout of a future cold strip mill at the West Plant and the combination between the hot strip mill and steelmaking shop?
- (3) Reduction of the amount of industrial waste generated and recycling of such waste should be given full study, and the plan and arrangement of the waste-related equipment should be incorporated.
- (4) A study should be made of the possibility of West Plant siting for equipment to replace No. 5 blast furnace and the coke ovens, which are now located in the East Plant.
- (5) How much advance consideration should be given to the possibility of concentrating equipment in the West

Plant in the future? Study should be given to the layout of the cold strip mill and port facilities and the future material flow.

## 5 Outline of Overall Plan

The new technologies developed and adopted for the first time in the world were the smelting reduction process for Cr ore in the new steelmaking shop and the endless rolling process in the new hot strip mill. Thoroughgoing automation was also incorporated, and labor productivity was improved.

At Chiba Works, the problem of aging of the work force is serious. A simulation of manning changes from March 1990 to March 1996 showed a reduction of approximately 1 000 persons in actual working manpower, even assuming Chiba Works hired 60 persons per fiscal year (actual result for 1990) while not filling the vacancies resulting from the retirement of Chiba Works personnel to the main group companies. To the extent that there were fears of a manpower shortage if the modernization of the steelmaking shop and hot strip mill was delayed, aging of the work force was an even more

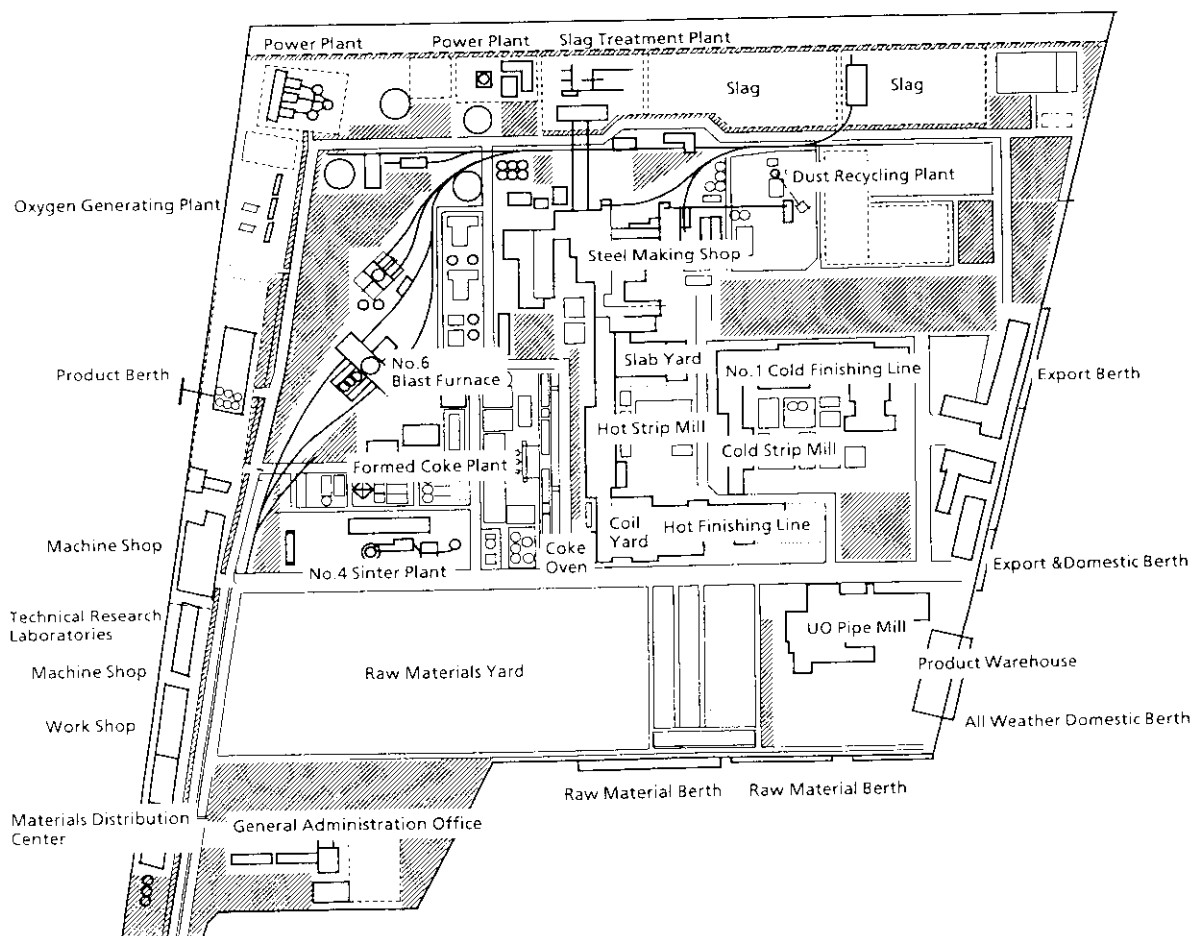


Fig. 3 Basic plan of layout in West Works

urgent problem, and it was therefore extremely important to achieve a significant improvement in labor productivity.

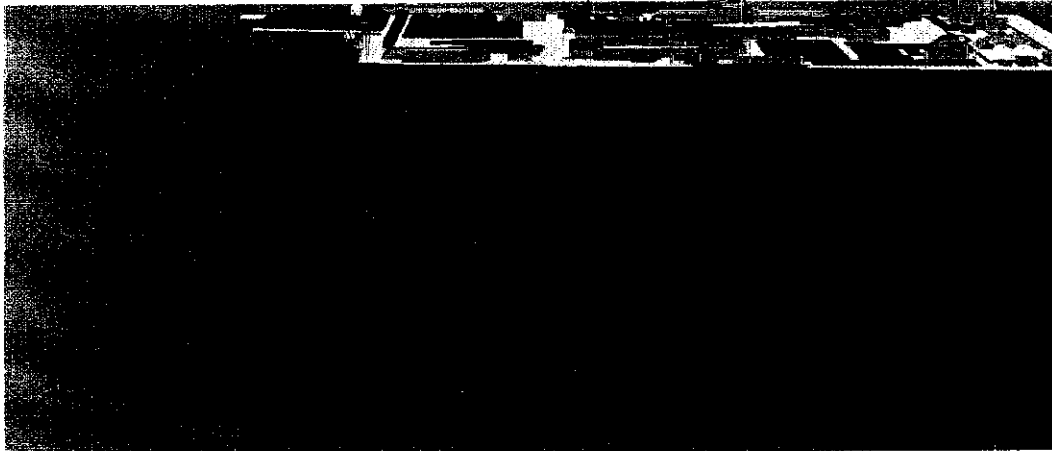
The technical content of the respective processes will be left to individual papers, and a general outline will be present here.

### 5.1 Layout of West Plant

Figure 3 shows in simplified form the layout of the West Plant which was adopted as the basic plan as a result of the above-mentioned study.

The study of the layout of the West Plant included a simulation of Works at it would appear from high-rise buildings in the vicinity, as shown in Photo 1. In the study of the West Plant, which assumed the future changes in the East Plant, the raw material yards were expected to require the strictest countermeasures from the viewpoint of image, but no large difference in terms of either appearance or environmental countermeasures were seen in any of the studies, even when the material yards were located as far as possible within the West Plant. On the other hand, the slag treatment yard is posi-

(a) View from north side



(b) View from east side

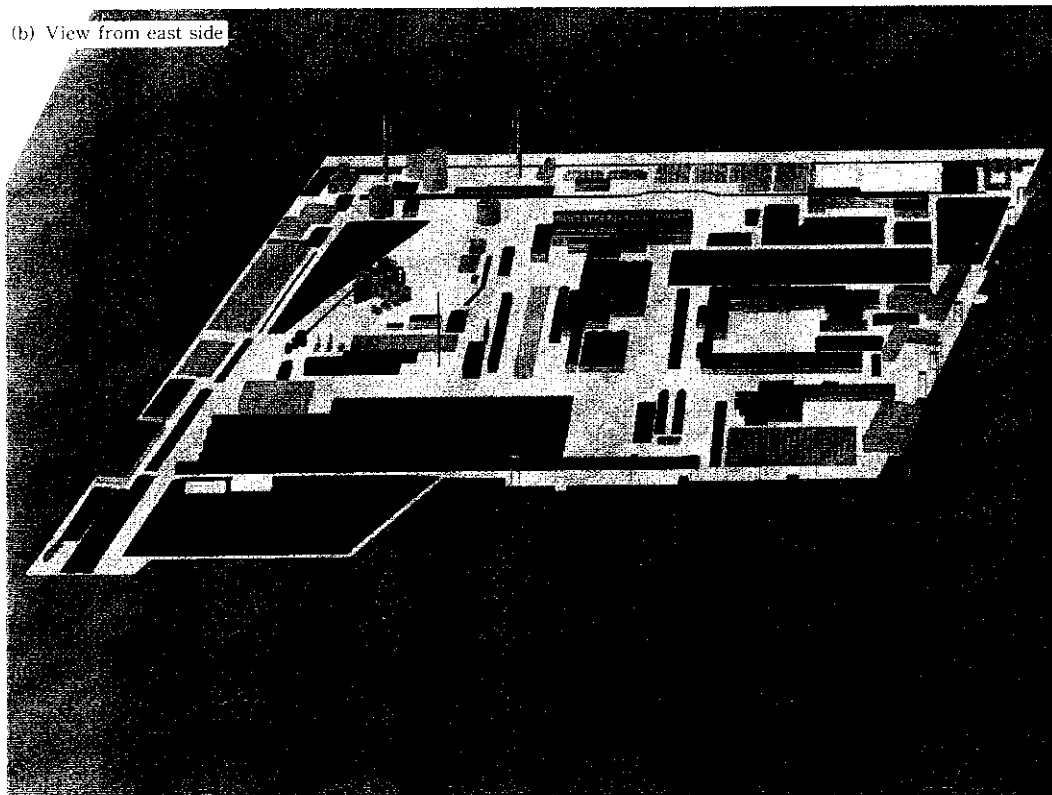


Photo 1 Computer graphic simulation of distant view

tioned most neighboring to the east within the precincts of the West Plant and requires countermeasures at an early point in time. With the current method of slag treatment by dumping, slow cooling, and aging, it was considered necessary to reduce the amount of slag and give consideration to the location of treatment from the viewpoints both of the problem of site area within the West Plant and of image. Regarding location, the planned image for the future envisions the possibility of moving the location of blast furnace slag treatment to the west side of the West Plant and simultaneously reducing the necessary area by using granulating process to the fullest extent possible, while treating steelmaking slag indoors in an area adjacent to the location where it is produced. The treatment of slag at the new No. 4 steelmaking shop was implemented in advance of this plan.

As another point deserving special mention, a process which uses recycling to reduce drastically the amount of industrial waste was planned and implemented in parallel with the modernization project with the aim of creating a steel works which can coexist with its urban environment. Because the dust and sludge generated in the steel works contain valuable substances, a treatment furnace which recycles these materials as resources for steel manufacturing was installed adjacent to No. 4 steelmaking shop to realize closed treatment.

At the time of the study, it was difficult to reach a conclusion regarding the possibility of newly constructing future iron source equipment in the West Plant to replace No. 5 blast furnace. The scale of the work will be excessive if it is necessary to relocate the coke ovens, but there was a possibility of arranging the facilities in the West Plant under certain assumptions. On the other hand, the formed coke process has been confirmed technically. However, it could not be concluded that blast furnace can be operated with formed coke only without conventional coke, and the study of the layout was left in the form of a mixed system with some conventional coke ovens.

The existing cold rolling facilities comprise two lines, No. 1 cold strip mill in the East Plant and No. 2 cold strip mill in the Oihama Area. The conclusion reached assumes an image in which the mill in the Oihama Area is left as it is, and No. 1 cold strip mill is replaced by a new mill in the West Plant. Under this plan, the existing export berth on the north side of the West Plant will continue to be used for exports, and new port facilities will be added for domestic vessels. In addition, the layout, direction, and size of the future No. 1 cold strip mill were studied with consideration given to the possibility that several coating lines may be added in the future.

The arrangement of No. 3 hot strip mill was a key point. Various layouts were studied to examine the possible combinations of the exit of No. 3 steelmaking shop, which quantitatively is a main facility, and the future No. 1 cold strip mill. As a result of a study of a

north-south layout (Plan 1) and an east-west layout (Plan 2) of No. 3 hot strip mill, as shown in Fig. 4, the east-west plan was adopted. In this plan, the rolling line is laid out along a straight extension of the transport line from No. 3 continuous caster. Although the combination of this plant arrangement with the road at the west side of the raw material yard, which will be main route in the future, is difficult dimensionally, endless hot rolling is possible with this layout.

## 5.2 Improvement of Material Handling System

Transportation of slabs by rail had occupied a large weight in transportation between the existing West Plant and other plants, but the direct linkage of the steelmaking shop and hot strip mill will fundamentally eliminate the need for slab transportation. Instead, coil transportation from the West Plant to the East Plant and Oihama Area will become the main transportation task. In addition to these main material flows, large change will occur in the material flow of various loose items. Efforts were therefore made to construct a new material handling system and improve its efficiency. Because rail transportation is used for large lots, it is not suited to synchronization and inventory reduction. A method of efficient, large-scale carrier pallets was adopted with the aim of minimizing the equipment investment, and is efficiently operated by a truck control system which issues transportation instructions automatically, 24 hours a day.

For the present, the rail lines will be left in place while No. 5 blast furnace is in operation, but in the future, these lines will be removed and the space will be used to widen roads and strengthen greening activities in order to give the site a less-cramped, more open feeling.

## 5.3 Design of Plant Color Scheme

The color scheme of the Works was included in this modernization. When new plant buildings, stacks, and other structures are erected, rather than the imposing, massive image of the steel works of the past, a color design which gives a warmer and more friendly impression to local citizens, customers visiting the works, and others making plant tours should be introduced. The planning was done with the assistance of a professional color designer, and included equipment to be constructed in the future. In conventional steel works, the colors of buildings are categorized by manufacturing function, such as smelting or rolling, but from the customer's viewpoint, this is not a particularly meaningful division, and was perhaps designed for persons involved in the steel manufacturing process. While zoning is still considered to some extent, basically three color systems are used in this project, with variations within each system. In the selection, consideration was given to the opinions of young persons and female employees. As a result, the basic colors specified were brown for iron and steelmaking, green for hot rolling, and blue for cold rolling, with accents used in each system. The paint

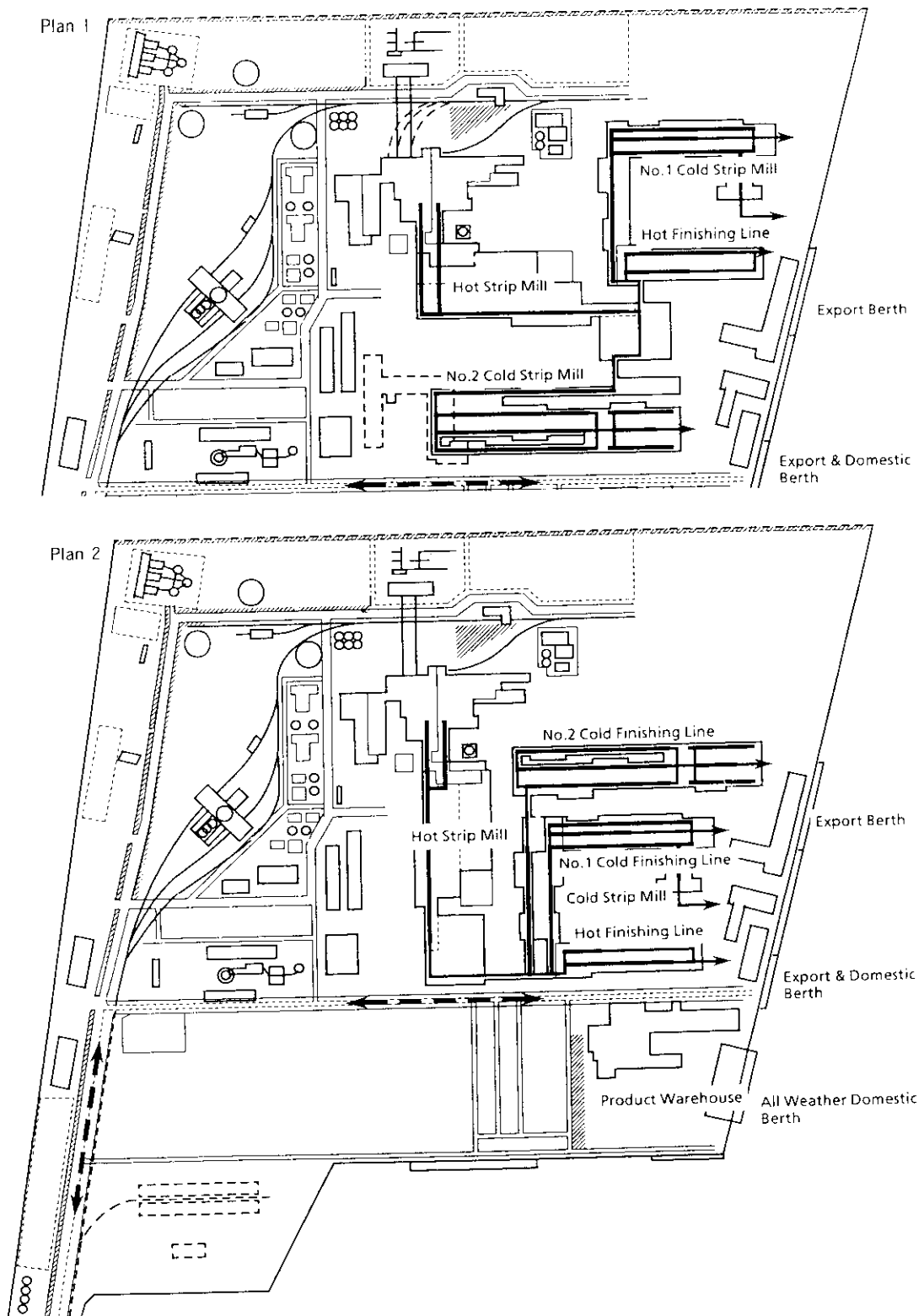


Fig. 4 Layout of hot strip mill and cold strip mill

color of indoor machinery and equipment was also harmonized with that of the structure. The hot finishing line is not a cold rolling process, but because it will be some time before the cold strip mill is constructed in the West

Plant, blue was used for the hot finishing line in consideration of overall balance. Stacks are not painted in the conventional red-and-white warning colors, but are finished to give a light impression, in a color design which



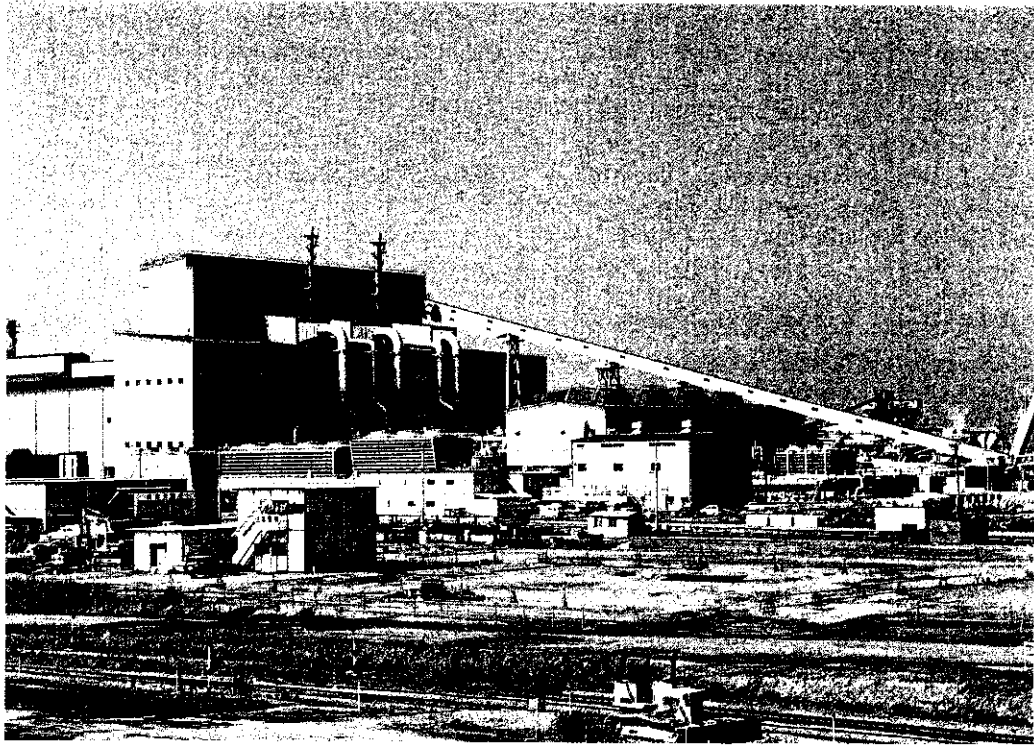


Photo 2 No. 4 steel making shop from north-east side

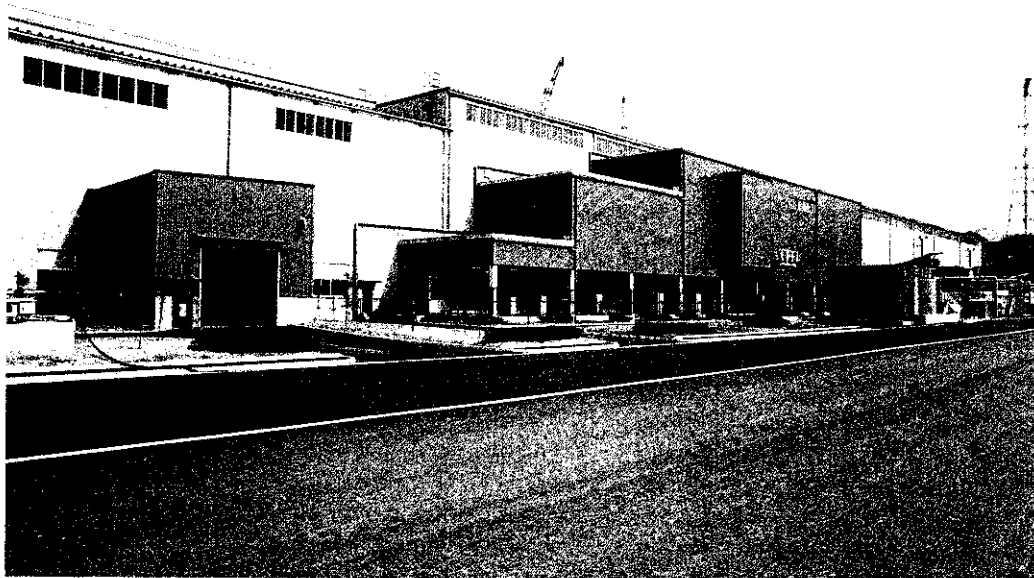


Photo 3 Hot finishing plant from west side

is in harmony with the plant as a whole. **Photo 2** shows the northeast side of the steelmaking shop; **Photo 3** shows the west side of the hot finishing plant. The paint

of existing facilities will be changed in accordance with this plan when the facilities are repainted, and the Works as a whole is expected to be given this finish.

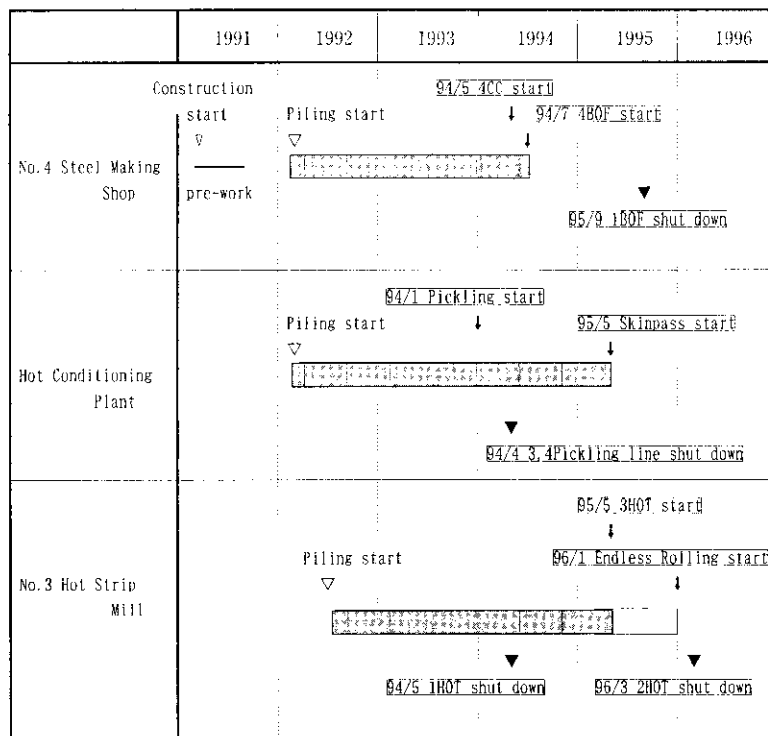


Fig. 5 Modernization schedule of Chiba Works

## 6 Overall Schedule of Chiba Modernization

Figure 5 shows the overall schedule of the Chiba Works modernization project. The modernization work began with ground improvement in the area of No. 4 steelmaking shop in April 1991. The new pickling line, which was the first facility started up in this project, began operation in January 1994, followed by No. 4 continuous caster and No. 4 steelmaking shop in May and July of the same year, respectively. The main construction was completed with the start-up of No. 3 hot strip mill in May 1995. Continuous rolling with the actual mill began in January 1996, and the rating up process proceeded smoothly. Of the older facilities, No. 1 steelmaking shop was shut down in July 1995, one year after the start-up of the new steelmaking shop. No. 1 hot strip mill, where the development experiments for the welding technique adopted in endless hot rolling were performed, was the earliest line to be shut down, in May 1994. Thereafter, one line at No. 2 hot strip mill was used until No. 3 hot strip mill was rated up. No. 2 HSM was then shut down in March 1996, completing the changeover from the old to the new facilities.

## 7 Conclusion

Counting from the feasibility study, the modernization of Chiba Works required approximately eight years to complete. The work was finished without accident, thanks to the generous cooperation and enthusiasm of all the related companies and persons.

A small-lot, short-delivery term production system was originally planned, but unforeseeably large economic change occurred during the period, and partial course corrections in the construction of this system and other points were unavoidable. In spite of these changes, the new Chiba Works achieved a strong startup as Kawasaki Steel's main steel works in eastern Japan. Although Chiba Works is a medium-scale steel works, which is a disadvantage in terms of steel works scale, the construction of the new facilities at the West Plant, in which Kawasaki Steel developed and incorporated the world's top level of advanced technology, such as smelting reduction in the new steelmaking shop and endless rolling in the new hot strip mill, has drawn intense interest as a project which realize important innovations in an internationally-competitive steel works specializing in high-grade steel products.