KAWASAKI STEEL TECHNICAL REPORT
No.28 (June 1993)
Special Issue on Chemicals and
New Materials and Construction Materials

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Masanari Tominaga, Ikuo Jo, Satoshi Miura

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Masanari Tominaga
Dr. Eng., Director, Assistant General Manager, Engineering & Construction Div.


Ikuo Jo
Staff Assistant General Manager, Construction Materials & Engineering Services Dept., Engineering & Construction Div.


Satoshi Miura
Staff Assistant Manager, Construction Materials & Engineering Services Dept., Engineering & Construction Div.

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1 Construction Material Industry and Market

Since 1980, domestic steel production in Japan has failed to register any significant increase from a level of slightly over 100 milion tons, while at the same time the Japanese steel industry has been compelled to reduce its percentage of exports. For these reasons, the possibility of future growth by Japanese steel mills now centers on three points: (1) increasing market share (or at minimum, maintaining share), (2) shifting the product mix toward higher value added products, and (3) creating new applications.

Where the second and third points are concerned, Kawasaki Steel's Engineering & Construction Division has made progress in expanding the application of steel in steel structures and in the field of water and gas utilities. Business development in construction materials, however, is now assuming urgent importance.

Because of the inadequacy of comprehensive and time-based statistics related to the construction materials industry and market, a quantitative discussion of the present situation in the industry and trends in the construction materials market is difficult. In macroscopic terms, **Fig. 1** shows domestic Japanese construction investment which, including purely private sector investment, was about ¥82 trillion in fiscal 1990, and the trend in investment as a percentage of GNP. In

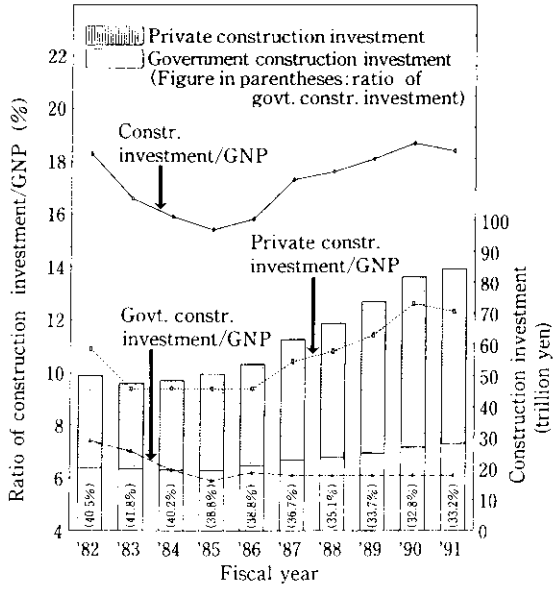


Fig. 1 Changes in construction investment and the ratio relative to GNP (apparent)

* Revised from the following two articles: (1) *Kawasaki Steel Giho*, 24(1992)3, 161-166; (2) ibid. 228-234

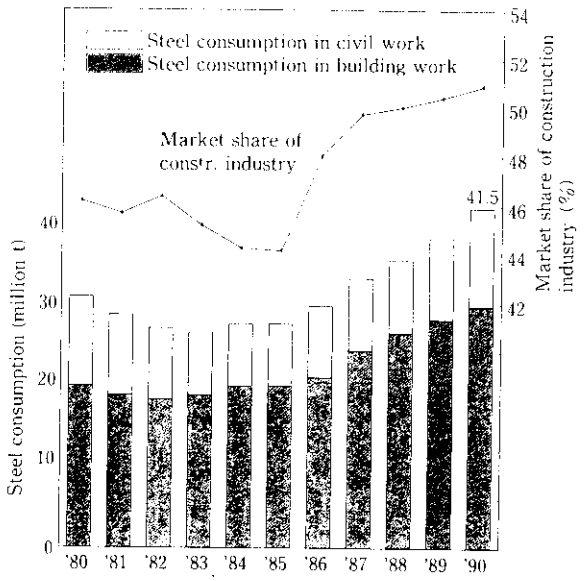


Fig. 2 Changes in carbon steel consumption in the construction industry (estimated)

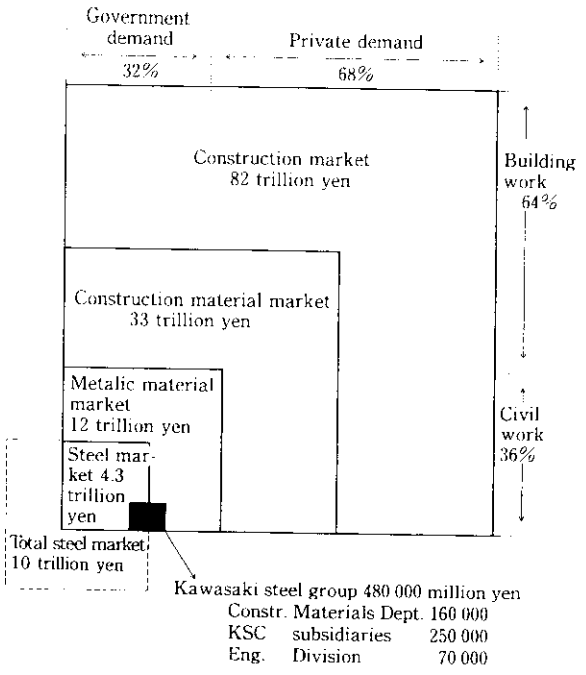


Fig. 3 Market scale of construction materials (1990)

FY 1990, the ratio of construction building work to civil work was 64:36, while the ratio of private sector spending to public spending was 68:32. These facts, along with the trend in the total floor space of new starts in residential and non-residential building (52:48 in FY 1990) and the movement in the number of new housing starts give a general picture of conditions in the construction materials industry and market.

Among applications for steel materials (**Fig. 2**), the general field of construction accounted for 41.5 million tons, or more than 50% of all steel consumption in fiscal 1990. Structural materials represented the greatest percentage. Building construction accounted for 37% of total steel consumption, while civil works totalled 13%. By industry, construction applications of steel accounted for a greater tonnage than shipbuilding, autos, heavy equipment and household appliances, or any other single industrial sector.

The roles played by the steel industry in the construction materials field can be categorized as follows:

(1) Development and supply of basic steel materials (materials for processing as construction materials)
(2) Supply of processed steel construction materials (e.g. structural and finish materials)
(3) Supply of comprehensive engineering services

Processed steel materials must now not only be functional, but also take into consideration aesthetic and architectural design aspects as well. In recent years, public, academic, and private interests have begun to work together through bodies such as the Public Urban Design Center (a foundation organized by the Ministry of Construction), the Japan Society of Civil Engineers, Architectual Institute of Japan, and the Landscape Material Promotion Committee of the Ministry of International Trade and Industry. Thus, it can be said, that we have arrived at a period during which the creation of an appropriate amenity environment is receiving strong attention.

The position of steel construction materials within the total market for construction materials is shown in **Fig. 3**, in which the monetary scale for the market is represented graphically. Although construction materials account for ¥33 trillion, or 40% of all construction investment, steel materials total no more than 13%, or ¥4.3 trillion of this amount. A look at the place of Kawasaki Steel group companies in this overall picture, suggests that the group has lagged behind in its efforts to promote new applications for steel construction materials, and that a future increase in the market share is desirable.

The entire construction industry is attempting a major transformation in response to changes in economic and business factors, such as the chronic labor shortage in Japan at the present time. Against this background, the requirements of the market for construction materials are undergoing the following qualitative changes:

(1) Diffusion and Expansion of Labor Saving Practices
  - Shift to factory production of materials conventionally processed at site (adoption of modular construction techniques); systematization
  - Shift to "progressive" work methods at site, elimination of 3D jobs (dirty, dangerous, and difficult jobs)
  - Introduction of robots
(2) Shortening of Work Periods and Simplification of Work Management

- Development of methods not affected by weather
- Consolidation of job categories for subcontracted work, assignment of greater responsibility for execution to subcontractors

If these procedural changes in the construction materials market can be effected, then the steelmaker or construction material processor will have several excellent possibilities for expanding the construction material business, as listed below, and can also expect to enjoy major business opportunities for new processes and construction material products satisfying the needs of the market place. Possibilities for business expansion include:

(1) Expansion of the Application of Steel Materials in Construction
   - More consistent product quality than other basic materials.
   - Easy adaptation to factory production of construction materials and to prefabricated methods
(2) Possibility of Increasing the Added Value of Products by Downstream Development
   - Development and systematization of new construction material products
   - Prime contractor implementation
   - Inauguration and organization of specialty construction business
(3) Possibility of Increasing Market Share Through Free Competition
   - Cultivation of needs not yet developed
   - Fluid nature of share distribution

2 Present Status of Construction Material Products of Kawasaki Steel Group

2.1 Overview of Kawasaki Group Activities

First, it would be useful to offer an historical overview of the presence of the Kawasaki Steel Corporation group in the fields of construction and construction materials.

Four main streams[1] can be seen in the history of Kawasaki group company involvement in these fields:

(1) The first stream began in 1950 in the plant-related civil engineering and construction sector, represented by the company's steel plants at Chiba and Mizushima, Nishiyama Memorial Hall, the Mizushima Works general administration building, and new research facilities.
(2) The second stream, beginning in 1962, was the construction materials sector, which consisted mainly of research and development work related to structural materials, steel structure research (Naganuma) activities originating in technical services, and most recently, the Makuhari Design Plaza.
(3) Third is Kawasaki Steel's Engineering & Construction Division, which, since its establishment in 1975, has executed a series of comprehensive construction projects using the company's own steel related technology, composite technology, and value added technology, and is continuing to expand and improve its activities.
(4) The fourth main stream, which dates from the 1960s, involves the establishment and business development of various Kawasaki group companies to assume responsibility for construction materials, processing, construction, and maintenance-related activities which the company had previously inaugurated.

The fusion and synthesis of these respective streams into a broader current, as they mutually support and stimulate each other, defines the present reality of the Kawasaki group company activities in the fields of construction and construction materials. This paper will focus on the second and fourth of these two streams, namely, on construction materials and the activities of the group companies.

If the general area of steel construction materials is divided into the market side and the supply side, it can be observed that an opportunity for business development exists where the mechanisms of the two sides come into contact. Some overlap exists in the businesses of the respective Kawasaki group companies, including the Kawasaki Steel's own Engineering & Construction Division (ED), but for the most part, they occupy separate niches. If these activities are evaluated in monetary terms (FY 1990), the supply of steel materials, including that of the four electric furnace companies, amounted to approximately ¥310 billion; structural steel materials, within the ED, about ¥70 billion; and finish building materials for the various group companies, about ¥100 billion. The total of all these activities is thus on the order of ¥480 billion, which is a relatively small share of the whole market.

2.2 Materials for Building Construction

The scale of the market for siding materials based on fiscal 1990 was ¥530 billion. Metal siding accounted for ¥140 billion, or somewhat more than 26% of this total. The three Kawasaki Steel group companies involved in metal siding (Kawasaki Steel Products Corp., Kawatetsu Galvanizing Co. Ltd., and Kawatetsu Metal Industry Corp. Ltd.) held a share of only ¥11 billion, or less than 8% of the total market. In non-metal siding, autoclaved concrete (ALC) and cement/concrete are quite prevalent, and aluminum is more commonly being used as metal siding than steel.

The categories of surface finish in metal siding, along with the price levels and market scale of various types, are shown in **Fig. 4**. Colored polyvinyl chloride coated materials are the least expensive in terms of construction cost (material and labor), followed in order of increasing cost by fluoro plastic coated materials, enamel baked, aluminum, aluminum cast, and stainless steel materials. Inexpensive materials are generally used in low-rise structures such as factories and warehouses, while more expensive alternatives are used in increasing

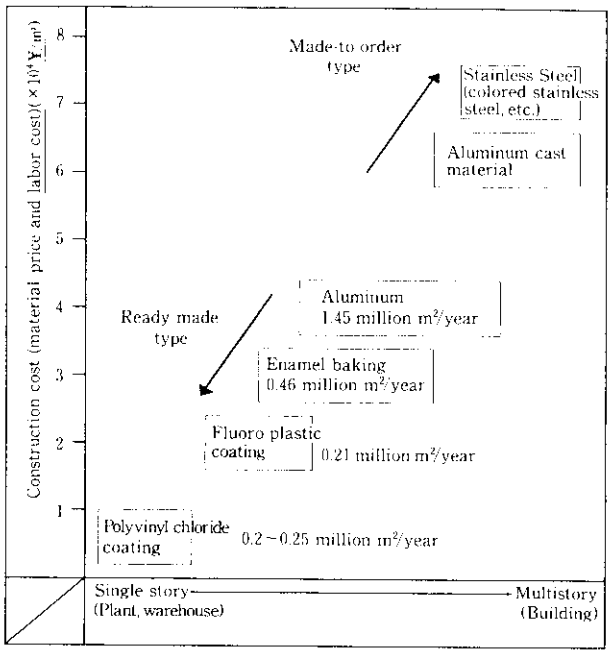


Fig. 4 Type of metallic siding material and construction cost (material price and labor cost) and market size

quantities as the height of the structure increases. Finally, siding may be classified into made-to-order materials, which generally cost more than ¥50 000/m^2, and standard, ready-made products, costing less than that amount.

In the construction materials market, the movement toward the diffusion and expansion of labor saving methods, and methods of shortening the work period and simplifying management, are proceeding hand in hand with higher levels of product functionality (fire resistance, heat insulation, durability) and design capability. Where metal siding materials are concerned, the development of the open joint curtain wall method has accelerated in response to increasing construction of high rise structures. This method is well adapted to prefabrication of siding materials, which is required as the size of steel frame buildings increases, and for a method of execution which does involve scaffolding. It is also important that this development work is progressing through joint technical research and development between design firms and general construction contractors. In addition, the market side has demanded the development of a wide range of surface finishes: materials such as stainless steel (including colored), aluminum (including colored), enameled, and fluoro plastic coated (post-coated) materials.

The size of the roofing materials market in fiscal 1990 was 320 million m^2 (products sold), for a sales volume of approximately ¥350 billion, with metal roofing materials accounting for 100 million m^2, or ¥80 billion (22.8%). Sales of metal roofing have grown strongly in recent years, but the three Kawasaki Steel group companies involved in the field (River Building Materials Co. Ltd., Kawatetsu Galvanizing Co. Ltd., Kawatetsu Steel Products Corp.) held a share of only ¥6.8 billion (8.5%) in FY 1990.

Among residential roofing materials, the metal roofing tile "Pregel" (produced by River Building Materials Co. Ltd.) has a long and successful history, but its simple design and the appearance of competing products demands new development.

In the field of metal roofing materials, a great need existed for a panel method to cope with the complex shapes of new building designs and skylights and gables, and provide value added features such as vibration damping and noise prevention, while also contributing to labor savings and reductions in installation time. Keeping pace with model changes by the manufacturers of prefabricated housing is a particularly pressing requirement. In addition to stainless steel roofing with outstanding corrosion resistance for large scale projects, heat-insulating roofing for new plant construction in the high tech sector is also needed. Aesthetic roofing materials are needed for urban type factories, and there is also strong demand for a boltless method for use with large scale folding sheets (River Building Materials Co. Ltd.) aimed at simplifying erection work. Where design features are concerned, the product line-up which includes "horizontally cladded metal roof" (Kawatetsu Galvanizing Co. Ltd.) is noteworthy.

Trends by type of metal roofing material are shown in **Fig. 5**, centering on "folded," "wave," and "side thatched" roofing. In particular, the reader should note

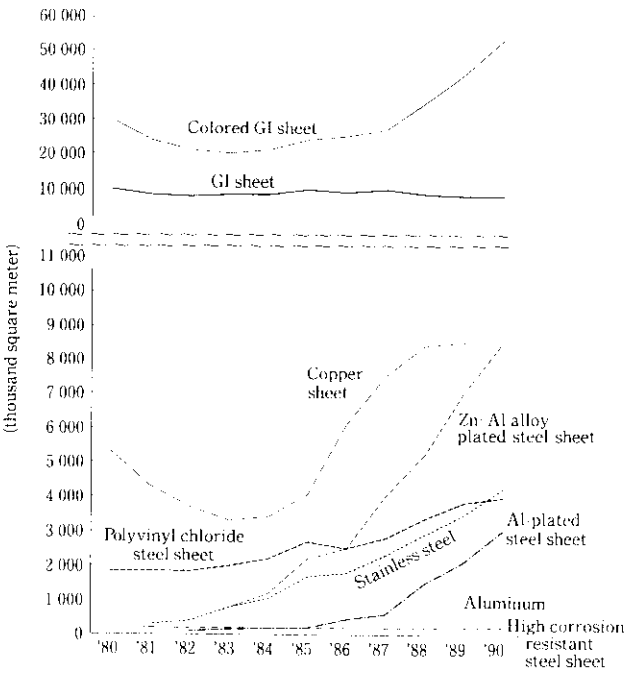


Fig. 5 Trend of metallic materials for roofing

the growth of stainless steel and Galvalume products.

The discussion up to this point should indicate the urgency of establishing a system of cooperation between the steel material manufacturer and the roofing material processor, and a "sound" system for processing, distribution, erection, and marketing, as well as the development of roofing products such as stainless and Galvalume steel sheets, boltless material for vibration damping roofing, and long, folded type roofing.

2.3 Materials for Civil Engineering

In civil engineering, well designed steel materials have long been used in aesthetic and landscape work. Actual examples of well designed construction materials, together with their roles, are shown in **Table 1**, which indicates the diversity of the steel products supplied for various applications.

For roads and bridges as one example, steel materials are not only used for structural support, but also to express the beauty of the structure itself by means of structural form, material properties, and alignment.[2,3] In addition, stainless steel, weather-resistant steel, and other new types of steel are used in lighting poles and sign poles to provide accents along the roadway, taking advantage of the beauty of the surface of the basic material and the quality of the workmanship.

Table 1 Examples of designed construction materials and their effects for various objects

Object	Examples of designed construction materials	Effects
Road, Bridge	Colored steel sheet pile Retaining wall covered with panels Lighting pole Guardrail Facing panel Pole with signboard Soundproofing Bus shelter Handrail Various bridge components etc.	To improve the roadway landscape and quality of environment around sidewalks.
Revetment	Colored steel sheet pile Revetment coverd with panels etc.	To offer an attractive river landscape and provide easy access to the river.
Park, Plaza	Lighting pole Symbol tower Monument Bench Playground equipment Parapet Telephone booths etc.	To offer a relaxed and comfortable environment

The girders visible beneath overhead expressways frequently create an esthetic problem in urban environments, but this can be solved and the environment given a more pleasant atmosphere by taking advantage of the design and coating features of cosmetic sheets used to cover the underside of the girders.[4] The advantages of steel in this application include the fact that various coatings can be applied to steel sheet and the light weight of the material, which facilitates installation.

In riverbank revetments, harmony with the surrounding environment is an important consideration. Steel materials such as panel-covered revetment materials and colored sheet pile, and composites of steel and other basic materials provide "water-friendly" properties matched to the specific river environment concerned, and help to create a more pleasant landscape.[5]

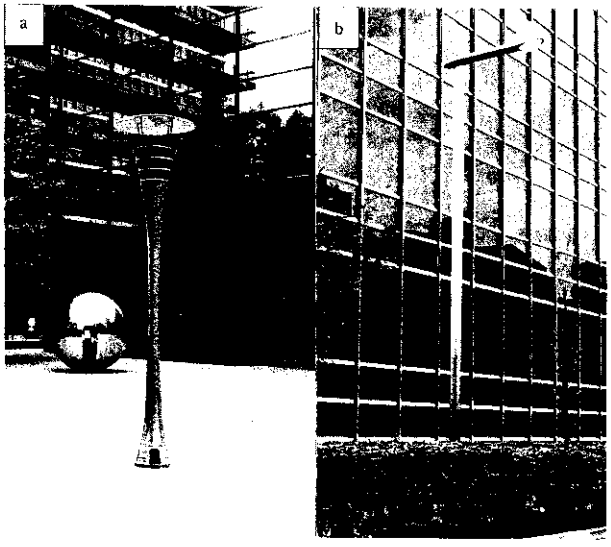
Installation of distinctive symbolic structures and monuments combining a variety of material properties is useful in organizing and giving unity to space within plazas and parks, and imparting to such spaces a feeling of freedom and leisure. Effective placement of "street furniture" makes the use of public places more convenient and creates a more comfortable environment.[6]

Together with these general trends, the use of steel as a landscaping material is continuing to change from what it was in the past. The use of steel in combined esthetic/functional applications is steadily increasing to include use not only in urban areas but also regional space and surrounding areas. Steel is thus playing a role in enhancing both the landscaping and the urban functions of infrastructure facilities. In similar fashion, Kawasaki Steel has applied its "well designed" construction materials to roadway and river projects.

With roads rapidly becoming more congested, there has been a movement to allocate some roadway space for pedestrians, and considerable progress in landscaping has been achieved. In particular, efforts have been made in recent years to improve the design quality of lighting poles, soundproofing walls, handrails, and similar hardware. Kawasaki Steel has responded by supplying well designed lighting poles and colored steel sheet pile retaining wall materials for the roadway environment.

2.3.1 Lighting poles

The role of lighting fixtures can be divided into (a) ensuring night-time safety for the motorist and pedestrian, (b) extending the useful hours and area of space at night, and (c) esthetically improving the urban landscape. The third of these roles has assumed increasing importance in recent years, since, as mentioned before, lighting fixtures are now used as accents to enhance the landscape. Moreover, during the evening hours, lighting serves as an environmental feature which defines the quality of space within roads, parks, and plazas, and lends beauty to the evening landscape. Against this



a: Ductile cast iron b: Stainless steel

Photo 1 Examples of designed street light poles

background, it should also be noted that the design of lighting poles is now characterized by (a) diversification of form, and (b) diversification of materials and color.

In the design of lighting poles, Kawasaki Steel uses weather-resistant steel, cast iron, stainless steel, and other steel materials as considered appropriate for the requirements at the location. The lighting pole shown in **Photo 1** a is made of cast iron, with a slender modern silhouette, giving the pole a contemporary environment presence as shown in the photo.

The lighting poles shown in **Photo 1** b has a unique structure comprising an SUS304 pipe press-formed to an elliptical shape as the supporting pole and a flat steel arm. The perceived shape of the elliptical pipe varies with the angle from which it is seen, giving the pole an variety of expression.

2.3.2 Colored steel sheet pile for the roadway retaining wall

Although steel sheet piles and pipe piles are used extensively for retaining and marine structures, corrosion-proofing measures have been an essential problem for securing their durability and safety. The company developed heavy-duty corrosion-resistant steel materials as a solution, and demand is increasing annually. Polyethylene (PE) and polyurethane (PUE) are used as coating materials, but, because carbon black is added to these materials in order to improve weathering resistance, the choice of color is limited to black. In recent years, greater importance has been attached to harmony between the environment and facilities such as river revetments and roadside retaining walls, and it is not possible to satisfy this requirement with black alone. Kawasaki Steel has solved this problem by manufacturing and marketing colored steel sheet pile, in which a

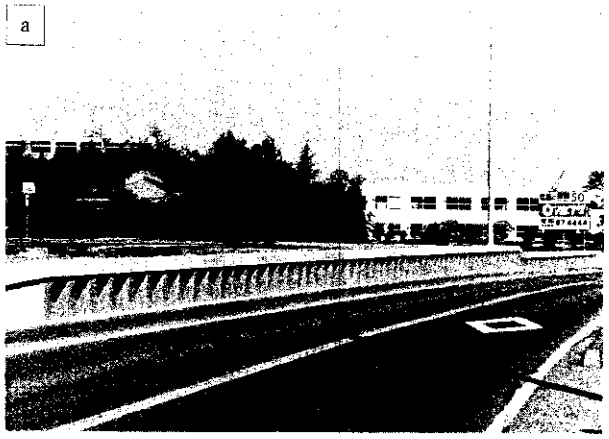


Photo 2 Colored steel sheet pile as the retaining wall (Okegawa-Urawa line in Saitama prefecture)

colored acrylic urethane is applied as a top coat over the polyurethane base.[7]

A free standing steel sheet pile method was adopted for the roadway retaining walls constructed for a 60 meter widening of a portion of an extension of the Okegawa-Urawa Prefectural Road in Urawa City, Saitama. Because the sheet pile was exposed in many places, colored steel sheet pile was used for aesthetic appearance. After the choice of colors was narrowed to a basic color using the SD method, photos of sheet piles of various colors were taken at the site and processed as illustrations. A perspective drawing was prepared in advance, and through consultation with those concerned with the project, a light brown which harmonized with the paddy fields in the background was chosen. The finished work is shown in **Photo 2**.

Changes in color with time are now being investigated using a color difference meter, but in the half year since the completion of the project, there has been no significant change in color. No rust has appeared at joints, and the waterproofing treatment is proving to be effective.

2.3.3 Colored steel sheet pile for river revetment

In order to discuss river-related civil engineering work, it is first necessary to note that lifestyles and values have changed as the country has grown more affluent, and a feel of comfort and abundance in the living environment is now considered important. The same change in values also applies to riverside landscapes. In addition to the flood control and irrigation facilities constructed to date, attractive scenery and a sense of "water-friendliness" are now desired. Thus, more diverse requirements are now placed on revetments which form an essential structural element for rivers protection. Steel sheet pile revetments, which perform aesthetic and other environmental functions, should be discussed with this social background in mind.

Steel sheet pile revetments have been used widely to

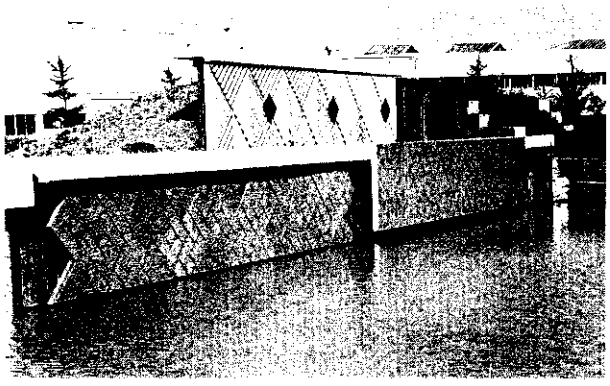


Photo 3 Full-scale model revetment covered with concrete panels (Upper, relief pattern; lower left, stony pattern; lower right, tile pattern)

Photo 4 Kawasaki Steel Design Plaza at Makuhari in Chiba Prefecture

date because they offer the advantages of excellent economy and ease of execution. However, because corrosion changes their color, landscaping-improvement techniques have been needed for steel revetment materials. Kawasaki Steel solved this problem, as mentioned previously, by developing colored steel sheet pile as a commercial product. In addition, Kawasaki Steel has also established a technique for landscaping revetments by covering the portions visible above water level with panels using its "panel revetment" product.[8]

The following three basic conditions are applied to panel revetment:

(1) Designs must conform to the surrounding environment in order to facilitate future design development.
(2) The material not only must be suitable for landscaping, but must also contribute to the rationalization of execution.
(3) The use of panel revetments must have no detrimental effect on the essential function of the revetment.

An example of the landscaping of a steel sheet pile revetment with panels is shown in **Photo 3**. When concrete panels are used, a stone or tile pattern is applied to the surface.

2.4 Functions of Design Plaza Makuhari

Understanding the trends discussed above, Kawasaki Steel opened its Design Plaza Makuhari in October 1990 with the goal of establishing a base for developing the construction materials business (**Photo 4**). The company thus inaugurated a wide-ranging service business oriented toward customer satisfaction (CS) and equipped with the functions of a product development center, design center, showroom, and communications center for information on construction materials. To strengthen the business relationships, the Kawasaki Steel group has joined with owners and operators, design consultants and architectural firms, and general and specialty contractors to begin a variety of customer promotional efforts related to construction materials.

As of February 1992, the Design Plaza Makuhari had received more than 10 000 visitors. The Design Plaza is emphasizes events and information activities, sponsors design competitions and design forums, and is publishes Construction Materials News (semiannual) and a general catalog of construction materials. Design Plaza Makuhari is deepening the exchange between the Kawasaki Steel group companies and the market, and is expected to develop into a powerful force for diversified management in the group's construction materials business activities.

3 Technical Trends and Future Tasks in Construction Material Field

As shown in Fig. 1, domestic investment in construction reached a high level of ¥86 trillion in fiscal 1990, but in fiscal 1991, both the floor area of new construction starts and the unit number of starts declined by 12–22% from the previous year as the building boom of the late 1980s slowed into recession. In the longer term, the creation of a quality infrastructure for the 21st century which will provide a real feeling of ease and abundance is a deep-rooted national desire, and steady progress is foreseen in the promotion of public investment plans for strengthening the wide-area communications network, constructing a safer national infrastructure, and establishing facilities to encourage regional activity.

At the same time, emergency infrastructure programs for regional cities, support for the quality of life in smaller towns, urgent measures to deal with the shortage of housing and residential land in major cities, and comprehensive programs for the development of local commercial infrastructure are all needed to prevent a unipolar concentration in the Tokyo Metropolitan area. The promotion of imports in this connection is also an important issue.

The effect of the programs described above will be to require a more positive response from the construction materials industry, which must not only provide a stable supply of materials, but must also provide planning and design proposals to the market and offer construction management practices which incorporate labor saving and factory prefabrication.

More diverse design and functional features in construction material products and the trend toward multiple product types are also difficult issues for the development of the construction materials industry, but the Kawasaki Steel group considers it important to take on the challenge of these problems.

According to Takeshi Nishizawa, President of GK Design Corporation, in order to create an ideal, livable urban environment, it goes without saying that both functionality and design are required in civil and general construction facilities, but it has also now become necessary to give much more careful consideration to landscape features comprising the tertiary facilities necessary in cities. By tertiary facilities, Nishizawa means street furniture such as subway entrances, pedestrian bridges, traffic signs, utility and light poles, advertising signs, protective shelving, planters, and pavement blocks. A survey conducted in 1988 indicated that the market for these tertiary construction materials may reach approximately ¥670 billion by the beginning of the 21st century. For this reason, much is expected from Kawasaki Steel group's CS activities, and in particular, the work of the Design Plaza Makuhari.

Considering the technological trends in construction material products, increasing opportunities for the use of stainless steel in both urban construction and landscaping facilities is anticipated in the future. Stainless steel offers many advantages to the contractor, owner, and designer, including consistency as a basic material, its "metallic" texture, its "clean" feeling and its durability. However, one design firm has pointed out that, in comparison with carbon steels, stainless steel presents the following problems: (1) Cladding work, roll forming, and welding are difficult, (2) uneven coloration and warping of the surface finish are problems, (3) soiling of the material surface entails cleaning costs, and (4) the material itself continues to be relatively expensive. Steel material makers and construction material processors and suppliers must actively pursue technical research and development in connection with these problems. In other words, R&D to improve customer satisfaction with stainless steel construction materials is an important task for the future.

The diversification of the functional and design requirements placed on construction materials and the trend toward a greater number of product types are problems which the construction materials industry must face if it is to expand. These problems are a natural result of the fact that every building and structure is ultimately the product of the diversity of the human desires, individual personalities, and imagination of its owners and designers.

4 Conclusions

This paper has described current conditions in the construction materials industry and market, and the construction material products of the Kawasaki Steel group companies. The authors have also presented an outline of technical trends in construction material products, and discussed the importance of the research and development demanded by the construction industry (market side) from the construction materials industry (supplier side), mainly in connection with finish construction materials.

In addition to concern for the practical possibilities of expanding its construction materials business (mentioned in Sec. 1), the Kawasaki Steel group is also involved in a number of larger management tasks, including overseas development and the establishment of a coordinating section which will determine business strategy for the entire group, from factory production and distribution through execution and marketing. Because these broader subjects lie outside the scope of this paper as essentially a technical report, the emphasis here has been on construction material products. In any case, the authors trust that this review of the issues facing the construction materials industry and market, focusing on new developments at Kawasaki Steel, will contribute to the future development of the industry.

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