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Sales Promotion by Japan's Steelmakers' Structural Engineers

Promotion des ventes par les ingénieurs de construction des aciéries japonaises

Verkaufsförderung durch Bauingenieure der Japanischen Stahlerzeuger

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SUMMARY

The structural engineers employed by Japan's federation of steelmakers, originally engaged in the construction of steel plant buildings during the industry's rapid growth from the 1950s to the 1970s, gained much experience in the construction of steel buildings. Since the late 1960s, their main activity has been the development and marketing of steel products and peripheral products, and construction using these products. Thus along with architects, consulting engineers and general contractors, the structural engineers employed by steelmakers exert great influence on the choice of building materials in Japan.

RÉSUMÉ

Les ingénieurs de construction des aciéries intégrées du Japon, à l'origine employés à la réalisation des constructions dans les aciéries au cours de la période de rapide croissance industrielle des décennies 50 à 70, ont acquis une grande expérience de la construction métallique. Depuis la fin des années 60, leur principale activité est devenue le développement et le marketing de produits en acier et de produits périphériques, ainsi que des construcions utilisant ces produits. Avec les architectes, les ingénieurs-conseils et les entrepreneurs, les ingénieurs de construction employés par les aciéries exercent donc, au Japon, une grande influence dans le choix des matériaux de construction.

ZUSAMMENFASSUNG

Die Bauingenieure von Japans vereinigten Stahlerzeugern, welche ursprünglich für die Konstruktion von Stahlwerkhallen während der hohen Wachstumsperiode von 1950 bis 1970 angestellt worden waren, konnten bei der Konstruktion von Stahlbauten reichliche Erfahrung sammeln. Seit den späten 60er Jahren lag ihre Haupttätigkeit in der Entwicklung und im Marketing von Stahlerzeugnissen sowie deren Nebenprodukten und in Konstruktionen aus diesen Produkten. Gemeinsam mit Architekten, Ingenieurbüros und Generalunternehmern haben daher die von den Stahlherstellern angestellten Stahlbau-Ingenieure grossen Einfluss auf die Wahl der in Japan verwendeten Baustoffe.

1. SELECTION OF STRUCTURAL MATERIALS FOR BUILDING

1.1 Selection of Structural Materials for Buildings in Japan

1.1.1 Customary Types of Structure in Japan, by Category of Building

Japan is exposed to two major threats of nature: earthquake and typhoon. Japanese buildings, other than those of small scale such as detached houses, are of three major structural types that provide adequate resistance against such natural forces: reinforced concrete (RC) structure; steel and reinforced concrete (SRC) structure; and steel (S) structure. These structures are built from two major industrial materials: cement and steel. Both materials can be produced domestically -- cement from raw materials found in Japan and steel from imported raw materials -- and the quality of Japanese cement and steel has long been of international level. Full capability in the design and construction of concrete and steel building frames is also available in the domestic market.

Under these conditions, how are the three major structural types being employed? RC structures are used mainly for low- and medium-rise (6 - 7 story) office buildings, apartment houses, school buildings, hospital, multistory warehouses, etc., and SRC structures mainly for medium-rise (7 - 15 story) office buildings, apartment houses, etc. S structures are chosen mainly for low-rise industrial buildings such as factories and warehouses, small-scale (2 - 5 story) office buildings and stores, and high-rise office buildings. For these kinds of buildings, the type of building structure is almost an automatic choice, since the uses described above are generally accepted among the architects, engineering consultants and general contractors involved in such construction in Japan. Therefore, it matters little which of the three parties takes the initiative in choosing the building structure type in a given case.

1.1.2 Cases Where Selection of Structural Type is in Question

Selection of the most suitable structural type becomes an issue only when the kind of building proposed represents a radical departure from the conventional categories, or when it is on the border between the categories of buildings described in the preceding section. The specific conditions bearing on such a building must then be taken fully into account.

1.2 Project Practice for Building Construction in Japan

1.2.1 Separate Design and Construction

In this project organization, designer and constructor are separate, as is typical in Europe. In some cases, the architect is separate from the engineering consultant for the project; in other cases, these two functions are united in a single design consultant. The latter case is more common in Japan.

1.2.2 Integrated Design and Construction

In this system of project organization, which is unique to Japan, a general contractor undertakes all the tasks involved, from design through construction, on a full turn-key basis. It is a system deriving from traditional Japanese practice based on a feeling of mutual trust. Leading general contractors in Japan employ excellent design staff within their own organizations, so that their design capabilities may be as good as those of independent design consultants.

1.3 Effect of Project Organization on Choice of Building Structural Type

1.3.1 In the Case of Separate Design and Construction

As a rule, a designer has the right to select the structural type to be used, though in some cases the client has this right. Where architect and engineering consultant are separate entities, the initiative in selecting the structural type often goes to the architect when viewed in broad perspective, but to the engineering consultant in detailed perspective. The general contractor as a rule, has no part in the selection. But there are a few cases in which the contractor proposes an alternative plan, or is so requested when construction cost or period or other considerations cannot meet preset conditions in the tender. Still, modification of the original plan in these cases is often limited to minor points.

1.3.2 In the Case of Integrated Design and Construction

In this case, the general contractor independently determines the structural type to be used, taking construction cost and period into consideration, though on a few occasions the client's own preference is adopted. Generally speaking, general contractors are more competent in cost analysis than design consultants. They are thus more often likely to select a structural type other than the customary choice from the standpoint of total cost than is true in the case of a project where design and construction are separate. This is why they often attempt to extend the application of the RC structure to the greatest possible height in the construction of apartment houses and other multistory buildings.

2. THE ROLE OF STEELMAKERS' STRUCTURAL ENGINEERS IN SELECTION OF STRUCTURAL MATERIALS

2.1 Background of Structural Engineering Staff of Japanese Steelmakers

2.1.1 Construction Engineering Staff in the Period of High Industrial Growth

Japan's steel plants lay in ruins at the end of World War II. After the war, however, the steel industry achieved remarkable growth while playing a pivotal role in the rebuilding of Japan. As early as 1953, crude steel production surpassed the wartime peak. It continued to climb steeply, reaching about 120 million tons in 1973 -- the year of the first oil crisis.

The steel industry's rapid growth during the 1950s and 1960s was accompanied by the construction of many integrated steelworks in coastal locations. Of course, the design and construction of these complexes required the work of engineering consultants and general contractors outside the steel companies. At the same time, however, a large number of structural engineers and specialists were recruited by the steel companies and played a significant part in the management and control of design and construction. The industry's growth was so rapid that several steelmakers recruited as many as a hundred engineers. Thus a substantial group of engineers within the steel industry became engaged in the design, construction and maintenance of steel-frame buildings of the largest and most massive class being built in Japan at that time. These engineers accumulated much know-how and experience in steel-frame construction.

2.1.2 Structural Engineers and Product Innovation

While continuing to grow at a rapid pace, Japan's steelmakers entered into keen sales competition with one another. There were continuing efforts to upgrade their steel products so as to fill up the wartime and postwar vaccum and catch up with international levels.

Vast amounts of steel went into reconstruction in the wake of war damage, and then into the rapid improvement of Japan's infrastructure, which was then in a far-from-satisfactory state. This is why the construction section has ranked exceptionally high in Japan's total steel demand, as compared with the corresponding figure in advanced Western nations. The construction section accounted for 51% of total steel demand in 1973 -- the year of the first oil crisis -- with building construction alone representing 34.2% of total demand. (See Figure 1.)

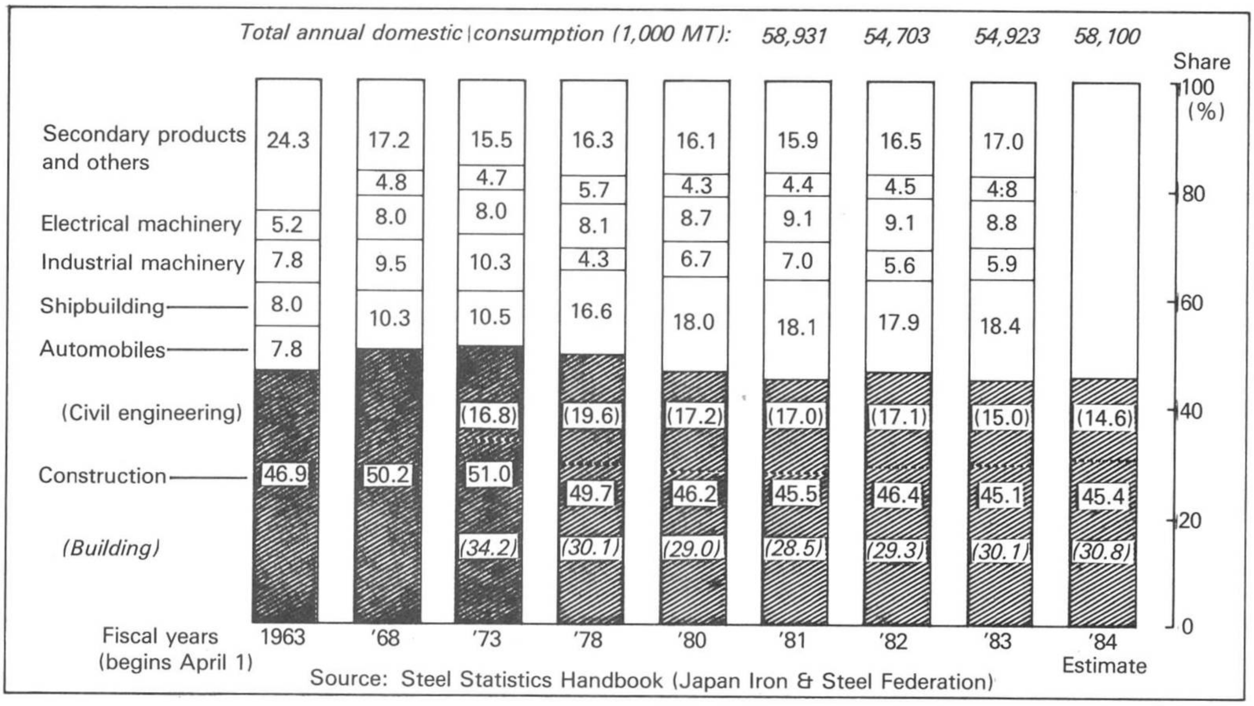

Fig.1 Domestic consumption of steel products and market shares in Japan

Meanwhile, Japanese steelmakers' staffs of structural engineers became active in introducing innovative steel products for use in construction of the steelmakers' own plants, thus helping to spread the use of these products. Typical examples at an early stage were the adoption of light-gauge steel shapes in the 1960s and, a little later, the application of H-shapes. The spreading use of light-gauge steel shapes led to the development of a huge market, demanding around one million tons of hot-rolled coils per year -- a level that has been maintained even in the recent period of low economic growth.

2.1.3 Structural Engineers and Market Development

With the start of production of H-shapes in the early 1960s, the majority of structural engineers employed by the steel companies changed their approach toward market development. Attention began to shift away from indirect means such as in-plant demonstration of how new products could be applied, in favor of the direct marketing approach.

Japan was about a half-century behind the West in the manufacture of H-shapes -- a fact attributable primarily to the wartime situation of the Japanese steel industry. Its scale was rather small, with wartime production peaking at 7.8 million tons of crude steel in 1943, and steel demand came mostly from the military. After the war, however, the construction industry replaced the armaments industry as the leading sector in steel demand. As noted above, construction began to account for about half of Japan's domestic steel demand. In parallel with this, steel production grew sharply, reaching 30 million tons of crude steel per year in the early 1960s. The introduction of H-shapes then became a necessity in order to meet the needs of the times.

H-shapes are virtually the ultimate in structural steel shapes: they have rational cross sections and can be mass-produced as rolled steels for structural use. Conventional shapes having smaller cross sections, such as channels, I-beams and assembled sections combining angles and plates, were not strong enough to be used in the structural frames of industrial buildings, which were becoming steadily larger in scale and heavier in loading. For structural members that would be heavily loaded, H-shaped section members built up by welding plates together came into use.

The next step was the introduction of H-shapes, a rolled product. Steelmakers' structural engineering staffs were not only involved in the construction of H-shape rolling mills, but also were mobilized on a large scale of market development activities aimed at promoting this promising new product for use as structural members.

The first task was to determine the size series of H-shapes. Structural engineers of Yawata Iron & Steel Co., Ltd., a predecessor of today's Nippon Steel Corp. and the first Japanese steelmaker to install a rolling mill for senior H-shapes, took the initiative in studying and designating the size series, with the cooperation of outside academic experts and structural engineers. All subsequent Japanese makers followed suit, and this size series was formally established in JIS (Japanese Industrial Standards).

2.1.4 Further Market Development for H-shapes

Market development for H-shapes really began with the attempt to promote sales of H-shapes in the newly established standard sizes. H-shaped section members built up from plates by welding were already popular to some extent, and steelmakers put much effort into familiarizing prospective users with H-shapes themselves. They prepared tables of H-shape sectional properties, design manuals, booklets of actual design examples of steel frames incorporating H-shapes and other technical materials -- all designed for ease of use by structural designers in general, who were accustomed to dealing with conventional structural members that were assembled by riveting angles and plates together. Using these reference materials, steelmakers made contact with individual major users such as engineering consultants and general contractors. In addition, presentations were made and publicity campaigns were mounted to gain the attention of prospective users in many localities.

The next step taken was to promote wider use of H-shapes of non-standard sizes, including heavy-gauge column sections for steel frames of high-rise buildings -- a category that mushroomed in Japan after restrictions on building height were eased in the late 1960s -- and H-shapes for girders with large depths. Steelmakers provided comprehensive data on product availability, fabricating properties, methods of connection and similar topics to engineering consultants undertaking large projects and to general contractors. In this effort, steelmakers' rolling specialists cooperated with associated fabricators, suppliers of welding machines, tools and materials, and other related engineers, all of whom worked closely together.

At the same time, new structural methods that combined H-shapes with precast concrete panels were developed as a means of expanding sales of H-shapes. These methods were applicable mainly to the construction of high- and medium-rise housing complexes.

2.1.5 Shift of Market Development Emphasis to Standardized Steel Frames

By 1969, seven years after full-scale production of H-shapes began, output exceeded 3 million tons per year. It peaked in 1973, the year of the first oil crisis, at about 5.5 million tons -- the highest annual production of H-shapes achieved to date in any country.

In the latter half of the 1960s, just after their indirect sales promotion approach to marketing H-shapes, steelmakers also began to design, fabricate and market standardized steel frames that incorporated H-shapes as basic elements. Their object was to utilize H-shapes in making products of still higher added value. Once again, steelmakers' engineering staffs played a most active part. Their computer-aided structural design capabilities, together with the standardization of structural members using H-shapes as semi-readymade steel members, the sales ability of outside steel dealers and the skills of local fabricators that are the customers for steel dealers, made possible the development and marketing of standardized steel frames.

Steelmakers' combined sales of standardized steel frames reached about 450,000 tons in the peak year of 1973, accounting for some 9% of total Japanese production of H-shapes. Their marketing contributed greatly to the nationwide spread of small and medium-size steel-frame buildings.

2.1.6 Further Shift of Focus to Peripheral Materials for Steel Frames, Machines and Tools, and Systematized Metal Buildings

Except in the very early stages of market development for H-shapes, the key to their market development was the introduction of convenient related materials that made the use of H-shapes more convenient, and of machines and tools for the same purpose. The most important moves of this kind included the development of deck plates for use in floor slabs of office buildings, for which rapid, lightweight construction was imperative; the introduction and improvement of high-strength bolts to supplant riveted joints; and the development of high-efficiency welding materials, machines and tools suited to field-welding operations.

Affiliates of the integrated steelmakers developed and marketed virtually all these materials, machines and tools, other than a few that were introduced by the steelmakers themselves. However, the identification of new requirements in steel-frame construction, the evaluation of their relative importance in overall development programs and other essential considerations were matters very much assisted and influenced by the steelmakers' structural engineers and their other specialists.

From about 1970, new metal building systems for industrial buildings (factories, warehouses, and the like) began to appear. A step beyond standardized steel frames, these systems included roofing, siding, fittings and other structural components in addition to the building frame -- and most components were steel-based. This trend led further to the development of building systems of bundled-up box unit type by some steelmakers.

In parallel with the commercialization of these steel-frame systems and metal building systems, most integrated steelmakers set up new divisions to handle sales of fabricated building products and building construction.

2.1.7 Role of Structural Engineers in the Low-growth Period

After the first oil crisis in 1973, construction work volume in Japan dropped sharply in both civil engineering and building construction. By 1979 construction had begun to show signs of recovery, but then the second oil crisis occurred. Since then, construction activity has remained almost stagnant. In particular, new construction projects by Japan's manufacturing industry, which had been among the world's largest in scale before the first oil crisis, declined far deeper than in other sectors of the economy. This brought about a sharp decrease in steel consumption, because S structures are most widely used in building construction by the manufacturing sector. Steel fabricators and metal building constructors thus began to face an extremely severe situation.

How did the construction-related divisions of Japanese steelmakers cope with this problem? Firstly, they focused their efforts on development and then improvement of new steel products, or new complex or composite materials that combine steel with other materials, for either structural or finishing use. Secondly, they explored new business areas. For instance, they went beyond the sale of steel-frame members, welcoming orders for building works, including erection, and comprehensive orders covering design through construction of metal buildings such as factories. Thirdly, they exported steel-frame members to overseas markets such as Southeast Asia and some oil-producing countries in the Middle East, and collected orders for steel-frame building construction from these markets.

None of these approaches was always successful and profitable. Indeed, the situation became worse in some respects. For example, there was less opportunity of developing a new product that would have great potential for creating a large-volume market. Competition grew keener among Japanese steelmakers and between steelmakers and general contractors. Japanese steelmakers met sharper competition in foreign markets, including that posed by newly industrializing countries, as well as country risks in financing.

Despite this unfavorable business climate, the industry's approaches succeeded in opening up new markets that otherwise could not have been found. Most recently, Japanese steelmakers have turned to joint studies and development regarding such basic themes as the development and improvement of steel materials for construction, fabricated products and new construction methods. These cooperative efforts are being made through the Kozai Club and similar organizations. This trend is not completely new. It should be remembered that, even in the high-growth period, steelmakers often cooperated in such joint efforts as standardization of shapes and qualities of steel products, preparation of reference data for prospective users and general publicity campaigns, with the cooperation of outside academic experts and other specialists.

Most market development activities were undertaken by individual steelmakers in the past, and this approach could still produce substantial results and stimulate reasonable competition in a period of expanding steel demand. In today's low-growth period, however, joint efforts are considered more important. This is because joint studies and development activities for standard steel products intended for building construction offer the advantages of lower cost, elimination of duplicated effort, greater ease in obtaining approval by administrative bodies, and greater dependability in the view of users.

The Kozai club, for example, with the object of promoting wider application of steel-frame buildings overseas, has cooperated in the publication of an English-language version on the design standards for steel structures compiled by the Architectural Institute of Japan and published a two-volume English-language guide, Steel Construction Guidebook (building construction edition and civil engineering edition). These publications provide much technical data and information that should pave the way for wider application of steel-frame buildings in Southeast Asia and other developing nations.

In addition, the Kozai Club has engaged in a broad range of activities related to the development and application of new products. Among them were the development of thin-web girder series of H-shapes for SRC structures that need little design consideration against buckling, and a study of the fireproofness of composite floor slabs consisting of deck plates and concrete. This study led in particular to official approval of the use of bare steel components within a designated fire duration, given specified shape and frame of the composite floor slab.

Through the Kozai Club, Japanese steelmakers also provided financial and technical cooperation to a joint U.S./Japanese government study of the earthquake resistance of steel-frame buildings. Similar cooperation is being offered for a new study to reappraise fire-resistant designs, now being conducted by the Ministry of Construction. Steelmakers are providing financial cooperation, materials and data regarding the properties of steel in high-temperature applications. This study is expected to contribute significantly to the improvement of fire-protection measures for steel-frame buildings.

3. INFLUENCE OF JAPANESE STEELMAKERS ON BUILDING STRUCTURES

3.1 Difference From Other Building Material Industries

Cement, steel and timber are the three principal structural materials for buildings. Cement and steel are industrially produced materials, while timber, strictly speaking, is not. The comparison made here will thus be between the cement industry and the steel industry.

Cement is the only industrial product used in the manufacture of concrete products, and so it shares the long history of concrete in building construction. Cement production has continued to grow at virtually the same rate, in terms of weight, as the domestic consumption of steel. Since World War II, remarkable technical breakthroughs have been achieved in the field of concrete, the introduction of the precasting method and the prestressing method, the development of autoclaved lightweight concrete panels and the introduction of sliding forms.

Almost all of these achievements have resulted not from the optional development efforts of cement manufacturers, but from the efforts of outside researchers or engineers employed by cement users. This is quite different from the situation in the steel industry. This may be attributed to the following facts: the cost share held by cement in RC-structured building skeletons is smaller than that held by steel in S-structured building skeletons; cement makers did not need to employ so many structural engineers for the construction of their own plants as did steelmakers; and cement makers themselves have not been so positive in extending their business directly into processed products. It can be said, in fact, that most of the practical technical know-how regarding RC structures has been accumulated by general contractors rather than by cement makers.

3.2 Influence of Steelmakers on Selection of Building Structural Type

As noted above, individual Japanese steelmakers moved beyond their earlier role as simply the suppliers of steel materials, using the experience gained by their own structural engineers as the basis for accumulating much know-how in the engineering and construction of steel-frame buildings as well as processing of building parts. Accordingly, even where the type of structure to be employed cannot be chosen in the customary manner, they can exert great influence on the decision through their own active proposals or by responding to consultations. In this way, they stand with architects, engineering consultants and general contractors as a fourth group that is active in the planning and execution of building construction projects.