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Development of "Metal Building" Superior in Environmental Performance and Design†

1. Introduction

With the increasingly serious problem of global warming in recent years, attention is now focused on the environmental performance of buildings. Buildings have a controlling effect on long-term energy efficiency and environmental impacts, and those in the industrial sector to which manufacturing industries belong are no exception.

For companies, industrial buildings such as factories and warehouses support everyday operations, and are not only basic infrastructure which forms the working environment of employees, but also affect operating costs, including energy costs, maintenance costs, etc., which steadily accumulate each year.

In comparison with buildings in other sectors, the designability and design quality of industrial buildings are seldom noticed, but for a company which aims to coexist with its local community and secure excellent human resources, while continuing to develop in the global economy, the design of factory architecture is an important element which symbolizes/publicizes the company's corporate culture and workplace environment, and inspires trust in the community and attracts human resources. The high design quality which can be seen in the factory architecture of the leading companies in Europe and the United States is already well known, but Japan has also entered an era when high design quality is demanded in factory architecture.

"Metal Building" is a pre-engineered metal building technology for industrial sector (non-residential sector) buildings which JFE Civil Engineering & Construction is developing throughout Japan. Based on the background outlined above, JFE Civil Engineering & Construction has also been begun efforts to expand the use of "Metal Building," which is superior in environmental performance and design, in order to make a multifaceted contribution to the sustainability of the business of manufacturing companies. This report describes the history of "Metal Building" to date, together with future development efforts.

2. History and Development of "Metal Building"

2.1 Introduction and Development of Cladding

"Metal Building" is a technology which JFE Civil Engineering & Construction introduced from the United States and began marketing in 1972 as the first pre-engineered metal building system in Japan. Although the mainstream in industrial buildings at the time was light-gauge steel framing with slate cladding, this all-metal pre-engineered metal building technology in which the steel frame, roofing, walls, and building accessories were completely standardized had a major impact on the field of industrial architecture.

Since "Metal Building" was introduced, JFE Civil Engineering & Construction has accumulated a sales record totaling more than 13 million square meters, with companies in manufacturing industries and logistics as its main clients, and has earned an excellent reputation as a pioneer in pre-engineered metal buildings which anticipate the needs of the times. In particular, adoption of "Metal Building" has centered on factory architecture for the dynamic local companies which support Japan's manufacturing industry.

The most important reason why "Metal Building" had steadily accumulated a record of sales, while earning a high evaluation from clients, is its unique cladding system, which is both environment- and people-friendly, providing superior heat insulation and sound insulation performance, and anticipates the needs of the times. This is realized by using double-coated, double-baked pre-painted steel sheets which feature excellent durability, low maintenance cost, and beautiful designability.

Two components of the "Metal Building" system which have won a particularly high evaluation and enjoyed strong sales growth in Japan are the "KB Panel Series" (**Fig. 1**), which is superior in heat insulation, durability, and workability, taking advantage of the concept of metal sandwich panel exterior walls, and the unique standing seam roof with a sliding clip system, "K Roof 21" (**Fig. 2**), which features a double-wrapped seam-jointed folded plate roof with high water-tightness and high thermal insulation performance, and is available in mat thicknesses up to a maximum of 150 mm.

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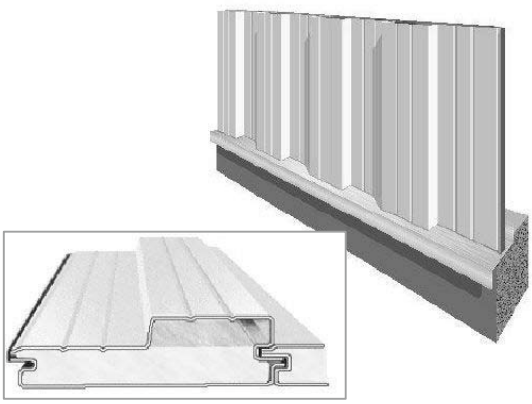

Fig. 1 "KB Panel," Wall system of metal building

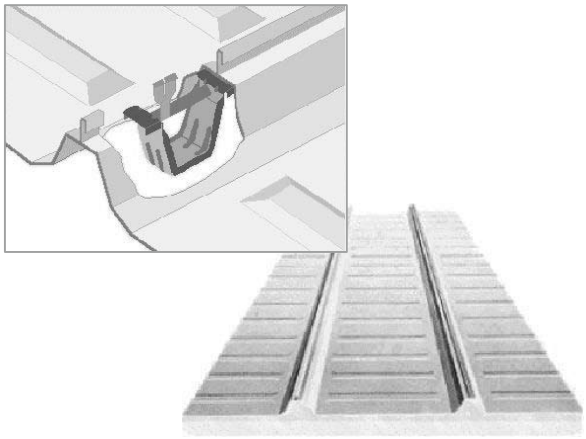

Fig. 2 "K roof 21," Roof system of metal building

To ensure that the cladding of "Metal Building" is compatible with the natural environment of Japan, various improvements which are unique to Japan were made, including enhanced water resistance by improvements in the ridge part and lapped splices of "K Roof 21," improved wind resistance by reinforcing the eave parts and the roof edge region, and response to demand for large-scale, long roofs by development of a site forming method. From the introduction of "KB Panel Series" and "K Roof 21" up to the present, both have been mainstay cladding components of "Metal Building."

2.2 Development of Structural System

At the time of introduction, the structural system of "Metal Building" was tapered steel (welded H-shape steel with a comparatively thin cross section, in which the height changes corresponding to the stress gradient). This was the same as in pre-engineered metal buildings in other countries. However, the range of applications was expanded from one-story building to multilevel buildings by using rolled H-shapes, which were continuing to gain acceptance in Japan, in the main members, and unique Japanese technologies were developed in accordance with the requirements of the Japanese legal and regulatory system, beginning with the New Aseismic Design Code of 1981.

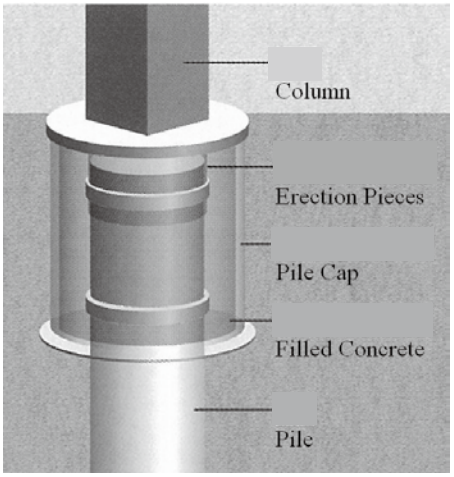

Fig. 3 "Ichi-Ichi Kiso," Non-footing column pile joint

In recent years, various new technologies have reached practical application, including NeoFrame[1], which is a steel frame erection method using all bolt connections, the NeoBase shallow foundation method, which shortens the time required for construction, the "Ichi-Ichi Kiso" Non-Footing Colum Pile Joint[2] (**Fig. 3**), which is a cap-type method for industrialized pile foundation construction with a short work time and superior environment-friendliness, and the NFEW (prefabricated wall panel (unit girt) construction method).

In all cases, these are pre-engineered metal building technologies with excellent seismic performance and reliability, and are oriented toward reducing construction time and costs by industrializing the building components.

3. Environmental Performance and New Development of "Metal Building"

3.1 Environmental Performance of "Metal Building"

Since the time of its introduction, the largest feature of "Metal Building" was its excellent heat insulation performance. Even today, when it has become possible to select diverse building materials, "Metal Building" continues to boast superior heat insulation performance. The record of sales of "Metal Building" is steadily growing, based on systematization of these materials in the total building exterior, together with high cost performance.

Figure 4 shows a comparison of the annual air-conditioning energy consumption of a building with exterior walls of ALC (autoclaved lightweight concrete, thickness: 100 mm) and metal roofing (steel sheet, thickness: 0.8mm, fiberglass insulation, thickness: 4 mm),

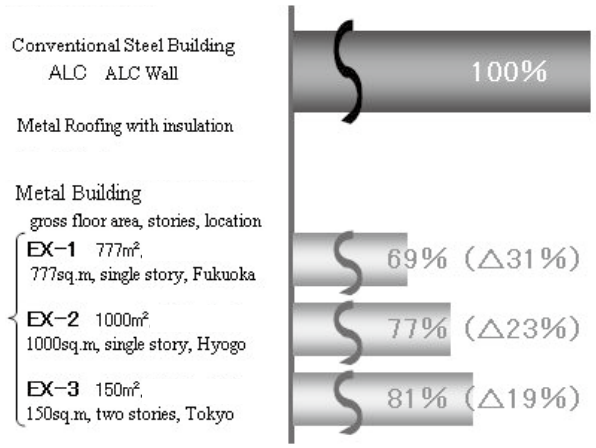

Fig.4 Comparison example of annual air conditioning energy between conventional building and "Metal Building"

which can be called the standard in conventional factory architecture, and "Metal Building."

Because the air-conditioning load of buildings is generally affected by the size of the building, its siting conditions, and other factors, the size of the air-conditioning load is not uniform. However, from Fig. 4, it can be understood that "Metal Building" demonstrates a substantial merit in reducing air-conditioning energy consumption. Moreover, due to the excellent heat insulation performance of the cladding, this tendency is even stronger in comparatively cold climates where the heating load is large.

3.2 New Development of "Metal Building"

As future development of "Metal Building," JFE Civil Engineering & Construction is putting great effort into enhancing added value in both the environmental and design aspects, aiming at buildings that can contribute to the sustainability and growth of the owner's business. In particular, this includes improvement of the working environment for employees, preservation of the regional environment, reduction of operating energy costs and maintenance costs associated with deterioration of the cladding, and designs which symbolize global/unique corporate cultures of clients.

3.2.1 Introduction of functional steel sheets in cladding

In step with the evolution of prepainted steel sheets produced by JFE Steel and JFE Galvanizing & Coating, prepainted Galfan and Galvalume were adopted for cladding. However, a changeover to "JFE ECOGAL®"[3] (new JIS (Japanese Industrial Standards) equivalent 5%Al-Zn-coated steel sheet) is planned for fiscal year 2009. Because "JFE ECOGAL®" has a smooth surface in comparison with conventional galvanized steel sheets, it is a superior product for use as substrate for high luster prepainted steel sheets. It also offers excellent environmental performance, as no chromates and chromium are used in the chemical conversion coating.

With the "KB Panel Series," a complete changeover to the anti-staining prepainted steel sheet JFE prepainted "Apia Clean"[4] is planned, and JFE "Dimple Color," which is a high designability steel sheet with a metallic tone, will be offered as an option (FY2009).

As a distinctive feature of JFE prepainted "Apia Clean," the beautiful appearance of this material can be maintained permanently, undiminished by changes over time, because remaining rain streaks caused by fine particles in exhaust gas, etc. are eliminated by the use of a hydrophilic coating. JFE "Dimple Color" realizes improved durability in combination with a premium appearance by using 3-coat painting, simultaneously with the striking beauty of its metallic tone.

3.2.2 New grades of "Metal Building"

In order to further strengthen the environmental performance of "Metal Building," JFE Civil Engineering & Construction offers new grades modeled on a typical factory building consisting of a one-story building as a yard and an attached 2-story office, as illustrated in **Fig. 5**.

First, the "Standard" grade shown in Fig. 5 (top) was added. This grade improves the design and insulation performance of the "Original" grade consisting of "KB Panel" and "K Roof 21."

Based on the "Standard" grade, the "Ecology (Louver)" grade in Fig. 5 (center) controls sunlight in summertime, and thereby reduces the air-conditioning load, by applying louvers with high designability over the windows, and the "Ecology (PV)" grade in Fig. 5 (bottom) reduces energy consumption by installing a photovoltaic power generation system on the walls and windows, and simultaneously sends a corporate message of "environmental consciousness".

3.2.3 Environmental performance of new grades

Figure 6 shows the results of a trial calculation of the environmental loads of the original grade and the three new grades, based on the model buildings in Fig. 5. As the environmental load, the annual air-conditioning energy consumption of the attached office part of the model buildings was compared and evaluated. The ecology (PV) grade is evaluated based on the reduction of the environmental load by annual energy generated by the photovoltaic system. Other conditions of the trial calculations are shown in Fig. 6.

As shown in Fig. 6, the new grades offer even higher environmental performance than the original grade.

JFE Civil Engineering & Construction is committed

(a) Standard grade

(b) Ecology grade applying louver

(c) Ecology grade applying photovoltaic generation system

Fig. 5 New grade of "Metal Building"

to proposing next-generation "Metal Building" technologies which combine smart, modern designs and advanced environmental performance in products from the original grade to the ecology grades.

4. Conclusion

"Metal Building" is a pioneering technology in environmental architecture, and has led the way in added value in the life cycle of buildings by incorporating high environmental performance in the industrial building

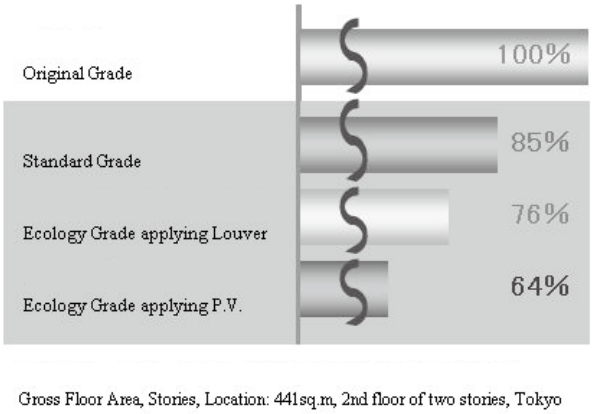

Fig. 6 Comparison of annual air conditioning energy between original grade, standard grade, ecology grade (applying louver), and ecology grade (applying photovoltaic generation system)

field in Japan.

In order to further strengthen this distinctive feature, JFE Civil Engineering & Construction will continue its activities in the future, aiming at environmental technology composite-type pre-engineered metal buildings which combine the diverse technologies of the JFE Group.

Note) This paper has presented an outline of the business development of JFE Civil Engineering & Construction to the company's domestic activities in Japan.

References

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2) General Building Research Corporation of Japan. "Pile Cap Ichi-Ichi Kiso" Non-Footing Column Pile Joint, Evaluation report of newly developed building technologies, GBRC Technical Certificate No. 06-03, 2006-05.

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