Long Metal Roof Tile, "PLEGEL"*

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1 Introduction

Colored galvanized steel sheets and ribbed seam roofing have long been used in residential roofing. The use of ribbed seam roofing, however, is now in sharp decline because of the material's many disadvantages: It retains heat, is unpleasantly noisy during rainstorms, corrodes easily and thus incurs high maintenance costs, and offers limited design flexibility. Recent trends have placed emphasis on steeper roof gradients as a design feature, i.e. as a visible architectural (aesthetic) feature of the structure. For this reason as well, conventional ribbed seam roofing has become an increasingly difficult product to market.

In order to develop a metal roof superior in both performance and design to other roofing materials such as those based on ceramic and asbestos materials, Kawasaki Steel Corp. introduced the PLEGEL ("metallic brick" in Swedish) manufacturing technique from KAMI Corp. in Sweden in 1980. A production line was installed River Building Materials Co., Ltd. factory and manufacturing commenced in 1981.

2 Production Process and Specification

2.1 Features of PLEGEL Manufacture

The features of the PLEGEL manufacturing process consist of the pressing of stepped portions after forming into a corrugated shape, so that the thickness of the portion worked may not be reduced as a result of working. In addition, the integrity of the surface coating film is not affected. During the early stages of production, the worked portion developed creases, and the product was not accepted by Japanese users.

In order to solve this problem, the roll former and metallic molds were improved, and a pressure adjustment method suitable for various types of raw materials (polyvinylidene fluoride resin galvanized steel sheets and polyvinyl chloride resin galvanized steel sheets) and corresponding air temperatures was developed. At present, creases rarely occur and PLEGEL is very well accepted by Japanese users.

2.2 Specifications

PLEGEL is made of a polyvinylidene fluoride resin galvanized steel sheet or a polyvinyl chloride resin galvanized steel sheet (0.5 mm in sheet thickness). It is corrugated in shape, provided with steps in the direction of flow and is designed to give the appearance of roof tiles. A typical product configuration is shown in **Fig. 1**.

The main specifications are as follows:

(1) Steel sheet used: Polyvinylidene fluoride resin galvanized steel sheet or polyvinyl chloride resin galvanized steel sheet (0.5 mm in sheet thickness)
(2) Base sheet width: 1 219 mm
(3) Effective width: 910 mm
(4) Height: 30 mm
(5) Total width: 1 110 mm
(6) Step height: 14 mm
(7) Step width (1 PLEGEL): 350 mm

In order to match PLEGEL specifications to the dimensions of the widely used architectural modules in Japan (which incidentally are based on traditional units of measure), the company has expanded the effective product width to 910 mm, and in addition, modification has been made so that products with five effective widths, that is, 8 steps, 7 steps, 6 steps and 5 steps can be manufactured to satisfy a variety of requirements for Japanese users.

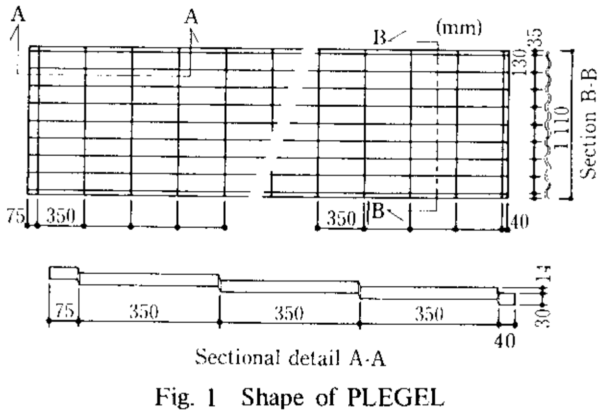

Fig. 1 Shape of PLEGEL

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3 Outstanding Features of PLEGEL

3.1 Watertightness

The individual PLEGEL unit is designed to be sufficient in length need to cover the span from peak to eaves, and thus eliminates the overlap pieces in ordinary construction. Consequently, PLEGEL exhibits excellent watertightness. This fact was confirmed in a storm watertight test carried out with dynamic wind pressure testing equipment at the Japan Testing Center for Construction Materials.

The test was conducted using the methods stipulated in "JIS A 1414 Watertight Test" and "JIS A 6509 Waterproofing Performance of Wooden Panel." A roof measuring 4 m × 4 m was erected over the pressure chamber and the entire surface of the model was subjected to pulsating pressure of synchronized sinusoidal waves approximately 2 seconds in duration centering around a mean pressure as shown in **Fig. 2**, while water was sprayed at a rate of 4 $l/m^2 \cdot$ min uniformly over the entire surface of the model for 10 min. Pressure was then removed for 1 min, and then again applied in cycles of 10-min pressurization and 1-min depressurizing. The result, as shown in **Table 1**, was satisfactory.

3.2 Thermal Resistance

Thermal resistance comparison tests between colored asbestos cement title and PLEGEL were conducted at

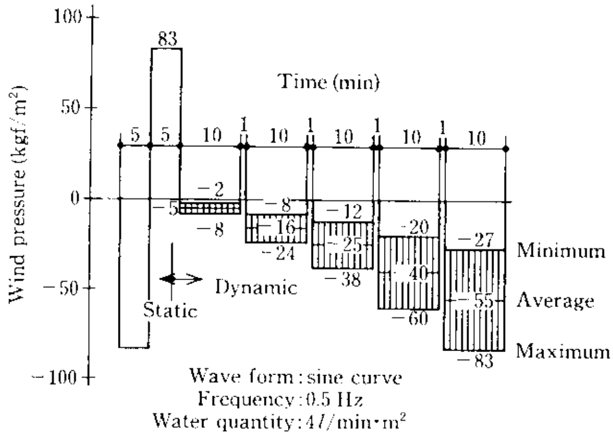

Fig. 2 Loading diagram of wind pressure for rainproof test

Table 1 Results of rainproof test

Average pressure	Standard roofing	Standard roofing + adhesive tape
5 kg/m²	No leak	No leak
16	No leak	No leak
25	No leak	No leak
40	No leak	No leak
55	No leak	No leak

Table 2 Results of thermal resistance test

Item \ Test piece	A PLEGEL	B PLEGEL + poly-ethylene 4 mm	C PLEGEL + poly-urethane 28 mm	D Colored asbestos cement shingles for roofing
Heat transmission resistance (°C/kcal)	0.59	0.68	1.85	0.56
Heat leakage resistance ratio to specimen D	1.05	1.21	3.30	1.00
Difference in heat transmission resistance from specimen D (°C/kcal)	0.03	0.12	1.29	0.00

the Construction Material Test Center in accordance with JIS A 1420 (Thermal Resistance Test Method of Adiabatic Materials for Dwellings). The test results, as shown in **Table 2**, indicated that PLEGEL had 1.05 times the thermal resistance of asbestos cement. The reason for these results is that PLEGEL has a corrugated shape, and the air layer on its reverse side is effective in increasing thermal resistance. Since a ridge ventilation system has been developed and is in practical use at present, warm air is discharged on the reverse side of the ridge, resulting in improved thermal resistance.

3.3 Ease of Installation

The long size and easy handling of PLEGEL permit a labor saving of more than 20% over that required with individually installed roof tiles. To cope with the complex roof shapes which have recently become popular, the co-arrangement method was devised and development of various related parts promoted. As a result, special working of the roofing materials on site has become unnecessary, and PLEGEL can be installed even by semiskilled workers. To further improve the safety and efficiency of field installation, the authors developed a panel construction method which fully utilizes the features of the long metal tiles shown in **Photo 1**. In this panel construction method a large roof panels are fabricated and fit to the roof truss, markedly reducing field operation time and improving the safety of high elevation installation.

3.4 Design Flexibility

Photo 2 shows an installation example of PLEGEL, used here as the roof of an elegant north-European style cottage.

3.5 Durability

Because the basic material of PLEGEL is high-durability polyvinylidene fluoride resin galvanized steel sheet, it is possible to offer a ten year guarantee on product life.

Photo 1 Erection of roof panel

4 Concluding Remarks

PLEGEL has won increasing acceptance since going on the market, and at present, is widely used by government offices, design offices, prefabricated construction material suppliers, and construction companies. It might be also be pointed out that when a serious earthquake occurred near Tokyo on February 17th, 1987, about 60 000 incidents of damage were reported, almost all involving broken roofing tiles, but no damage was found with any PLEGEL roof.

In the future the authors plan to proceed with the development of new materials (stainless steel and aluminum) and new shapes for PLEGEL, as well as parts and construction methods to satisfy the requirements of users.

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Photo 2 PLEGEL applied to the roof of a cottage