Technical Report

Development of Folding Plate Roof Construction Method with Excellent Wind Pressure Resistance Performance

Yoshihisa YAMAMOTO*

Abstract

We have developed a fitting-type folding plate with excellent wind pressure resistance performance and workability of temporary roofing. The developed product has a structure in which the clip is eliminated and the folding plate is fixed directly to the tight frame. It results in strengthening of the negative pressure joint and the wind pressure resistance, and the workability of temporary roofing more than triple that of the general seam-type folding plate. This development offers a solution to problems such as the reduction of damage to buildings caused by typhoons and other disasters and labor shortages at construction sites.

1. Introduction

In recent years, unprecedented abnormal weather generated by global warming such as record-breaking heat waves and disastrous rainfalls has been occurring every year in many regions of the world. In particular, Japan, which is surrounded by sea, and is on the typhoon trajectory, has long suffered from the damage caused by typhoons, e.g., Ise Bay Typhoon in 1959, the still freshly remembered Typhoon No. 21 which hit the Kansai region in 2018, and Typhoon No. 19 which caused extensive damage in Chiba Prefecture in 2019.

Against such a background, Nippon Steel Coated Sheet Corporation which handles steel sheet roofing materials has tackled the development of the high-strength folding plate construction method that excels in wind pressure resistance performance. The high-strength folding plate NISCROOF™ L145 (hereafter referred to as L145) developed by Nippon Steel Coated Sheet dramatically increases the wind pressure resistance by reviewing the fixing structure of the roofing material, and furthermore, shortens the construction time by minimizing the number of constituent component members. Thus, the folding plate roof construction method having high strength and excellent workability has been realized. This paper compares the performance of L145 with that of the conventional seam-type folding plate and describes the results.

2. Objective of Development

To evaluate the strength of the folding plate roof, the bending proof stress test of the folding plate body specified in JIS A 6514 has been conventionally employed. However, in view of the reported cases of the past strong wind accidents in which damage occurred not only on the body of the folding plate, but also at the joint section of the folding plate, in the 2007 version of the Standard of Steel Roofing[1] (hereafter referred to as SSR2007) used as a guideline for the design and construction of steel plate roof, evaluations taking into consideration both the bending proof strength of the folding plate body (cross-sectional performance values) and the joint strength of the folding plate are required.

Herein, although the bending proof stress (cross-sectional performance values) of the folding plate body is determined by the cross-sectional configuration, since the folding plate is generally designed according to the base material (in terms of width, plate thickness, steel grade) having a high distribution amount, the cross-sectional configurations of folding plates become more or less similar to each other necessitated by the relationship between the height and the working width. As a result, the cross-sectional performance values become almost equivalent; however, the joint strength varies greatly, depending very much on how the folding plate body is fixed to the tight frame. In recent years, the seam-type folding plate system wherein a folding plate body is fixed to a tight frame via a metal fitting (clip) (**Fig. 1**) is mainly used. The strength at which the tightening clip stretches and escapes from the folding plate body is the lowest joint strength of the seam-type folding plate, and is dominant in the wind pressure resistance performance of the folding plate. Then, in L145, a structure that fits the folding plate directly to the tight frame (**Fig. 2**) was employed, and a dramatic increase in joint strength was successfully achieved.

* Processing Products Section, Building Materials Development & Technical Dept., Nippon Steel Coated Sheet Corporation
3-2-1 Kuiseminamishinmachi, Amagasaki City, Hyogo Pref. 660-0822

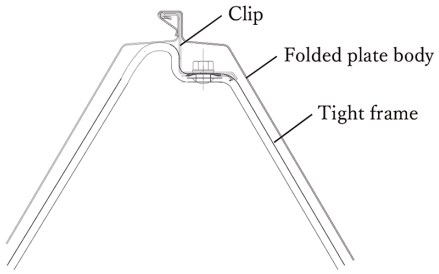

Fig. 1 Seam-type folding plate

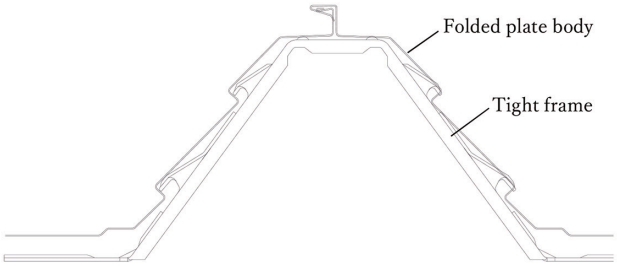

Fig. 2 Fitting-type folding plate (L145)

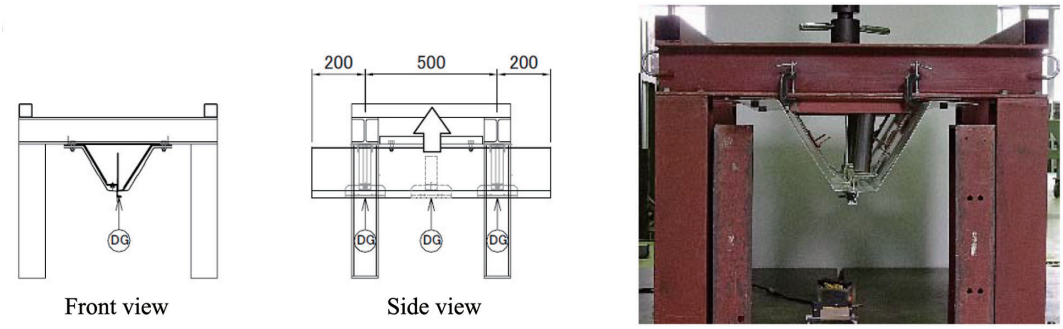

Fig. 3 Specimen for joint strength test

3. Performance Comparison

The results of the comparisons of various performances of L145 and the general-purpose seam-type folding plate are shown below.

3.1 Joint strength

To evaluate the wind pressure resistance, negative pressure joint strength evaluation was implemented pursuant to the standard test of SSR2007 (**Fig. 3**). In **Figs. 4**, **5**, results are shown. The general-purpose type seam-type folding plate exhibited the fracture morphology wherein the clip connecting the tight frame and the folding plate body stretched and escaped from the folding plate. On the other hand, in L145, the fitting claw on the tight frame was either reversed or broke through the folding plate, and thus fracture was reached. As a result, it was confirmed that the maximum proof stress of L145 was about three times or more higher than that of the general-purpose type seam-type folding plate.

3.2 Wind pressure resistance performance

In order to grasp the wind pressure resistance performance of the folding plate roof as a whole, implementation of the pressure box type pressure resistance performance test (**Fig. 6**) that exerts uniform wind pressure load on every area of the specimen is effective. The evaluation method is described in the aforementioned SSR2007. With the test results (**Fig. 7**), it was confirmed that, similarly to the results of the joint strength test, L145 had a strength about three times higher than that of the general-purpose type seam-type folding plate.

3.3 Workability

As mentioned earlier, in L145, since there is no clip and the folding plate body is fixed to the tight frame directly, L145 is also excellent in workability for temporary roofing as compared with the general-purpose type seam-type folding plate. The typical working efficiency of roofing work of a worker per day is about 150 m^2 per

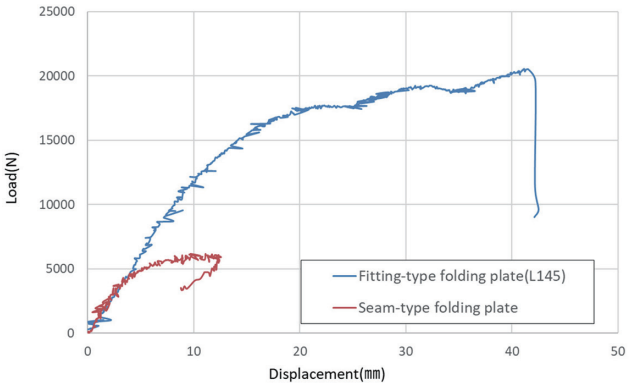

Fig. 4 Results of joint strength test

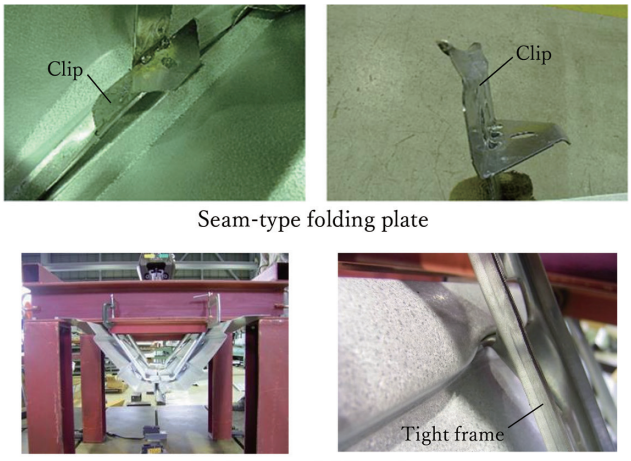

Fig. 5 Damaged appearance of specimens after joint strength test

worker in the case of the seam-type folding plate, and about 300 m^2 per worker in the case of L145 (roofing construction area; 1 000 m^2 or larger, tight frame installation work excluded). Although the efficiency may vary more or less depending on the shape of the roof and/or the skill of workers, it was confirmed that L145 provides a roofing execution rate about two times higher than that of the seam-type folding plate.

Fig. 6 Specimen of wind pressure resistance test

4. Conclusion

As described above, it was confirmed that L145 had superior wind pressure resistance and workability of temporary roofing as compared to the general-purpose seam-type folding plate. With this, domestically L145 has been widely used in Okinawa, a region with strong winds, and employment by large stores and distribution warehouses is expanding nationwide where high wind pressure resistance is similarly required. As mentioned at the beginning of this paper, the environment has been changing on a global scale in recent years, and abnormal weather phenomena such as typhoons and heavy rains that exceed our expectations have been taking place frequently throughout Japan. And furthermore, in parallel with the environmental issues, a shortage of workers is also becoming a major social issue. It is foreseen that the demand will increase in the areas of building materials and construction methods that can respond to various issues faced by modern society such as the aging society with a decreasing number of children and shortage of workers in addition to natural disasters. Nippon Steel Coated Sheet will continue to develop products that solve environmental and social issues, thereby contributing to people's comfortable living and the creation of a beautiful future.

Reference

1) Japan Metal Roofing Association (an incorporated association): Standard of Steel Roofing (SSR2007)

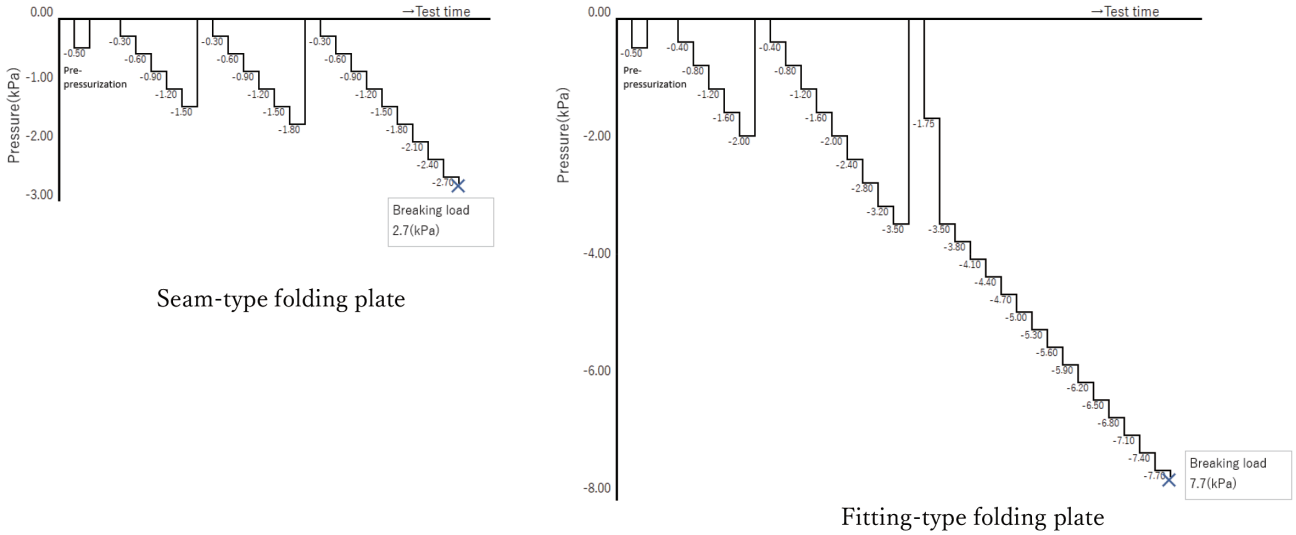

Fig. 7 Relationship between pressurization procedure and breaking load for dynamic wind pressure resistance test

Yoshihisa YAMAMOTO
Processing Products Section
Building Materials Development & Technical Dept.
Nippon Steel Coated Sheet Corporation
3-2-1 Kuiseminamishinmachi, Amagasaki City,
Hyogo Pref. 660-0822