Technical Report

Application Technology of Steel Decks for Timber Building

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Abstract

This report presents application technologies that take advantage of the features of steel decks: long span and load-proof performance, for roofs of timber buildings. Generally, structural design methods of conventional steel decks can withstand only vertical loads, so in order to apply steel decks to timber buildings, it is necessary to establish structural design methods that can handle vertical and horizontal loads with only steel decks. We developed a construction method for roofs of timber buildings that joins steel decks together and on all four sides, and established structural design methods that can withstand both loads. Application of this construction method to the roofs of timber buildings enables construction and design that achieve economic rationality. This construction method has been certified by the designated performance evaluation organization.

1. Introduction

Recently, there has been a significant increase in the awareness of environmental issues starting with the Sustainable Development Goals (SDGs). Under such circumstances, the Law to Facilitate Timber Use for Buildings to Contribute to Realizing Carbon-neutral Society was enforced in Japan and thereby, there is a growing trend toward using timber for buildings.

With these factors as a background, Nippon Steel Metal Products Co., Ltd. has been working on technologies for applying steel decks, which are mainly used for steel structures, to the roofs of timber buildings.

2. Issues with Application of Steel Decks to Timber Buildings

One issue with using timber for non-residential buildings is how to secure the in-plane shear performance of horizontal structure planes (e.g., roofs). Generally, structural plywood is used for timber horizontal structure planes. However, if structural plywood is used for non-residential buildings, the intervals required to drive nails to join the structural plywood plates need to be short due to longer spans and higher loads. This increases the number of members, such as beams and smaller beams used in conjunction with large ones (hereinafter, "small beams"), that serve as support members for the structural plywood, which raises a concern that the economic rationality may deteriorate. To resolve these issues, we developed the timber NBR construction method™ in which steel decks that enable long spans and that can bear high loads are applied to timber buildings.

3. Outline of the Timber NBR Construction Method™

Building roofs have to be able to bear horizontal loads by earthquakes and winds, in addition to vertical loads such as dead loads and snow loads. Generally, steel decks used for steel structures are a separate-type structure in which the steel decks bear vertical loads and the horizontal braces bear horizontal loads.[1)] Meanwhile, the structure of timber buildings is one where the structural plywood plates bear both vertical and horizontal loads. In the timber NBR construction method™ (hereinafter, "this method"), steel decks are applied to the roof structure of timber buildings to bear both types of loads (**Figs. 1**, **2**, and **3**). The features of this method are shown below.

3.1 Reduction of the number of beams and small beams

In the roof structure of timber buildings, beams and small beams that serve as support members are arranged according to the size specifications of the structural plywood plates. In addition, to secure the proper performance of in-plane shear force working on the horizontal structure planes, the structural plywood plates and beams/small beams need to be joined by nailing. Modules for which the intervals between the beams and small beams are 910 mm or 1 000 mm are used.

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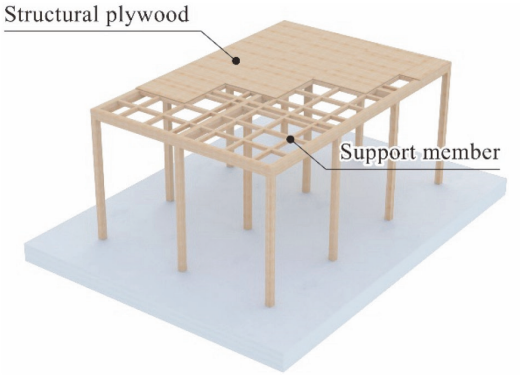

Fig. 1 Structure of structural plywood

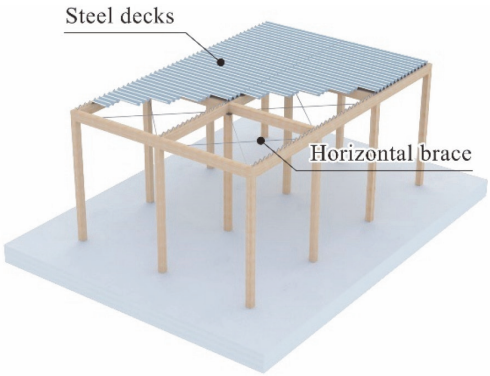

Fig. 2 Structure of conventional steel decks

Fig. 3 Structure of Timber NBR construction method™

On the other hand, as the longest span in this method, for steel decks 50 mm in height, the support span can be extended to 3.2 m, and for steel decks 75 mm in height, the support span can be extended to 5.0 m. Longer spans can contribute to reducing the numbers of processing and construction for girders and beams as well as the number of sections to be joined.

3.2 Omission of horizontal braces

In this method, steel decks are joined on all four sides to timber frames, and the steel decks are joined with each other. As a result, the steel decks on the horizontal structure plane behave like a single plane so as to resist horizontal loads. Due to this mechanism, a couple of forces at the joints between the steel decks and timber frames are borne by the timber frames in the member axis direction that is perpendicular to the in-plane shear force and by the joints on all those of the timber frames. Therefore, the boundary conditions are advantageous (**Fig. 4**). Thus, the use of the newly established structural design method[2] eliminates the need for the installation of horizontal braces; because the structure is finished only with steel decks and timber frames, the workability and surface design may be improved. This method has been certified by the performance evaluation organization.

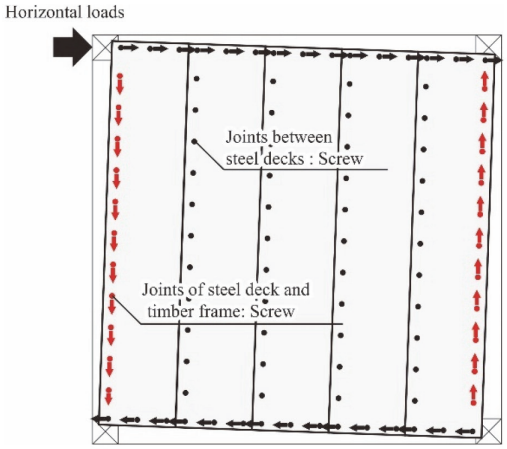

Fig. 4 Structural mechanism for horizontal loads of Timber NBR construction method™

3.3 Structural performance

As standard specifications of nailing to structural plywood for timber buildings, the joint intervals are 150 mm or less. To secure large in-plane shear performance, as a typical case, nailing to the four sides of a structural plywood plate (with a thickness of 24 mm or more) and to the support members so as to form the shape of "8" is required.[3]

In this method, self-drilling tapping screws are used to join steel decks and timber frames and as the standard joint intervals in the longitudinal direction of the steel decks, two specifications of 150 mm and 200 mm are set. For the joint interval specification of 200 mm, the in-plane shear performance is equal to that of the aforementioned specification of nailing in the shape of "8" and thereby the workability can be improved. On the other hand, for the joint interval specification of 150 mm, the in-plane shear performance is higher than that of the aforementioned specification of nailing in the shape of "8." Moreover, the joint intervals can be set based on the required performance and needs for higher construction efficiency, and thus flexible design is possible (**Fig. 5**).

4. Conclusion

This paper outlined the timber NBR construction method™ that draws on the characteristics of steel decks and that enhances the efficiency of the design and construction of timber buildings. We will continue to contribute to society by enhancing security and cost efficiency by promoting application technologies that can be applied to various types of buildings in the future as well.

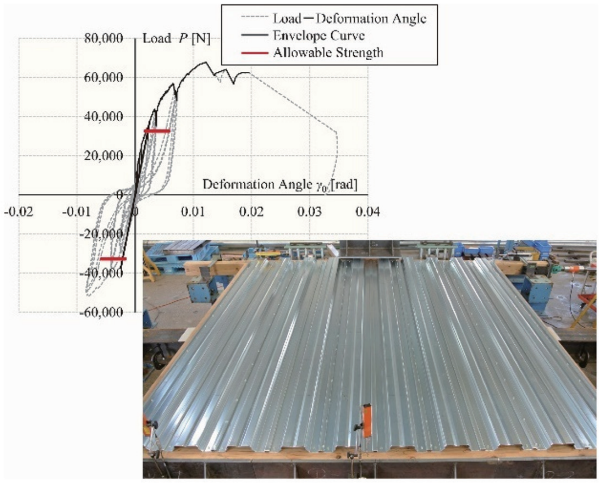

Fig. 5 Structural performance of Timber NBR construction method™

References

1) Japanese Society of Steel Construction (a general incorporated association): JSS III01-2018 Design and Construction Manual for Steel Deck Structures. 2019
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