A PULTRUDED GFRP DECK PANEL FOR TEMPORARY STRUCTURES

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Introduction

In the replacement or major rehabilitation of highway bridges, traffic must detour through or around the bridges. Although several different types of deck systems are currently used to furnish the roadway surface for the deck-on-girder type of temporary structures, in practice a steel deck panel and galvanized steel-grating system are commonly used. However, due to heavy vehicle traffic and steel corrosion, the steel deck panel often needs to be repaired and any deteriorated or deformed panels need to be replaced. Furthermore, the service life of the steel deck panel is generally limited by fatigue because the panel is fabricated by a welding process.

This paper presents the design, analysis, and fabrication of a reusable pultruded GFRP (glass fiber-reinforced-polymer) deck panel that can be used to furnish the roadway surface of temporary structures. The objective of this paper is to propose a viable GFRP deck panel to overcome the steel corrosion and fatigue problems of conventional steel deck panels.

Design of Deck Profile

Deck Panel Profile

The size and weight of a reusable deck panel used for temporary structures must be small and light enough to be capable of being handled by light lifting equipment for easy installation and removal work. In this paper, the dimensions of the proposed GFRP deck panel are assumed to be the same as those of a conventional steel deck panel.

Fig. 1 shows a cross-sectional profile of the proposed 750 mm x 200 mm GFRP deck panel. The thicknesses of the top and bottom flange are assumed to be the same so that the deck panel can be inverted if one side of the deck panel is deteriorated. On the other hand, the outer web is slightly thicker than the inner web. Thus, the main design variables considered are the thicknesses of the flange, the inner web, and the outer web.

The standard design truck load specified in [1] was used as a design live load; and the self-weight of the deck panel was considered to be a dead load. The overall design process was driven by deflection limits because the elastic modulus of GFRP composites is lower than that of steel.

The deflection limit recommended by EUROCOMP [2] ranges from span/150 to span/400. In this study, a deflection limit of span/400 was assumed to reduce the vibration of the deck panel under a live load.

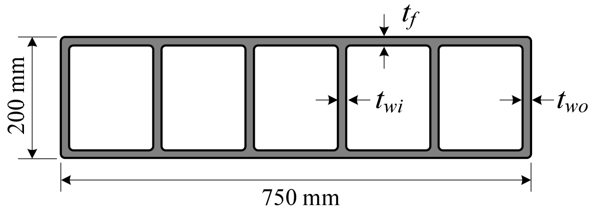


Fig. 1 Cross section assumed for design.

Materials

In view of the initial costs and FRP market in Korea, E-glass fibers and unsaturated polyester resin were chosen as the main constituents of the GFRP deck panel. For design purposes, however, the mechanical properties of the flanges and web of the GFRP deck panel were assumed on the basis of the results of existing work [3]. Fig. 2 shows the stacking sequences of the FRP patterns assumed for the flanges and webs.

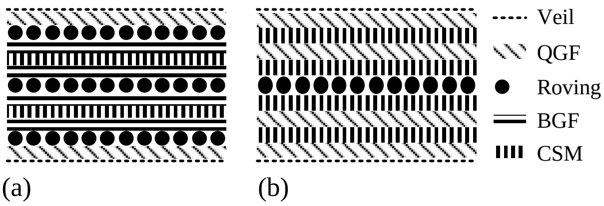


Fig. 2 Material architecture for (a) flange; and (b) web.

The constituents are the unidirectional E-glass fiber roving, continuous strand mat (CSM), biaxial glass-fiber fabric (BGF) with ply angles of $0^o/90^o$, quadriaxial glass-fiber fabric (QGF) with ply angles of $0^o/+45^o$ $/90^o$ $/-45^o$, and unsaturated polyester resin.

Structural Analysis

Due to the symmetry of the panel, a quarter of the panel was analyzed by means of ABAQUS [4]. In the FE model, the flanges and webs were discretized by a four-node shell element. Fig. 3 shows the deflected shape and Tsai-Wu failure criterion contour of the GFRP deck panel. Overall, the stresses induced in the GFRP deck panel are smaller than those of the design strength limits. As expected, the flexural stiffness, and hence the deflection limit, was identified as a critical design parameter of the GFRP deck panel.

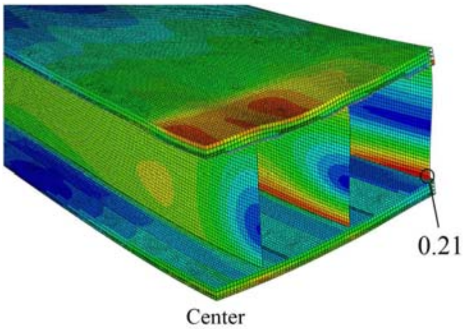


Fig. 3 Deflected shape and Tsai-Wu failure criterion contour.

Fig. 4 shows the cross-sectional dimensions of the GFRP deck panel that determined based on the results of the FE analysis; these dimensions correspond to the dimensions of a fabricated steel pultrusion die.

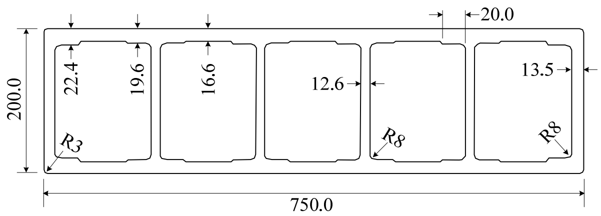
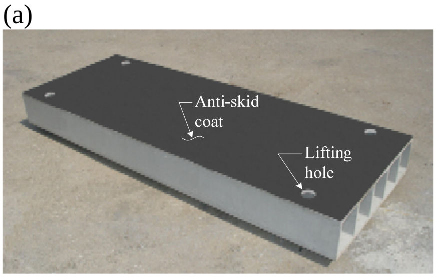


Fig. 4 Cross-sectional dimensions of GFRP deck panel (units: mm).

Fabrication

Fig. 5 shows a pultruding GFRP deck panel section during the pultrusion process. The pultruded GFRP sections were cut into several pieces to fabricate the GFRP deck panel for practical application. In terms of the cross-sectional dimensions, the GFRP section pultruded in this study is the largest single unit fabricated by the pultrusion industry in Korea.

(a)



(b)

Fig. 5 Fabrication of GFRP deck panel: (a) fabrication process; and (b) sample.

Practical Application

Fig. 6 shows a GFRP deck panel being installed to furnish the roadway surface of a temporary structure. During the installation, workers could easily handle the GFRP deck panel, with and without the assistance of a small forklift, because the GFRP deck panel (150 kg) is almost half the weight of a conventional steel panel (280 kg) of the same size.

Fig. 6. Installation of GFRP deck panels.

Conclusion

This paper presents the design and analysis of a reusable pultruded GFRP deck panel that can be used to furnish the roadway surface of temporary structures. The GFRP deck sections were successfully pultruded for practical application.

The results of the design and analysis of the GFRP deck panel proposed in this study indicate that the deflection limit controls the overall design process because E-glass fibers are used to reduce the initial cost of the GFRP deck panel.

The GFRP deck panel's light weight and ease of handling make it ideal for the rapid construction of temporary structures and for the reduction of the dead load in superstructures. All of these benefits may lead to a significant reduction of costs for the contractor. Furthermore, the use of GFRP composite materials for the developed deck panel eliminates the steel corrosion problem encountered in conventional steel deck panels. The non-corrosive GFRP deck panel can be effectively used for temporary structures built in highly corrosive environments such as coastal regions.

References

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