Experimental behavior of a GFRP bridge deck

Korea Institute of Construction Technology KSCE O Lee, Young-Ho, Park, Ki-Tae
Korea Institute of Construction Technology KSCE Jeong, Jin-Woo, Hwang, Yoon-Koog

1. Introduction

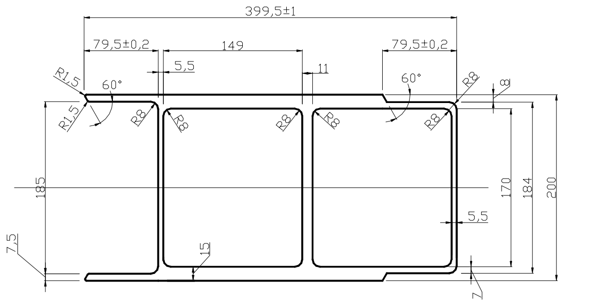
The FRPs (Fiber Reinforced Plastics) are relatively new materials in bridge construction. In spite of their higher initial costs, the FRPs possess several advantages over the conventional materials: high strength to weight ratios; excellent durability; and competitive life-cycle costs. Although, significant efforts have been made in the area of utilizing FRPs in the bridge construction including the decks, hybrid systems, tendons, and rebar, the bridge decks have received most attentions. This may be due to the fact that the lightweight of FRPs is ideal for the rapid construction, reducing in dead load of superstructures. If the existing concrete deck can be replaced with the FRP deck, the load carrying capacity of the superstructure can be increased without strengthening the girders.

This paper present the optimum cross-section and the physical properties of GFRP(Glass Fiber Reinforced Plastics) deck module with a hollow cross-section, and verify the performance of GFRP deck module based on test samples produced by the pultrusion method.

2. GFRP DECK DESIGN

Because FRP material is more expensive than existing steel material and concrete, hollow cross-section, which maximizes cross section efficiency and reduces amount of materials, is widely used in bridges. Even though complex section formations are technically available due to pultrusion method, generally rectangle-shaped, triangle-shaped and trapezoid-shaped sections are widely used.

KICT [1] reviewed various cross-section formations that had been applied to FRP bridge deck in US and Europe, and determined that cross-section of FRP deck should be rectangle-shaped after considering structure performance, possibility of construction, and ease of manufacture. KICT [2] also optimized specification of cross-section and a property of material as shown in Fig. 1 and Table 1. Glass fiber, which is robust as compared to price and ideal for mass production, and vinylester, which is suitable for pultrusion method, were used in FRP deck. One unit module for GFRP deck is formed by two cells as Fig. 1.



(unit : mm)

Fig. 1 - Optimum Structural Shape for a GFRP Deck

Table 1 - Optimum Material Property of FRP Deck

(Unit: GPa)

Description	E_{11}	E_{22}	n_{12}	G_{12}	G_{13}	G_{23}
Flange	22.588	15.988	0.255	3.704	3.704	2.218
Web	18.337	10.983	0.255	4.403	4.403	1.282

3. Pilot Test

We produced test samples using various results from the design optimization and pultrusion method, and verified the performance of the GFRP deck. We performed two tests: fiber direction flexure test and FRP deck test. The performance results are as follows.

3.1 Fiber Direction Flexure Test

Flexure tests were performed on three specimens in order to verify basic flexure performance on the developed FRP module. The procedures for the tests are shown in Fig. 2. Displacement control was used as load weighting method to give failure.

The load-deflection curve is displayed in Fig. 2. As the Fig. 2 implies, the relationship between load and displacement move linearly until failure. We observed various failure modes such as web buckling failure, compressive failure of upper flange, bond failure of upper flange, and failure of joint between flange and web. We also observed that more than two failure modes take place simultaneously. The view of flexure test on fiber direction of FRP module and the failure shape of test samples are displayed in Fig. 3.

The test results are compared with the FEM analysis result in Table 2. As Table 2 implies, flexure stiffness derived from

Keyword : Fiber Reinforced Plastics, Pilot test, FRP deck
Address : 2311, Daehwa-Dong, Ilsanseo-Gu, Goyang-Si, Gyeonggi-Do, 411-712, Republic of Korea, Tel : 82-31-9100-734

the FEM analysis was about 80% of test results. However, failure load correlated with the analysis result. It is believed that physical characteristic of FRP material used in this test was superior to the design material properties, and the material was structurally safe regardless of the applied adhesives.

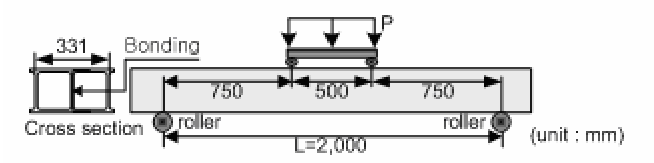


Fig. 2 Loading Condition of FRP Module

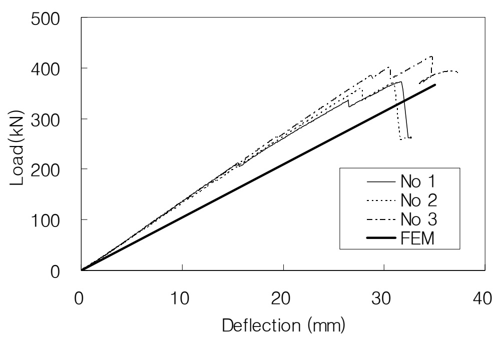
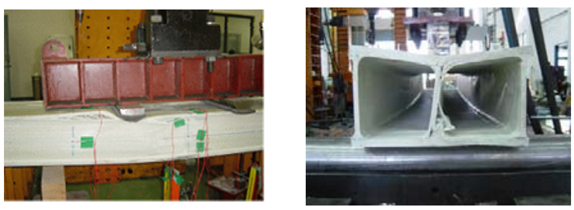


Fig. 3 Load-Deflection Curve

Table 2 - Test Results of Fiber Direction Flexure Test

Description		Max Deflection (mm)	Failure Load (kN)	Bending Stiffness (kN /mm)
Result of Analysis		35.0	367.0	10.5
Test Results	No 1	26.2	342.0	13.0
	No 2	27.8	360.0	12.9
	No 3	28.3	380.0	13.4
	Average	27.4	360.7	13.2



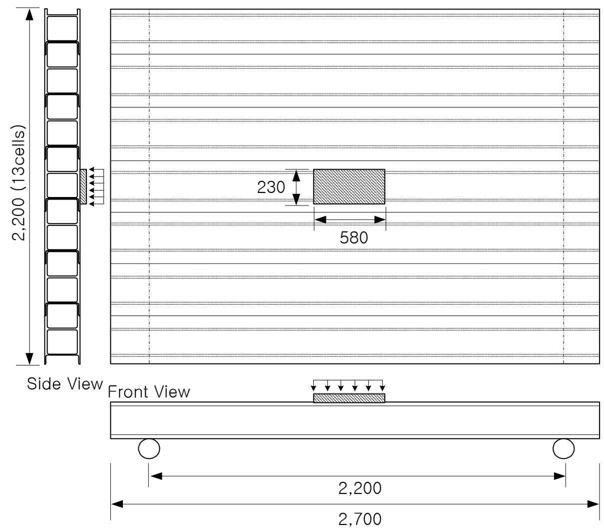
(a) Compressive Failure (b) Buckling

Fig. 4 Failure Shape

3.2 FRP Deck Test

Static weighting test were performed on the sample shown in Figure 5 to study the characteristics of the FRP deck similar to the actual FRP deck consisting of the proposed cross-section. As for the load weighting area, we imitated a truck wheel and allowed the load of uniform load to exert on a weighing plate of 230mm x 580mm.

In test results, we observed that the failure had occurred at the adhesive side between upper flanges near the load weighting plate, and the failure load was 431kN. The failure load was four times larger than the axial design load of 94kN as specified in the specification [3].



(unit : mm)

Fig. 5 Prototype of FRP Deck Flexure Test

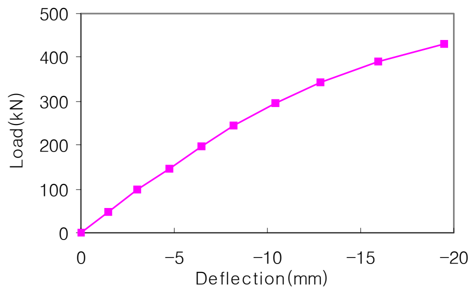


Fig. 6 Load-Deflection Curve (FRP deck)

4. Conclusion

In the case of fiber direction flexure test, it was found that the measured failure loads correlated with the analysis result. In addition, the failure load of FRP decks was four times larger than the axial load of design truck load DB-24, as specified in the specification [3].

Based on the test result, it was realized that it is safe to design using modeling technique applied to this analysis because the measured result was generally larger than the computed value.

References

1. Korea Institute of Construction Technology (KICT), *Development of GFRP bridge decks (in Korean)*, Report No. KICT 2002-050, Goyang, Korea, 2002.
2. Korea Institute of Construction Technology (KICT), *Development of GFRP bridge decks (in Korean)*, Report No. KICT 2003-050, Goyang, Korea, 2003.
3. Ministry of Construction and Transportation (MOCT)., *Standards specifications for highway bridges* (in Korean), 2nd ed., Korea, 2000.