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Pullout Behavior of Concrete-Headed GFRP Rebars

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ABSTRACT

The use of the headed GFRP rebars is increased instead of bending GFRP rebars. In this study, the newly developed concrete-headed GFRP rebars are presented. The pull-out test for the GFRP rebars with the diameters of 13 mm, 16 mm, 19 mm are performed and their behavior including the pull-out capacities are examined.

1. INTRODUCTION

GFRP rebars were used primarily to replace rebars in the corrosive environment in North America and are now being deployed worldwide in structures. If the GFRP reinforcement is difficult to secure a sufficient development length depending on its application position, a bent GFRP rebar can be used similar to a steel rebar. However, it is difficult to obtain sufficient tensile strength because GFRP reinforcement bars are formed only in the longitudinal direction and bending due to the fibers results in stress concentration. ASCE(2009) requires that the bent GFRP rebar be used with a strength reduction of about 40 percent compared to the tensile strength of the straight GFRP rebar. In addition, since the thermosetting resin is used, the GFRP rebar is difficult to perform on-site processing, and it must be manufactured in a factory. To overcome the limitations of such bent GFRP bars, ComBAR have proposed headed GFRP bars with plastic heads (see Fig. 1). Major GFRP rebar makers in the United States and Canada have also introduced them. Mohamed, et. al. (2012) reported that the strength reduction of the plastic headed GFRP rebars increased up to maximum 64%.

In this study, a new concrete-headed GFRP rebar is proposed, in which the head is formed by cutting the end of GFRP rebar in the longitudinal direction and casting concrete-like filler (see Fig. 1). The principle of increasing the adhesion surface of GFRP and concrete head through end cutting was used. Compared to the existing plastic headed GFRP rebar, it has lower production cost and can be integrated with

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concrete.

Fig. 1 Plastic headed GFRP rebar of ComBAR(www.schoeck-combar.com) and concrete-headed GFRP rebar proposed in this study

In this study, the concrete-headed GFRP bars with diameters of 13 mm, 16 mm, and 19 mm were tested with parameters of the concrete head length, i.e., adhesive length. The strength reduction compared to the straight GFRP rebars were analyzed in according of the length.

2. TEST PROGRAM

The test specimens were made to have concrete heads at both ends as shown in Fig. 2, and a total of 42 specimens (14 test variables, 3 identical specimens per a test variable) were fabricated according to experimental parameters (GFRP diameter and concrete head length). Fig. 3 shows the fabrication processes and the test set-up using the 1000 kN UTM(Cho et al. 2016, Cho et al. 2017).

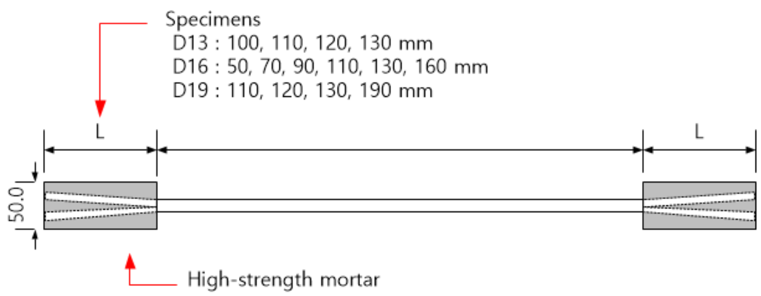

Fig. 2 Test specimens

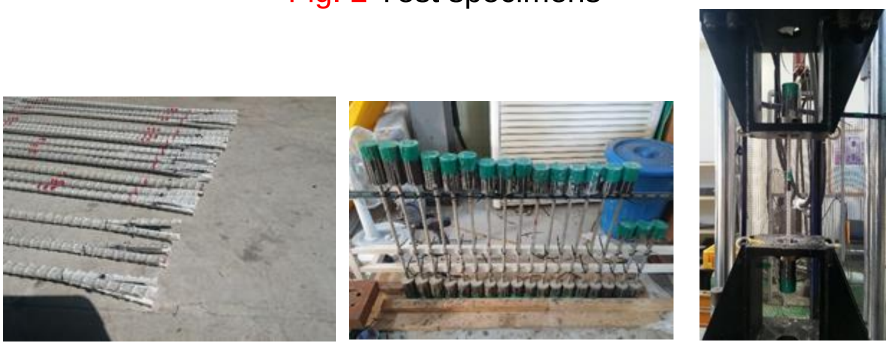

Fig. 3 Fabrication processes and test set-up

3. TEST RESULTS

The proposed concrete-headed GFRP rebar causes adhesive failure when the concrete head length is short and tensile failure when it is long. However, the tensile strength is lower than the tensile strength of ordinary GFRP bars due to the cross - sectional loss caused by longitudinal cutting of the GFRP rebar ends. Fig. 4 is a schematic diagram of the failure load and failure mode.

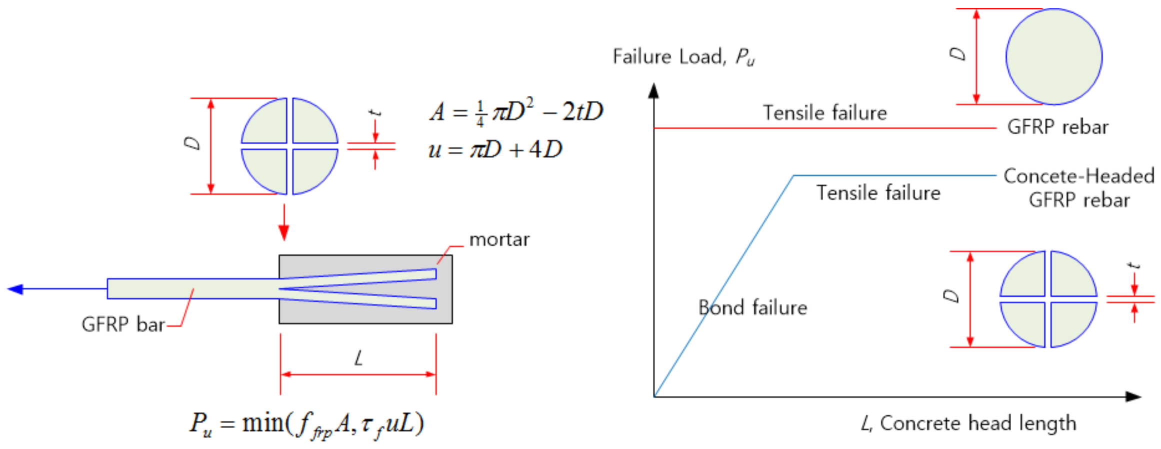

Fig. 4 Fabrication processes and test set-up

Fig. 5-7 shows the failure loads according to the concrete head length. The test specimens of 13 mm in diameter had no experimental parameters for short head lengths, and all the specimens were subject to tensile failure (Fig. 5). The test specimens of 16 and 19 mm in diameters were subject to tensile failure when the head lengths were more than 110 mm and 130 mm, respectively. Otherwise, bond failure occurred in the specimens(Fig. 6-7). These results are in good agreement with the prediction in Fig. 4. Compared with the tensile strength of the ordinary GFRP rebars without cutting, the strength reduction of the concrete-head GFRP rebars is about 70%.

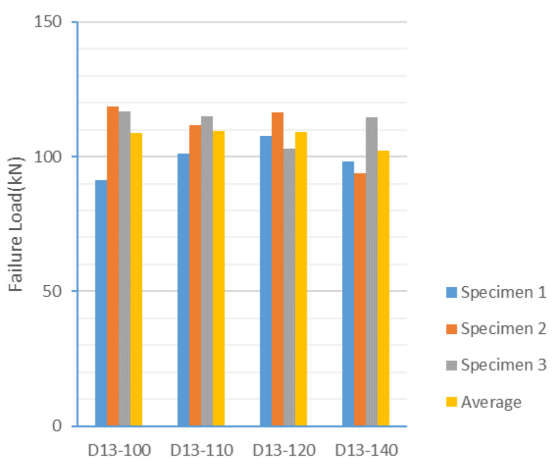

Fig. 5 Specimens with diameter 13 mm

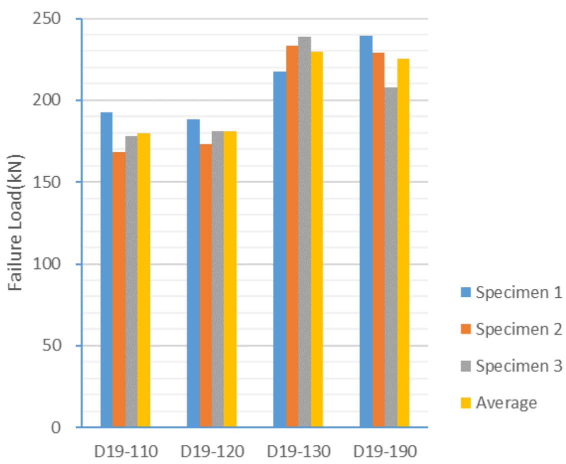

Fig. 6 Specimens with diameter 19 mm

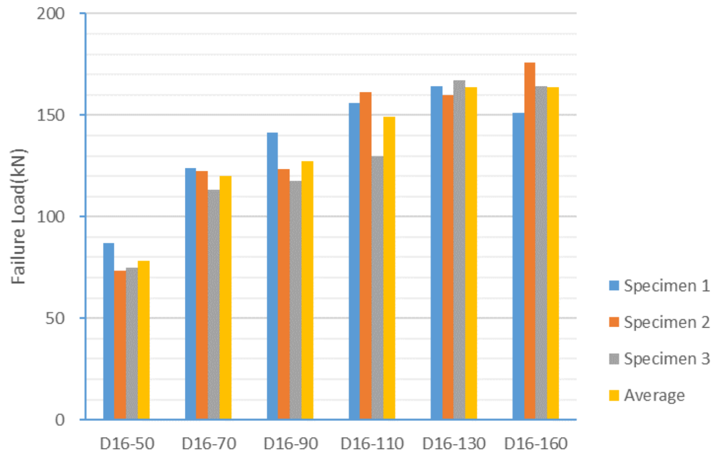

Fig. 7 Fabrication processes and test set-up

3. CONCLUSIONS

A cost-effective concrete-headed GFRP rebar is newly developed. Behavior characteristics were analyzed by tensile test according to the length of concrete head. In the future, pull-out tests on the concrete-headed GFRP rebars embedded in concrete is carried out and the behavior characteristics in real situation are analyzed.

ACKNOWLEDGEMENT

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