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# Internal Structure and Mechanical Properties of Injection Molded FRP Bolt with High Fiber Content

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Fiber-reinforced plastics (FRP) are being used in a variety of fields because of their high specific stiffness and strength, and excellent properties such as corrosion resistance and electrical insulation. As one example, the practical application of bolts as fastening parts is expected. Although there have been many studies on the molding method of FRP bolts and the accuracy of their shape and dimensions, there have been few reports on the mechanical properties of FRP bolts molded by injection molding. Moreover, the dominant factors of the mechanical properties of injection-molded FRP bolts with high fiber content for long-term use are unknown.

In this paper, in order to create high-strength injection molded bolts, effects of molding conditions on internal structures such as fiber length and fiber orientations of FRP bolt which have high fiber content were investigated by cross-sectional observation. In addition, a static tensile test was conducted, and dominant factors for tensile strength were investigated.

In this study, M12×40 mm GFRP bolts were fabricated by injection molding. The glass fiber length in the pellets was 9 mm, the fiber content was 60 wt%, and aromatic polyamide was used as the matrix resin. A 100-ton injection molding machine was used to mold the FRP bolts, and the mold temperature was changed between 120°C and 150°C.

Fig.1 shows the results of the internal structure quantification. Due to the high fiber content, the average fiber length remained only about 0.4 mm at all mold temperature. The fiber orientation coefficient decreased as the mold temperature increased. As the mold temperature increased, the cooling rate of the flowing resin decreased, which may have decreased the fiber orientation coefficient due to a decrease in the rate of the skin layer where the fibers are oriented in the flow direction.

Fig.2 shows the results of tensile tests. Strength prediction equation with modified Kelly-Tyson model was used to calculate the theoretical strength. The experimental results were less than 50 % of theoretical one at all mold temperatures. The effect of the fiber orientation coefficient and fiber length distribution changed the theoretical strength, but the results of tensile tests showed little change. By observing the fracture propagation behavior, initial fracture occurred from cracks around the center of the bolt. Furthermore, the cracks propagated through the resin, not the fiber/resin interfaces, and eventually fractured. This fracture mechanism indicates that fiber length and fiber orientation do not affect tensile strength.

From these results, the cracks around the center of the bolt, which cause the initial fracture, may have been generated by shrinkage of the resin when the bolts were cooled in the mold, and controlling shrinkage would suppress the initial fracture and increase strength.

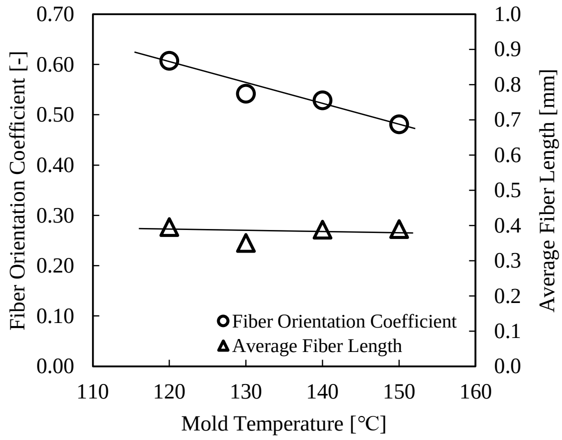


Fig.1 Fiber orientation coefficient and average fiber length at different mold temperatures

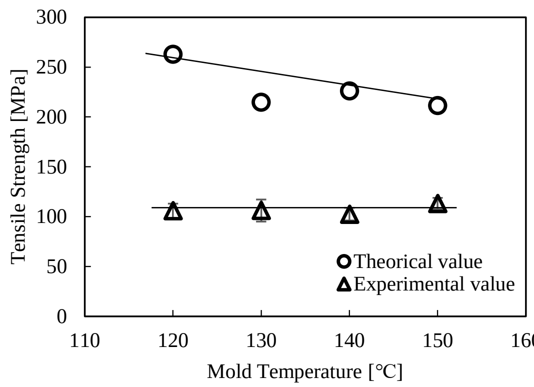


Fig.2 Results of tensile test