RECYCLING OF WASTE FRP AS FILLER FOR NEW FRP PRODUCTS

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Abstract

Ground waste FRP (gwFRP) was investigated as filler for new glass fibers-based FRP. Addition of gwFRP to an unsaturated polyester resin (UPR) at 10% resulted in 10wt% reduction in bending stress, whereas the calcium carbonate addition did not. This reduction was possibly due to the resin fraction of gwFRP. On the other hand, irregular FRP products manufactured in an FRP factory were ground (giFRP) and added to UPR at 10wt% to produce new FRP test pieces and products. Strength examinations using the FRP test pieces showed no weakening in bending stress, tension strength, and impact resistance, as compared to FRP prepared using the pure and calcium carbonate-added UPR. In addition, the giFRP-added FRP bathtub and cover showed the same breaking load and bending stress as the no filler-added and $CaCO_3$-added ones, indicating that giFRP can be used as the filler for UPR to produce new FRP products.

Keywords: *filler, ground waste FRP, recycling, unsaturated polyester resin*

1. Introduction

The annual generation of waste FRP in Japan has been more than 40,000 t for these years [1]. Since FRP has fibers, chemical recycling of resins requires separation of fibers, hydrolysis/dissolution [2,3]. This results in limited application of the processes for waste FRP. As for whole material recycling, ground waste FRP has been applied as filler for resins and pains and as a fine aggregate for mortars [4]. Since the required pretreatment is simply grinding, these are the promising use application.

Among the material recycling purposes, we focused on filler for resins because of the possible advantage in less weight as compared to conventional filler, such as calcium carbonate. Since mixing of different kinds of plastics should be avoided from the viewpoint of recycling, it is preferable that waste FRP is applied for the resin same as that used in this waste FRP. Therefore, this study was carried out to investigate the feasibility of using ground FRP containing unsaturated polyester resin (UPR) as the filler of UPR of new FRP products.

2. Materials and Methods

Ground waste FRP (gwFRP) containing UPR was supplied from Prehabu-kogyo, Hiroshima, Japan, while in this factory irregular FRP products manufactured in Tokumou Resin, Japan were ground (giFRP). In both ground FRP, grass fibers and UPR were found, and the median size was about 25 μm. gwFRP and giFRP were used as filler for UPR, while $CaCO_3$ was used in the control experiment. In the experiment to identify the cause for weakening of UPR by addition of gwFRP, ground grass fibers and UPR were respectively used as filler.

In order to investigate the feasibility of using ground FRP as filler of UPR itself, gwFRP was added to UPR and well mixed, followed by 30 min of degassing in vacuo. After hardening gwFRP-added at 20°C, the UPR test pieces were examined for bending stress according to JIS K6911 [5]. On the contrast, giFRP was used at 10wt% as filler of UPR together with a glass fiber sheet to produce new FRP board, bathtub and cover by a hand lay-up method. The FRP test pieces were obtained by cutting the board and examined for bending stress, tension strength, and impact resistance at -20°C, 20°C and 60°C. As for bathtub and cover, breaking load and bending stress tests were carried out respectively.

3. Results and Discussion

Figure 1 compares the bending stress of UPR test pieces to which gwFRP or $CaCO_3$ was added as the filler. As the added amount of gwFRP increased, the bending stress became weaker, whereas the calcium carbonate-added UPR showed weakening at more than 30%. When the virgin UPR and glass fiber sheet were respectively ground and used as the filler, the former but not latter showed the similar reduction in the bending stress (data not shown). These results indicate that the resin fraction of gwFRP is the possible cause for its weakening effect.

When the giFRP was added at 10wt% as the filler to UPR for new FRP test pieces, its weakening effect was not observed. A comparison of bending stress and tension strength showed no difference among the giFRP,

$CaCO_3$, and mixture-added test pieces, while temperature influenced these properties (Fig. 2). In addition, all samples had the same relationship between the absorbed energy and impact angle in the impact tests (Fig. 3). On the other hand, the bending stress of the giFRP-added FRP test piece was more than twice than that of the gwFRP-added UPR. The results indicated that the weakening effect by addition of gw/giFRP was negligible as compared to the strength increase by the combinational use of glass fiber sheet in FRP production.

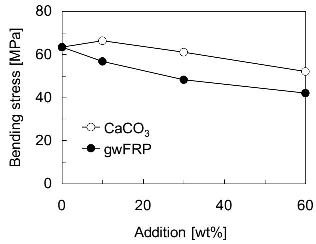

Fig. 1 Bending stress of the UPR test pieces to which gwFRP or $CaCO_3$ were added.

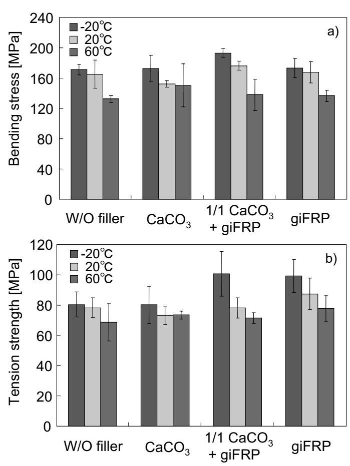

Fig. 2 Bending stress (a) and tension strength (b) of the FRP test pieces to which giFRP, $CaCO_3$, and their mixture (1:1) were added. Bars indicates standard deviation (n=3) with an exception for 1/1 $CaCO_3$+giFRP (b) (n=2).

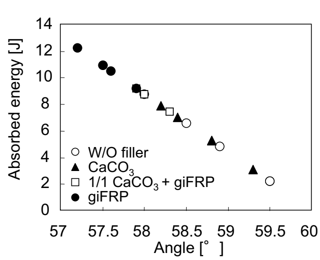

Fig. 3 Relationship between the absorbed energy and impact angle of the FRP test pieces to which giFRP, $CaCO_3$, and their mixture (1:1) were added.

The breaking load of the FRP bathtub and bending stress of the FRP cover are shown in Fig. 4, where no weakening appears for the giFRP-added products as compared to no filler-added and $CaCO_3$-added ones. This indicates that giFRP can be used as the filler for UPR to produce new FRP products.

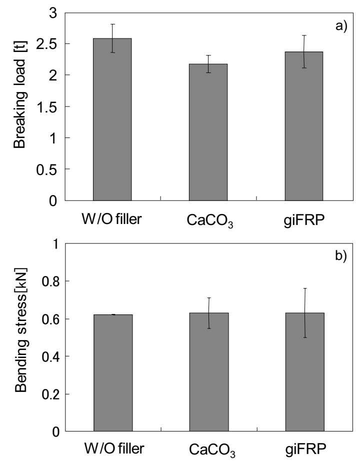

Fig. 4 Breaking load of the FRP bathtub (a) and bending stress (b) of the FRP cover to which giFRP and $CaCO_3$ were added. Bars indicates standard deviation (n=3) with exceptions for W/O filler (a & b)(n=2).

4. Conclusions

Addition of gwFRP to UPR at 10% resulted in 10wt% reduction in bending stress possibly due to the resin fraction of gwFRP; however a series of strength examinations using the giFRP-added FRP test pieces showed no weakening in bending stress, tension strength, and impact resistance. Since the giFRP-added FRP bathtub and cover showed the same breaking load and bending stress as the no filler-added and $CaCO_3$-added ones, the results confirmed that giFRP can be used as the filler for UPR to produce new FRP products.

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