T he Tensile Strength Properties of CFRPs and GRRPs f or Unnes Electric Car Body Material

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The Tensile Strength Properties of CFRPs and GRRPs for Unnes Electric Car Body Material

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Abstract. This paper describes composite materials tensile testing of electric car body material. The UNNES electric car body must be developed using a high strength and lightweight material. A fiber-reinforced plastic composite is widely used for the concerned objective. Selection of the type of composites, variations in fiber orientation, and the number of fiber layers will affect the tensile strength of the material. Composite materials use Carbon-fiber-reinforced plastics (CFRPs) and glass-fiber-reinforced plastics (GFRPs) variation to the fiber areal weight, variations in fiber orientation and the number of fiber layers. The CFRPs areal weight consists of 230 gsm and 400 gsm. The GFRPsareal weight consists of 400 gsm and 600 gsm. Fibre orientationsconsist of 0º and 45º. Number of fiber layers consists of one layer and two layers. Various variations were then tested to figure out their tensile to get ultimate tensile strength of materials. Standard test method for tensile test was conducted using ASTM D3039. Tensile specimen geometry used a type of balanced and symmetric fiber orientation, with 25mm in width, 250 mm in length, and 2.5 mm in thickness. The result shows that the more fiber areal weight and the layer number were used, the more its tensile strength would increase, beside it increased the ultimate tensile strength of the material for both glass and carbon fiber with 0^o and 45^o fiber arientation. Fiber plain wave with 45^o has greater tensile strength compared to any other variation.

INTRODUCTION

UNNES electric car is a car with an electric motor with a capacity of 11 passengers made in Semarang State University. UNNES electric car body must be made with a lightweight material but has high strength. Composites with the type of fiber-reinforced plastic are the solution to that problem. Carbon-fiber-reinforced plastics (CFRPs) and glass-fiber-reinforced plastics (GFRPs) are new materials that have high performance [1,2]. Both types of these composites have high strength-to-weight ratio and excellent fatigue strength [3], high corrosion resistance so that the material is so widely used in the fields of aerospace and automotive industries [4,5,6]. Mechanical properties and GFRPs CFRPs with epoxy-reinforced not only depend on the intrinsic characteristics of CFRPs and GFRPs of the epoxy resin, but also by the interfacial interactions in the CFRPs and GFRPs / epoxy interphase [7,8]. Fiber-matrix adhesion is one of the key parameters for the mechanical properties of carbon fiber and glass reinforced polymer [9]. Therefore, this study reported the ultimate tensile strength of CFRPs and GFRPs epoxy -reinforced of samples made with variations in fiber areal weight, fibre orientation and number of fibre layers.

EXPERIMENTAL

Composite Molding

Hand lay-up method based on epoxy matrices and fiber fabric reinforcements (Glass fiber and Carbon fiber) was used during the composites molding. Fiber fabric reinforcements with fiber orientation balanced (Plain Weave). In the variation of fiber orientation of each fiber was arranged at an angle of 0º and 45º. On varying the number of fiber

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layers, each composed 1 layer and 2 layers. Matrix used general purpose Eposchon Bisphenol A-epichlorohydrin epoxy resin mixed with Eposchon Polyaminoamide general purpose epoxy hardener in the ratio 1:1.

Tensile Stress

Tensile test was carried out according to standard ASTM D3039, using at least 3 specimens (length 250 mm, width 25 mm and 2.5-3 mm thick) on any variation of the composite. In this study, the specimens used rectangular shape specimens of polymeric composites with no-tabs according to the type of balanced fiber orientation in ASTM D3039 [10]. The tensile tests were performed in a universal testing machine 100kN UPH- Tarno GROCKI type, with the piston velocity approximately 2 $mm.min^{-1}$, at room temperature. The following calculation was used to calculate the tensile strength [10].

$$F_{tu} = \frac{P_{\max}}{A} \tag{1}$$

where F_{tu} is theultimate tensile strength (MPa), P_{max} is the maximum load prior to failure (N), A is the average cross-sectional area (mm^2).

RESULT AND DISCUSSION

The Ultimate Tensile Strength of Glass Fiber

The results of the ultimate tensile strength glass fiber made of a single layer on the fiber orientation 0 ° with variations of fiber areal weight are shown in Table 1

TABLE 1. The ultimate tensile strength of glass fiber single layer withfiber orientation 0°

Fiber areal weight(gsm)	F_{tu} (MPa)
400	30.9
600	45.5

Table 1 describes that the biggerfiber areal weight of the composite specimen with glass fiber reinforcement, the more the ultimate tensile strength increases. It occurs because the fiber areal weight is closely linked to the dimensions of the fiber used; the greater the fiber areal weight, the more ultimate tensile strength will increase. In addition, the results of the ultimate tensile strength of glass fiber made of double layer on the same fiber orientation are shown in Table 2.

TABLE 2. The ultimate tensile strength of glass fiber double layer with fiber orientation 0°

Fiber areal weight(gsm)	F_{tu} (MPa)
400	38.4
600	49.9

When compared to the ultimate tensile strength results of glass fiber made of single layer versus double layer on the fiber orientation 0 °, it is apparent that for the ultimate tensile strength of a double layer has increased, it reinforces the theory that the larger the fibre areal weight causes ultimate tensile strength will be increased as well.

The ultimate tensile strength of the glass fiber is not only influenced by the fiber areal weight but there are other factors that influence it, namely fiber orientation. For the glass fiber orientation 45 ° of the specimen made of single layer, the ultimate tensile strength results are shown in Table 3.

TABLE 3. The ultimate tensile strength of glass fiber single layer with fiber orientation 45°

Fiber areal weight(gsm)	F_{tu} (MPa)
400	35.0
600	48.0

The ultimate tensile strength of glass fiber single layer with different fibreorientation in Tables 1 and 3 for the glass fiber orientation 45 ° has increased if compared to the fiber orientation0 °. Likewise against double layer specimen with the fiber orientation 45° has anultimate tensile strength which is higher when compared to specimens with fiber orientation of 0 °. The results of the ultimate tensile strength of double layer specimen with the fiber orientation 45 ° are shown in Table 4.

TABLE 4. The ultimate tensile strength of glass fiber double layer with fiber orientation 45°

Fiber areal weight(gsm)	F_{tu} (MPa)
400	48.2
600	52.6

The ultimate tensile strength shown in Table 2 and 4, indicates a significant increase, so it can be concluded that the specimens were made with the same number of layers and different fibers orientationproduce a different values of ultimatetensile strength. In this case the ultimate tensile strength of glass fiber orientation45 ° higher than the fiber orientation of 0 °.

The Tensile Strength of Carbon Fiber

The results of the ultimate tensile strength carbon fiber made ofa single layer on the fiber orientation 0 ° with variations of fiber areal weight are shown in Table 5

TABLE 5. The ultimate tensile strength of carbon fiber single layer with fiber orientation 0 °

Fiber areal weight(gsm)	F_{tu} (MPa)
230	34.8
400	45.4

If it is compared to the ultimate tensile strength of fiber areal weight and with fiber orientation, the resultsare the same, namely 400 gsm and 0 ° in a single layer between the glass fibers (30.9 MPa in Table 1) with carbon fiber (45.4 MPa in Table 5) indicates a considerablysignificant increase. This is because the carbon fiber has a higherultimate tensile strength than the glass fiber. The results of ultimate tensile strengthof carbon fiber made of double layer with the same fiber orientation 0 ° shown in Table 6.

TABLE 6. The ultimate tensile strength of carbon fiber double layer with fiber orientation 0 °

Fiber areal weight(gsm)	F_{tu} (MPa)
230	39.3
400	50.5

In comparison to ultimate tensile strength of fiber areal weight and with fiber orientation are the same items, namely 400 gsm and 0 ° on the double layer between glass fiber (38.4 MPa in Table 2) with carbon fiber (50.5 MPa in Table 6) indicate very significant increase. On the other hand an increase of in the ultimate tensile strength at specimen was caused by numberof layers, namely from 34.8 MPa be 39.3 MPafor 230 gsm and 45.4 MPa be 50.5 MPafor 400 gsm. Carbon fiber is also applicable on the same terms that the larger the fibre areal weight leads to the increasing ultimate tensile strength of the material. The ultimate tensile strength result of carbon fiber made ofsingle layer with fiber orientation 45°is shown in Table 7.

TABLE 7. The ultimate tensile strength of carbon fiber single layer with fiber orientation 45 °

Fiber areal weight(gsm)	F_{tu} (MPa)
230	49.2
400	61.0

From the evaluation of a significant increase in ultimate tensile strength of fiber areal weight of 400 gsm single layer with the fiber orientation 45 ° between the glass fiber is 35 MPa (Table 3) and the carbon fiber is 61 MPa (Table 7). So also the ultimate tensile strength of carbon fiber single layer with different fibers orientation between 0 ° in Tables 5 and 45 ° in Table 7 has increased from 34.8 MPa to 49.2 MPa for 230 gsm and 45.4 MPa be 61 MPa for 400 gsm. The evaluation of the ultimate tensile strength of carbon fiber made of double layer with fiber orientation of 45 ° is shown in Table 8.

TABLE 8. The ultimate tensile strength of carbon fiber double layer with fiber orientation 45 °

Fiber areal weight(gsm)	F_{tu} (MPa)
230	50.6
400	62.0

The results of the ultimate tensile strength between glass fibers and carbon fibers in the fiber areal weight 400 gsmand same fiber orientation45 ° respectively increasedfrom 48.2 MPato 62 MPa. This increase occurred because the the ultimate tensile strength of carbon fiber is higher than glass fibers.Based on the results of ultimate tensile strength of carbon fiber on a double layer with a fiber orientation0 ° is 39.3 MPa for the fiber areal weight 230 gsm has increasedsignificantly in the ultimate tensile strength by 11.3 MPa at fiber orientation 45 °. While the ultimate tensile strength of carbon fiber for the fiber areal weight 400 gsm in double layer with the fiber orientation0 ° is 50.5 Mpa, it has increased to 62 MPa at fiber orientation45 °.From the evaluation of the results of the ultimate tensile strength of the material carbon fibre, composite materials made of double-layer carbon fiber with fiber orientation 45 ° is recommended to be used as the Unnes electric cars body.

CONCLUSION

Based on the experiment, it can be concluded that:

1. The larger the fiber areal weight and number of layers used, the greater the ultimate tensile strength of both the glass fiber which has fiber orientation 0 ° and 45 ° as well as the carbon fiber that has fiber orientation 0 ° and 45 ° would be.
2. The plain weave fibre with fibre orientation 45° has greater ultimate tensile strength than the fiber orientation 0° both in carbon fiber (CFRPs) and glass fibre (GFRPs)

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