Effect of water absorption on static and creep properties for jute fiber reinforced composite

K. Takemura
Department of Mechanical Engineering, Kanagawa University, Japan

Abstract

Natural fiber reinforced composite is focused on in order to solve some environmental problems. In this study, the effect of absorption on the mechanical properties of natural fiber composite is examined. Jute fiber is used as the reinforcement from the viewpoint of cost. The matrix is Polypropylene (PP). Static and creep tests for Jute Fiber Reinforced Plastics (JFRP) are conducted in dry and wet conditions. As a result, it is understood that the static strength and stiffness for JFRP decreases with increased water absorption. The strength of the re-dried specimen is not as high as that for the non-absorption specimen. For creep tests, there is already an effect of water absorption at the primary creep stage. At the secondary creep stage, the effect of absorption is greater than that of the other stages. The effect can be calculated by the strains for dry and wet specimens.
Key words: jute fiber, polypropylene, water absorption, strength, creep.

1 Introduction

Fiber Reinforced Plastic (FRP) is widely used for many engineering products. However, recently there have been some environmental problems, especially with the disposal of glass fibers that could not be burned out. So, natural fibers such as jute, bamboo, hemp and flax are focused on as reinforcement [1, 2].

Jute is focused on from the viewpoint of cost [3, 4, 5], so Jute Fiber Reinforced Plastics (JFRP) is used in this study.

Natural fibers absorb more water than glass fibers and matrix, so the effect of water absorption to mechanical properties is examined.

High Performance Structures and Materials II, C.A. Brebbia & W.P. De Wilde (Editors)

2 Specimens and experimental procedure

2.1 Specimen

Jute fiber is used as reinforcement. Polypropylene (PP) which is modified with 5% maleic acid PP is used as matrix. Specimens are made by an injection molding method. Two fiber weight fractions (30 % and 50 %) and two pellet lengths (12 mm and 4 mm) are used. For each specimen, a Dry type and a Wet-type specimen are used. Dry-type specimens are kept in an electric oven for two weeks before tests. A Wet type specimen absorbs water for 70 days after drying. The length, breadth and thickness of the specimen are 130mm, 25mm, 3 mm, respectively.

2.2 Water absorption test

Three types of specimens are kept in water for 70 days. The water absorption is examined per week.

2.3 Static bending test

Three-point static bending tests for Dry and Wet type are conducted in a laboratory condition. The crosshead speed is 5 mm/min. The load, deflection and strains on both tensile and compressive sides are recorded. After absorption, some specimen dried to the initial weight. The static test for this Re-dry type specimen is conducted too.

2.4 Bending creep test

Three-point bending creep tests for Dry and Wet type specimens are conducted. The load of 39 N is applied. The limit of this creep test is 1000 hours.

3 Results and discussion

3.1 Water absorption test

Figure 1 shows water absorption under no loading condition. The absorption starts at the beginning of the test. The speed of the 30%-12mm specimen is lower than that of the 50%-12mm specimen. So, it is understood that the absorption speed of the high content specimen is bigger than that of the low content specimen.

The speed of the 50%-4mm specimen is big compared with the 50%-12mm specimen. So, the water absorption property of the low fiber length specimen is better than that of the long fiber specimen.

In this test, the highest water absorption is above 10%.

3.2 Static bending test

Figure 2 shows the bending stress-strain curve for the 50%-12mm specimen. The strength for the Dry specimen is about 95MPa. After the maximum stress point,

High Performance Structures and Materials II, C.A. Brebbia & W.P. De Wilde (Editors)

stress decreases before fracture. On the other hand, the strength of the Wet type is about 77MPa. From this result, the effect of water absorption is great on the static bending strength. For initial stiffness, the effect of water absorption is small. After the strain reaches 0.5%, the effect becomes bigger.

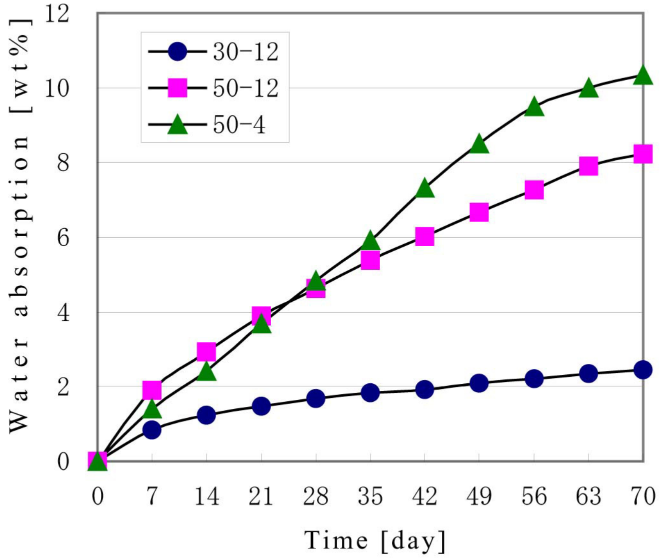

Figure 1: Water adsorption for JFRP.

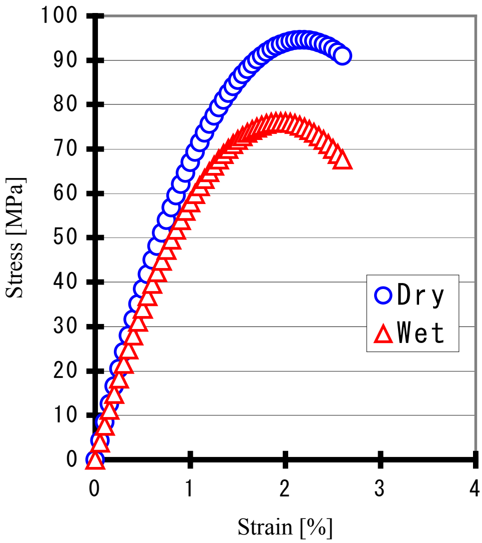

Figure 2: Bending stress-strain curve for Dry and Wet specimens (50%-12mm JFRP).

High Performance Structures and Materials II, C.A. Brebbia & W.P. De Wilde (Editors)

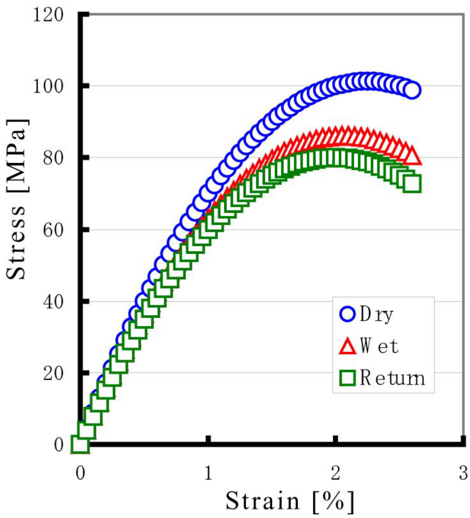

Figure 3: Stress-strain curve for the Re-dry specimen (50%-4mm).

Figure 3 shows the stress-strain curve of the 50%-4mm specimen. In this figure, “Return” means the Re-dry specimen. The strength of the Re-dry type specimens is lower than both the Dry and Wet type specimens. The initial stiffness is similar to the Wet type specimen. However, after 1% strain, the stiffness of the Re-dry specimens decreases. The fracture strain of the Re-dry type specimen is the same as the other specimens. So, the static properties for Re-dry specimens is not as high as Dry and Wet specimens.

Table 1 shows the decrease rates of strength and stiffness. The decrease rate means the difference in strength and stiffness for both Dry and Wet type specimens divided by those of the Dry type one. For the PP specimen, the effects of water absorption occur. The decrease rates of the 50%-4mm specimens are the same as that of PP. The highest rate is nearly 20%.

Table 1: The decrease rate of strength and stiffness for the Wet type specimen to the Dry type one.

	Decrease rate for Stiffness[%]	Decrease rate for Strength[%]
30wt% 12mm	24	19
50wt% 12mm	11	20
50wt% 4mm	8	15
PP	10	16

High Performance Structures and Materials II, C.A. Brebbia & W.P. De Wilde (Editors)

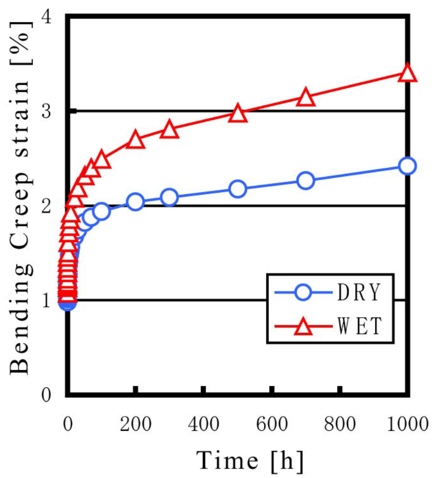

Figure 4: Bending creep curves for Dry and Wet type specimen (30%-12mm).

3.3 Creep test

Figure 4 shows the relationships between creep strain and time. The initial strains for both specimens are different. So, there is an effect of water absorption at the beginning of the creep test. In the secondary creep stage, the slopes of both specimens are constant. The slope of the Wet type specimen is greater than that of the Dry specimen. At 1000 hours, the slope is still constant.

Figure 5 shows the effect of fiber content to creep properties. The creep strain of the low content specimen (30%) is bigger than that of the high constant specimen. The difference of creep strains between Dry and Wet type specimens seems to be big for the 30% specimen. From this figure, it is difficult to estimate the effect of water absorption to creep properties. So the effect rate is used to examine them.

Table 2 shows the creep strain and the effect rates for three types of creep tests. The effect rate at the end of test is not as great as that at the end of that in the primary creep region. So, it is understood that the effect rate for water absorption appears in the transit creep region.

At the end of this creep test, the effect rate for a 50%-4mm specimen is about twice for a 50%-12mm specimen. On the other hand, the effect rate for 50%-12mm specimen is about 2.1～2.7 times greater than that for a 30%-12mm specimen. So, the effect rate of the wet type specimen is great for the short fiber length and high weight fraction specimen.

So the effect of water absorption can be estimated by the creep strains for Dry and Wet specimens.

High Performance Structures and Materials II, C.A. Brebbia & W.P. De Wilde (Editors)

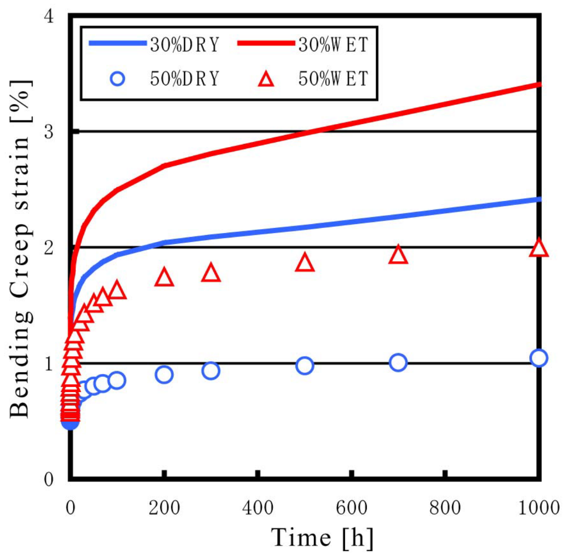

Figure 5: Effect of fiber content to creep properties under Dry and Wet specimen (12mm).

Table 2: Effect of water absorption for Dry and Wet specimens in the creep test.

	Strain at the end of primary stage[%]	**Strain at the end of the test [%]**
30wt%, Dry,12mm	**2.00**	**2.40**
30wt%, Wet,12mm	**2.70**	**3.40**
Rate	**35.0**	**42.0**
50wt%, Dry,12mm	**0.95**	**1.05**
50wt%, WetT,12mm	**1.87**	**2.00**
Rate	**96.8**	**90.5**
50wt%, Dry,4mm	**0.88**	**0.98**
50wt%, Wet,4mm	**2.50**	**2.69**
Rate	**184**	**174**

High Performance Structures and Materials II, C.A. Brebbia & W.P. De Wilde (Editors)

4 Conclusions

In this study, the effects of water absorption for Jute Fiber Reinforced Plastics (JFRP) are examined. As a result, the following conclusions are obtained.

(1) The static strength and modulus for JFRP decrease by water absorption. The strength for the re-dry specimen is not as high as that for the non-absorption specimen.
(2) At the primary creep stage, there is an effect of water absorption on the strain. The effect for the high fraction specimen is greater than that for the low fraction specimen.
(3) At the secondary creep stage, the effect of absorption is greater than that of the other stages.
(4) The effect can be calculated by the strains for the dry and absorbed specimen.

References

[1] D.N.Saheb and J.P.JOG, Natural Fiber Polymer Composite: A Review, Advances in Polymer Technology, Vol.18, No.4, 351-363, 1999.
[2] B. Singh, M. Gupta and A. Verma, The durability of jute fiber-reinforced phenolic composite, Composite Science and Technology 60,81-589, 2000.
[3] D. Ray, B.K. Sarkar, A.K. Rana and N.R.Bose, The mechanical properties of vinylester resin matrix composites reinforced with alkali-treated jute fibers, Composite Part A, 32, 119-127, 2001.
[4] S. Das, A.K. Saha, P.K.Choudhury etc., Effect of Steam Pretreatment of Jute Fiber on Dimensional Stability of Jute Fiber, J. of Applied Science, 76,1652-1661,2000.
[5] J. Gassen and V.S.Gutowski, Effects of corona discharge and UV treatment on the properties of jute-fiber epoxy composites, Composite Science and Technology, 60, 2857-2863, 2000.

High Performance Structures and Materials II, C.A. Brebbia & W.P. De Wilde (Editors)