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THE STRENGTH ANALYSIS OF SPAR I BEAM PROFILE MADE OF COMPO-SITE MATERIAL USING THREE POINT BEND TESTING

Lenny Iryani[1], Fithri N. P[2], Andi M. Kadir[3] & Bambang Irawan[4]

[1]Research Scholar, Aeronautical Engineering, Mechanical Engineering Department, State Polytechnics of Bandung, West Java, Indonesia

[2,3 & 4]Research Scholar, Technology Center for Strength of Structures, Agency for the Assessment and Application of Technology (BPPT), Indonesia

ABSTRACT

In this work, the strength of the spar I beam profile of the UAV wing structure were analyzed by using three point bend testing. The three point bend testing were conducted by using controlled load cell of Newton NT-502A series with maximum capacity of 2000 kg. The spar I beam profilewere made from composite material of carbon fiber prepreg. The thickness of the component were about 0.25 mm and 0.5 mm. The maximum load of the three point bend testing of the spar I beam profile gives value of 11 kN. It was shown that the strength of the spar I beam profile gives good efficiencies compared to the weight itself.

KEYWORDS: *Composite, Three Point Bend Testing, Spar, I Beam Profile, UAV*

Article History

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INTRODUCTION

The use and the function of Unmanned Aerial Vehicles (UAV) recently spread out not only in Aeronautical Engineering but also in Civilian Commercial Industry (Romero etal, 2009). There are several missions that UAV can be provided(He, 2019). In military field, the purpose of the UAV are used to the tactical operations (Hassan, 2014), moving target tracking (Liao et al, 2020), military surveillance system (Nagarani, et al, 2020; Wargo et al, 2014), etc. Not only in the military field, the use of UAV are also growing rapidly in civilian organizations (Austin, 2010) such as for the agriculture and smart farming (Gramatikiset al, 2020; Boursianiset al, 2020; Zhaoet al, 2014), aerial photography (Evers and Masters, 2018; Klostermanet al, 2018), natural disasters response and humanitarian relief aid(Estradaet al, 2019). The use of UAV can be in commercial, recreation-al, and scientific field.

One of the most popular materials which is used in UAVs structure are composite material (Goyaletal, 2020; Beck, etal, 2011). It has one of the good consideration for the UAV structure. The composite material itself gives an advantage, i.e. the reduction of the lightweight of the structures, best possible mechanical properties, durability, good transparency for communication/sensor frequencies, cost to manufacture/maintain, etc (Beck etal, 2011). The use of the composite material can be reduced more than 20% of the weight of the structure compared by using an equivalent aluminum alloy component (Becketal, 2011).

The synthesis, spectroscopic characterization and dynamic mechanical analysis of the UAV manufacturing materials using composite material are explained by Elfaham (Elfahametal, 2019).It is shown that composite material with the carbon fiber densities 100 gives better properties than carbon fiber 200. It gives high storage modulus and low damping.

In this work, the strength of the carbon fiber composite material of the spar I beam profile were analyzed. By using the experimental method, i.e. three point bend testing, the strength of the structure were carried out.

SPAR I BEAM PROFILE

The primary component that generates lift in an airplane is the wing. Wing configuration and shape affected to the amount of the lift (Kim and Liou, 2017; Kumaretal, 2018; Hamertonetal, 2018). The main parts of the wing structure consist of spar and ribs. Most of the loads acting on the wing are supported by spars (Basriet al, 2019).The wing shape aremade from ribs which is have an airfoil shape as shown in Figure 1. The detail configuration of the wing design are explained briefly by Marco, et.al. (Marco, etal, 2019).

In this work the spar of the UAV wing structure made of composite material are being analyzed by using three point bent testing. Spar of the wing have an I beam profile as shown in Figure 2.There are other shape not only I profile but also there is T, C, rectangular shape (Wang et al, 2019; Mishra et al, 2015; Richards and Suleman, 2017).

The length of I beam profile are 600 mm and the width are 30 mm. Meanwhile the height of the profile are 70 mm. The profile have a thickness of 0.5 mm in the middle of the profile and 2.82 mm both in the top and bottom of the profile.

The configuration of the spar I beam structure consist of four part in C shape, i.e. two part in the top and the bottom of profile, and two part in the middle of the profile. The C shape in the top and in the bottom consist of fiber-reinforcement layer in $\pm 45^o$ direction. The $\pm 45^o$ of layer are showed with shaded area as it can be seen in Fig. 4. Meanwhile the C shape of the part in the middle of the pro-file were using Uni Directional (UD) fiber-reinforcement layer. The properties of the fiber are shown in Table 1. The adhesive used to bond the layers are Araldite AV 4076-1 and hardener are HV 5309-1. The density of the adhesive are 1.3 gr/cm^3.

The manufacturing process of the composite materials are the important step to produce the composite materials with a good quality and good properties which is meet the properties requirement (Adrian et al, 2010). In this section the I beam profile manufacturing process are presented.

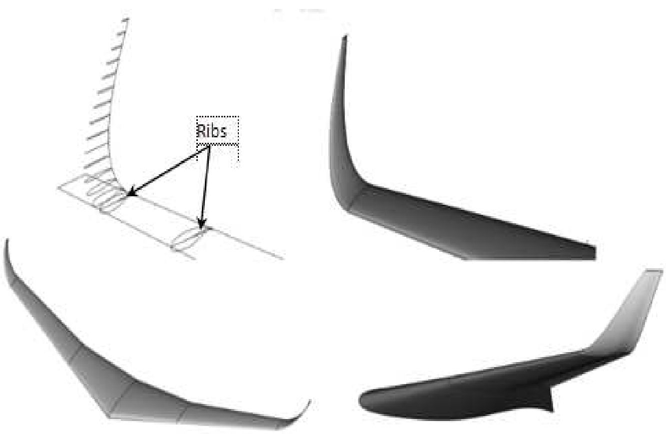

Figure 1: Ilustration of Ribs in Wing Structure (Marcoet al, 2019).

Tabel 1: Material Database (KVE, 2015)

Carbon Fiber	Fiber Mass [gr/m^2]	Thickness [mm]	s_{1C} [MPa]	s_{2C} [MPa]	E_1 [GPa]	E_2 [GPa]
Uni Directional	600	0.58	1308	50	141	12
± 45^o	200	0.25	240	240	20.8	20.8

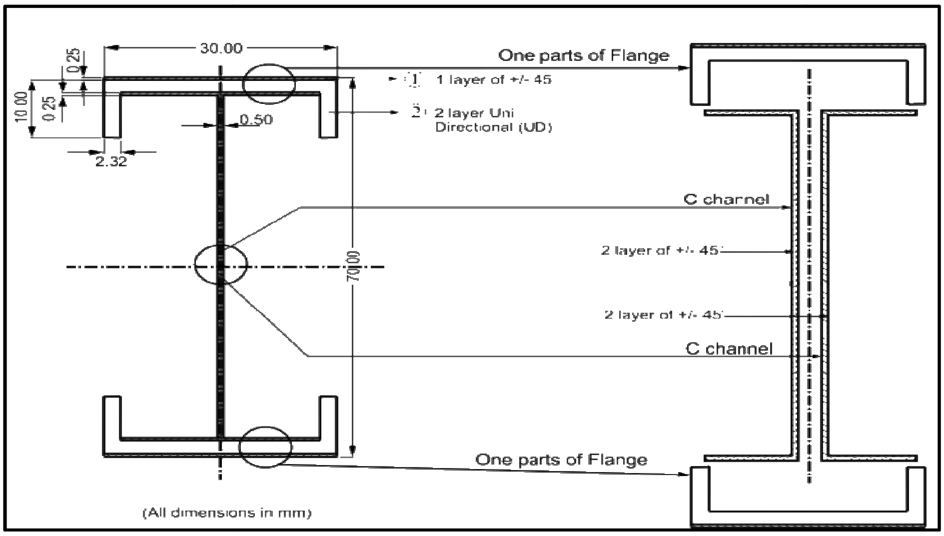

Figure 2: Dimension of the Spar I Beam Profile.

EXPERIMENT PROCESS

The experimental process of the strength analysis spar I beam profile are performing by using three point bending testing. The specimen were placed in two fixed grip of the machine and the load cell placed in the middle of the specimen as shown in Figure 7. The distance of the two fixed grip are 600 mm.The weight of the spar I beam profile were about 500 gr.

The load applied to the specimen are performed by operating the controlled load cell and displayed in monitor as shown in Figure 3. The experiment conducted until the specimen are broken. The digital display of the load cell measurementused in the experiment are Newton NT-502A series. It has a maximum load of 2000 kg.

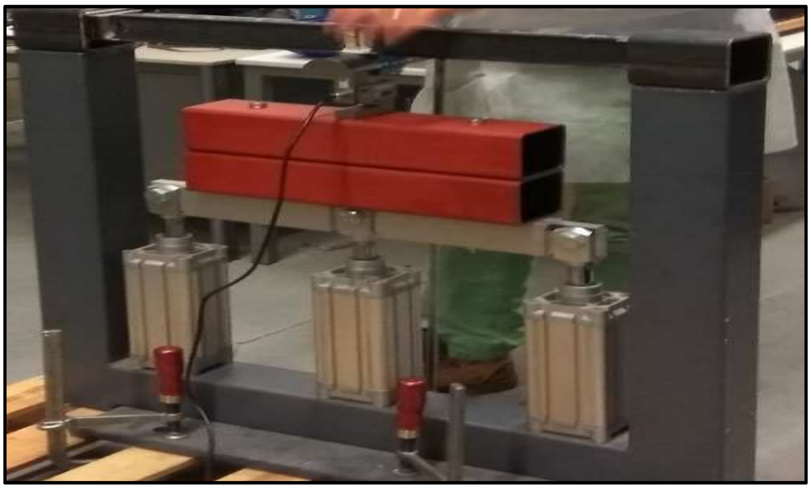

Figure 2: Dimension of the Spar I Beam Profile.

Figure 3: Display of the Load Cell Measurement.

RESULTS AND DISCUSSIONS

In this work, the manufacturing process of the spar I beam profile using composite materials has been conducted. There are several important notes that should be considered in the future work for the manufacturing process of the composite materials. One of the important notes are the process of stacking layers of the fiber reinforcement layers. It should be noted that there are no air trapped in the layers of the profile. In the present work, the trapped air are still exist even though it is very small, i.e. shown in the white dot in the surface of the profile.

The process to bonded together each part of the profile are also important thing have to be considered. The use of the adhesive should be as less as possible but still have to be sure that it is bonded correctly and strongly. The excessive adhesive will contribute to the weight of the profile. It will influence the weight of the profile, i.e. adding the weight of the structure.

In this work, the excessive adhesive on the spar I beam profile gives contribution about 25% additional weight to the total weight of the spar I beam profile. It is become one of the consideration to the next manufacturing process. On the other hand, it gives good bonded strength between the component profile of the spar I beam profile and also the stiffness of the spar I beam profile increase.

The three point bend test were conducted to examined the strength of the spar I beam profile. The three point bend test was chosen because of the critical load of the spar I beam profile in the wing structure are in the bending moment mode.

The result of the load from the experiment process are shown in the display measurement. When the spar I beam profile was broken, the display measurement gives some value of 11,074 N. It can be concluded that strength of the spar beam profile was 11.074kN.

CONCLUSIONS

In this work, the manufacturing process of the spar I beam profile by using composite materials and the three point bend test were conducted. The manufacturing process were done by using hand lay-up method and vacuum bagging process. In the manufacturing process it should be considered about the use of the adhesive to bond the component of the profile. The excessive adhesive will contribute to the total weight of the profile/structure.

In the three point bend test, it can be seen that the strength of the spar I beam profile are 11.074 kN. It gives a good value of the strength compared to the weight of the profile for about 22 N/gr. It can be concluded that by using composite material the design of the spar I beam profile gives an efficient profile, i.e. its strength give a high values by using only 500 gr weight of the spar structure. In the further work, the analysis of the strength of the spar structure using composite materials will be conducted by using other spar profile, i.e. square profile, double C channel and using other method of the manufacturing process.

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