Wing Static Test of LSU-02 NGLD Aircraft Using Whiffletree Method

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Abstract. Wings of LSU-02 NGLD has been tested using the Whiffletree method. The LSU-02 NGLD wing consists of spars made of aluminum, ribs made of balsa wood and skin made of composite material consisting of Balsa, Epoxy and E-glass wood. This study aims to determine the results of testing using the Whiffletree method and analyze the patterns of data obtained from testing. The types of sensors that used in this test are LVDT, Load Cell and Strain Gauge. The LVDT sensor is placed at the tip of the wing and the load cell is placed at the tip of the Whiffletree's support. The strain gauge used is the UBFLA-1-3LT type for aluminum spar, BFRA 3-5 type for inner wing and BFLA 5-5 type for the skin at the tip of the spar. Test results show that the LSU-02 NGLD wing configuration has failed when the load is 2.5g. Failure can be seen in the Strain Gauge 1 data that is mounted installed on Aluminum Spar.. These results have met the maneuver limits for normal category aircraft between 1.52 to 3.8g [1]. The results of this study still need to be compared with testing method based on sand bag method to determine the difference of data.

INTRODUCTION

LSU-02 NGLD (New Generation Low Drag) is the development of LSU-02 aircraft (LAPAN Surveillance UAV-02). This aircraft is an UAV (Unmanned Aerial Vehichle) with a wingspan of more than 2 meters. To find out its capabilities, this aircraft requires structural strength testing, one of them is wing static test. Yang.K et al [2] presented that wing static test is very important test to know the bending strength of the wing. Wing static test conducted at Pustekbang LAPAN are static testing using the sand bag method as a load distributor. This method is quite effective for aircraft with small wingspan such as LSU-02 and LSU-03 [3]. This test method is a simple test that the most popular and has been widely used in static test of aircraft wings [4]. However, this sand bag method becomes less efficient when applied to wings with longer wingspan because the addition of sand with maximum loads can be limited and dangerous to one coordinate axis [5]. Currently, Pustekbang LAPAN is conducting a new wing testing method using the Whiffletree method. Testing with this method is expected to be safer and more efficient when compared to sand bag method.

For the normal category of UAV, the load of maneuver limits that must be met is between 1,52 to 3,8 g. For aircraft with acrobatic maneuvers the load of maneuver limits that must be met is between 3 to 6g [1]. According to FAR 23 (Federation Aircraft Regulation 23), which is the standard of UAV testing, states that to determine the load that can be allowed as long as the aircraft material does not fail is the amount of the limit load multiplied by 1.5 as the safety factor [6]. This standard means that the load factor that must be achieved in the wing testing of the LSU-02 NGLD wing is between 1.52 to 3.8g. Testing using whiffletree can be a faster, cleaner, cheaper, and safer test [7].

The results of the tests that have been done to LSU-05 using whiffletree method there are differences in values where the greater of lift force is given, the percentage of difference in total value of load cell with load cell 8 is smaller. This difference of value can occur due to the installation of a whiffltree system which is not in accordance with the

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initial design so that further correction needs to be done [2]. The parameter that used for this testing is the result of schrenk method analysis. Testing is carried out on the half wingspan configuration by giving a load gradually [8]. The use of the Schrenk method is suitable for use in the initial design because it is faster and simpler than the computational fluid dynamic (CFD) method [9].

METHODOLOGY

Calculations using the Schrenk method have been carried out on the simulation of the LSU-02 NGLD wing with 18kg of MTOW. This is the calculation of the load distribution of the wing:

TABLE 1. Results of load calculation using the schrenk method for LSU-02 NGLD aircraft wings [8]

Loading of Numbers	Point						Total
	1	**2**	**3**	**4**	**5**	**6**	
1 (n=0.5)	0,80	0,99	1,06	0,59	0,47	0,46	4,37
2 (n=0.7)	1,12	1,38	1,48	0,83	0,66	0,65	6,12
3 (n=1)	1,61	1,97	2,12	1,18	0,94	0,92	8,75
4 (n=1,5)	2,41	2,96	3,18	1,78	1,41	1,39	13,12
5 (n=1,7)	2,73	3,35	3,60	2,01	1,60	1,57	14,87
6 (n=2)	3,21	3,94	4,24	2,37	1,88	1,85	17,49
7 (n=2,5)	4,02	4,93	5,30	2,96	2,35	2,31	21,87
8 (n=3)	4,82	5,92	6,36	3,55	2,82	2,77	26,24
9 (n=3,8)	6,11	7,50	8,06	4,50	3,57	3,51	33,24

The wings of LSU-02 NGLD with 18kg of MTOW have a long chord root (Cr) 0.27 meters, chord tip (Ct) 0.19 meters and a length of half span is 1 meter.

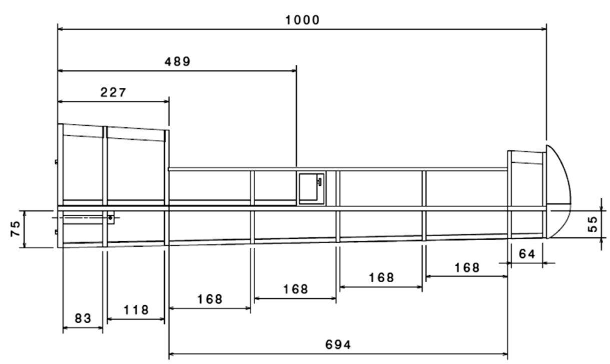

FIGURE 1. configuration of half wings LSU-02 NGLD [10]

This wing is made of composite material consisting of Balsa, Epoxy and E-glass fiber for the skin. This type of composite has been tested in the Material Testing Laboratory – Aeronautics Technology Center. The test results were 346.15 MPa for tensile strength and 10673.4 MPa for elastic modulus. Spar wings are made of Aluminum and ribs are made of Balsa wood. The calculation results of the lift force distribution in the schrenk method are used as data in calculating the amount of force and arm moments needed to design whiffletree. whiffletree design uses whiffletree in excel developed by *3Dwhiffletree.com*. Whiffletree configuration can be seen in Figure 3. Point 1 to 6 in the table 1 is the total weight when the load is given and is the place where Whiffletree's arm is placed. Wing static test of LSU-02 NGLD is accompanied by 1 LVDT, 1 Load cell and 3 strain gauge. Strain gauge is placed on aluminum spar, inner wing and skin. The strain gauge used is the UBFLA-1-3LT type for aluminum spar, BFRA 3-5 type for inner wing and BFLA 5-5 type for the skin at the tip of the spar. Strain sensors that placed on the wing surface was used to monitor wing deformation[11]. LVDT is placed on the tip of the wing and load cell at the top of whiffletree. All strain gauge sensors are connected to NI 9235 while LVDT and Load cells are connected to NI 9237 and monitored via PC.

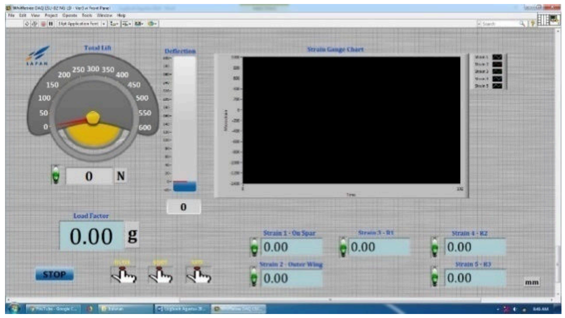

FIGURE 2. User Interface of wing static test of LSU-02 NGLD

Strain gauges, LVDT and load cell readings are zero when the wing have not been pulled. The total channels used are 7 channels and monitored simultaneously. Data collection is gradual from 0.5 to 3.8 g and stopped when the wing is broken. Data collection is based on the load given in table 1. Changes in data that observed in the user interface are raw data. The User Interface that used in this study is shown in Figure 2.

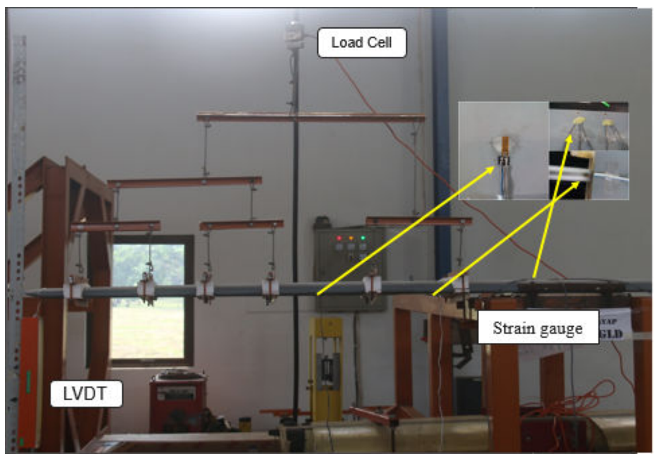

FIGURE 3. The Configuration of Whiffletree

RESULTS AND DISCUSSION

For each data obtained from the sensor will be compared with the load that been given. This is the results of data from the five sensors installed:

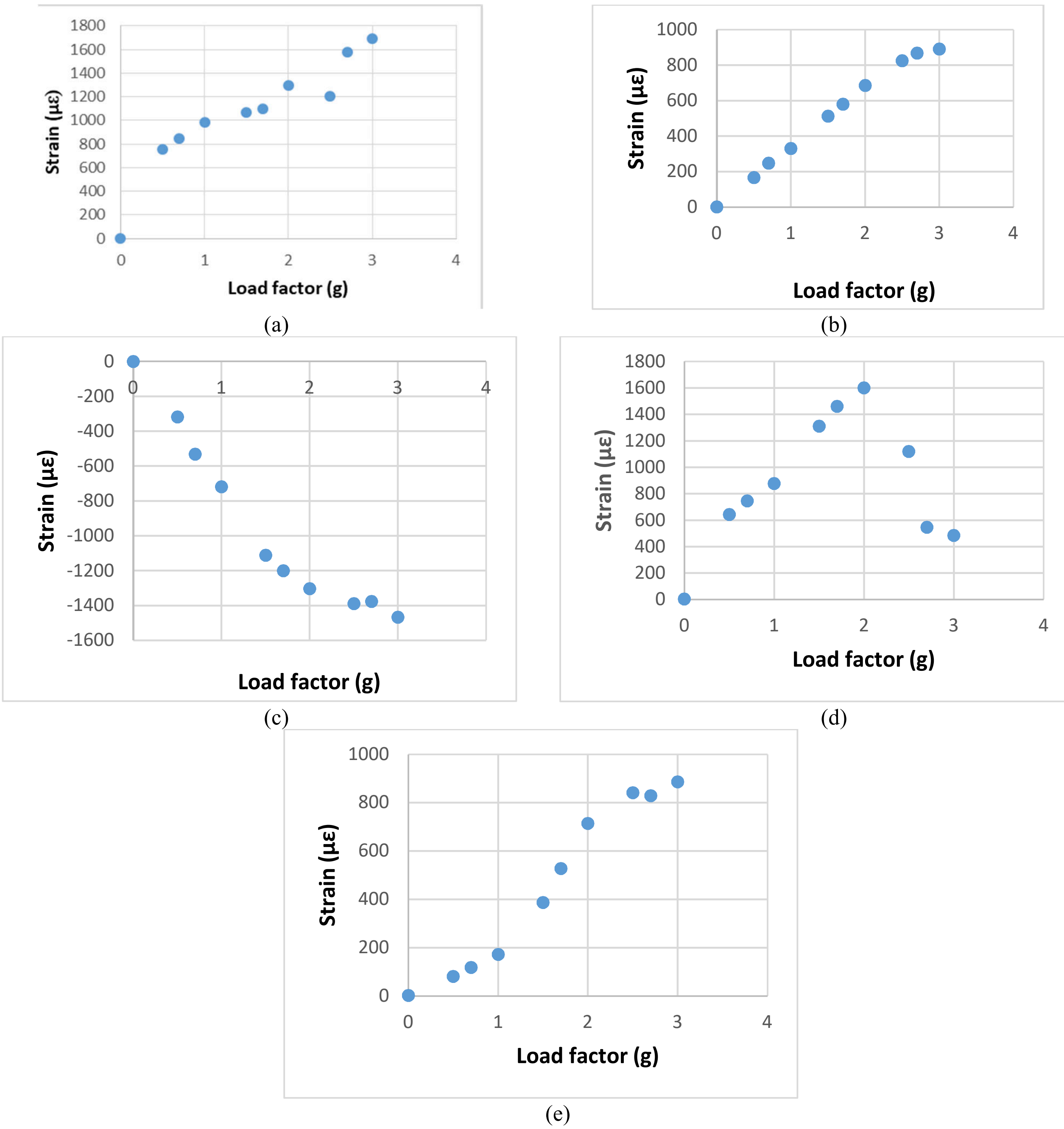

FIGURE 4. Graph data of strain gauge results (a) at aluminum spar, (b)at lower surface of the wing, (c)at inner wing 0° to spar direction, (d)at inner wing 45° to spar direction, (e)at inner wing 90° to spar direction.

Failure occurs in aluminum spars when the load is 2.5g. Strain 1 is a sensor that was installed in the aluminum spar and the change of graphs can be observed when a load is 2.5g. The changes of graph were also observed in the other four strain gauges although not too significant because they were not affected by buckling. Unlike the case with strain gauge 1 that gets the effect of failure directly. Broken results at 2.5g have met the limit maneuvering standard of normal aircraft. These results also show the wing part that needs to be developed is a spar because failure occurs on the spar. This data also still needs to be compared with wing testing using the whole wing versions.

FIGURE 5. Buckling on skin of LSU-02 NGLD's wing.

CONCLUSIONS

The test results showed that the wing of LSU-02 NGLD experienced structural failure when the load is 2.5g. Failure occurs in Aluminum Spar. This result meets the maneuver limits permitted by normal category aircraft [1]. Data results still need to be compared with the test results using sand bag method with full wing configuration. The results will also be more complete when compared with the Whiffletree method using actuators.

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