Study on the health monitoring method using frequency shift by AE method

AE 法における周波数変化を用いた CFRP 健全性評価の研究

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1. Introduction

We have been studying the damage evaluation method during the tensile test of CFRP (Carbon Fiber Reinforced Plastic) materials by AE method[1][2]. We reported previously that there were some possibilities to detect a sign of delamination occurred by the variation of frequency shift of AE signals concentrated part of AE waves during the tensile test of CFRP materials [3]. In this study, we confirmed that if the material was soundness, the concentrated part of F.C.O.G (Frequency Center Of Gravity) of AE wave would be risen with increasing the load stress. On the other hand, it was also confirmed that the concentrated part of F. C. O. G was decreased when damage occurred. Thus, decreasing the concentrated part of F.C.O.G of the AE signal is getting the potential to be a phenomenon of just before the delamination has been occurring [4].

In this presentation, we monitored the AE wave propagation tendency during the tensile test to investigate the cause of the change in the frequency of the AE waves. As a result, it was confirmed that the AE wave propagation phenomenon had been changed by the stress being loaded.

2. Experimental Procedures

The test specimen was manufactured by laminating Toreyca prepreg (P3252S-20). The laminated configuration was [0/45/90/-45] 4s. In this test, we used the two sensors as shown in Fig. 1.

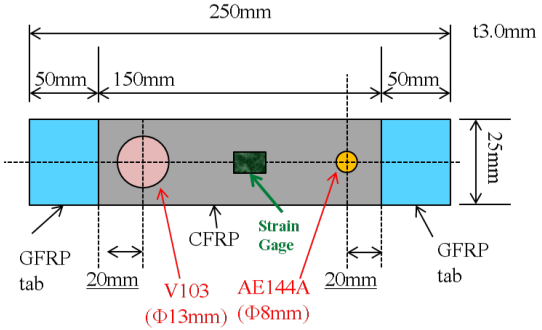
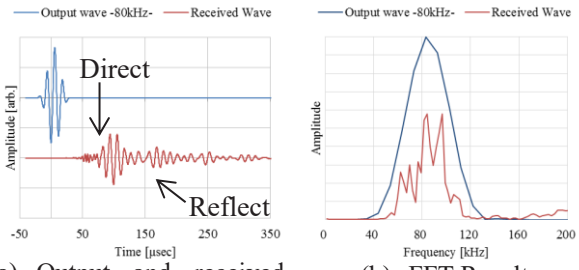


Fig. 1 CFRP Specimen (Size and Sensor Location)

We confirmed the propagation tendency of the AE wave by the method that V103 sensor would transmit the sin burst waves and AE144A receives the signals. Frequencies of the output sin burst waves were obtained from 20kHz to 400kHz (20kHz step). Sample of the output and received waveforms (80kHz) are shown in Fig. 2. Received waveform was mixed with the direct propagated wave and reflected wave from the edge of the specimen. Frequency of the direct wave was about 80kHz. It was almost the same frequency of the output wave. Therefore, we monitored the amplitude of the direct wave.



(a) Output and received waveforms (80kHz) (b) FFT Results

Fig. 2 Samples of Signal

Until the specimen is broken, tensile stress was increased 200MPa each (it was 800MPa, in this test). The sin burst waves were transmitted when the load was applied at each load stage. We confirmed the propagation tendency when the stresses were 200MPa, 400MPa, 600MPa and 733MPa (just before broken).

3. Result

First, we confirmed the behavior of the concentrated part of F.C.O.G. as shown in Fig. 3. The left vertical axis and green circles are concentrated part of F.C.O.G, the right axis and red line are strain, and the horizontal axis is applying stress. The yellow triangles show the timing of the propagation test. From 0MPa to 400MPa, concentrated part of F.C.O.G was become higher with the stress increased. At higher pressure than about 500MPa, frequency shift occurred and F.C.O.G was concentrated between about 70kHz and 80kHz. In this result, damage began to occur in

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the specimen such as delamination and fiber cut higher than 500MPa from the past our research.

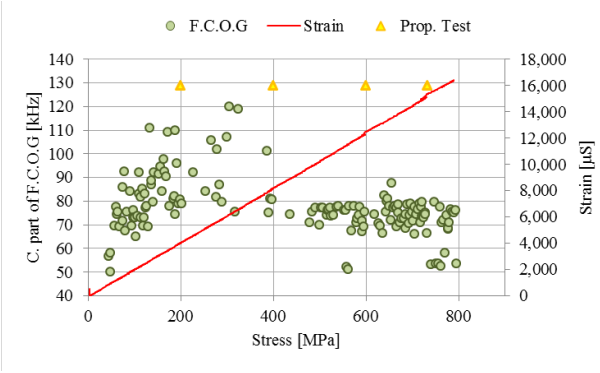

Fig. 3 Result of concentrated part of F.C.O.G

Results of the propagation test show the Fig. 4. The vertical axis shows the test pressure, horizontal axis shows the output frequency, and the color shows the logarithm amplitude base on the amplitude at 0MPa. Increasing amplitude shows the red, decreasing amplitude shows the blue that compared the amplitude at 0MPa.

At higher frequency than 200kHz, amplitude color became white to blue with the stress increased. It was considered that the ultrasonic wave was more attenuated by material damage. On the other hand, at lower frequency than 200kHz, amplitude color became white to red with the stress increased.

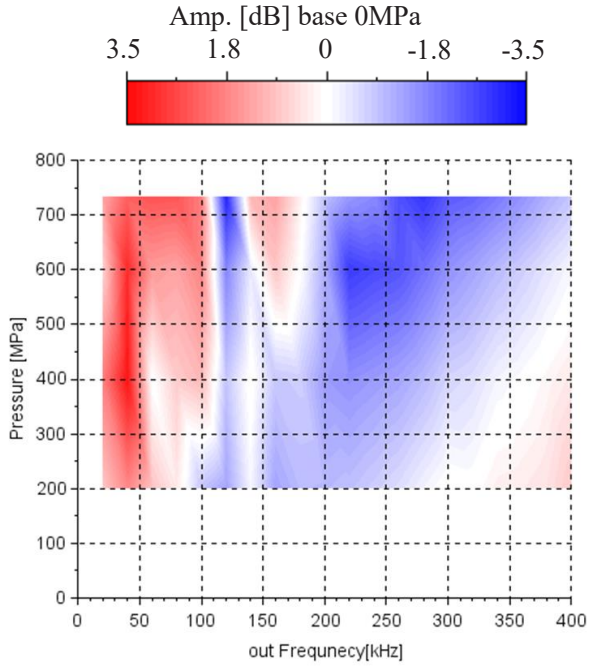

Fig. 4 Results of propagation test.

The propagation tendency of the each frequency during the 20kHz to 120kHz show the Fig. 5. These frequency band is used the calculation by F.C.O.G. The vertical axis shows the amplitude, and horizontal axis shows the test pressure. The amplitude levels of 60kHz and 80kHz were increased in more than 500MPa. Theses frequencies are similar to the concentrated part of F.C.O.G during the tensile test.

In these results, main reason of the frequency shift is that any change of the ultrasonic wave propagation tendency in the low frequency band at 20kHz to 120kHz.

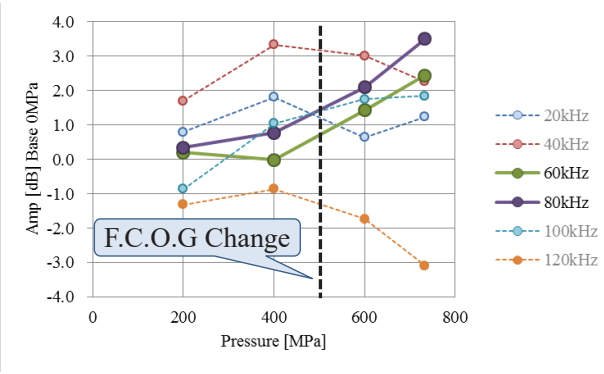

Fig. 5 Propagation tendency of each frequency at 20kHz to 120kHz

4. Conclusion

In this paper, we investigated the AE wave propagation tendency at the time of the stress applying in the CFRP tensile test. As the results, it was confirmed that the propagation tendency of AE wave was changed and signal of the low frequency band was amplified when a stress was applied to the specimen. From these facts, the cause of the decrease of the concentrated part of F.C.O.G is expected that any change of the ultrasonic wave propagation tendency by stress applying is the main reason. In the future, we plan to investigate why the propagation tendency changes.

References

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