PROPAGATION ANALYSIS OF FLEXURAL WAVES BY WAVELET TRANSFORM

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The purpose of this study is to investigate the possibility of structural health monitoring by using the propagation of flexural waves. Then, we investigate the velocity of the propagation of flexural waves. In this paper, the rectangular aluminum thin plate is used in the experiment, which is basic element of structures. The specimen, that is the rectangular thin plate, is excited at one point by the exciter, and, the displacement of vibration is measured by using two non-contact displacement sensors. The velocities of the propagation of flexural waves are analyzed by wavelet transform. As a result, the velocities of the propagation of flexural waves could be measured exactly by wavelet analysis. Therefore, it is found that the structural health monitoring by using the flexural waves is possible.

INTRODUCTION

Recently, a lot of structure such as a ship become large-sized and complicated. It is very difficult that the health of structure is always understood. When the damage is occurred to these structures, it does not cause a fall of strength of the structure and may be connected to an important reason. Thus the development of the health monitoring system for these structures is very important problem. However, there are a few studies about identification of the damage for the thin plate [1]-[2]. Furthermore, there are few studies about identification of the damage that took advantage of propagation of the wave motion. The wave motion is possible the wide inspection is possible. Then, we pay attention to wave motion of vibration in order to identify the damage. The purpose of this study, the method of analysis is developed to understand the damage of the structure by propagation of flexural waves. Thus at first, in this study, we examine by experimental analysis, in order to elucidate the propagation of flexural waves in the structure.

EXPERIMENT AND ANALYSIS

Summary of experiment

The specimen and the equipment of experiment are shown in Figure 1. The specimen made by aluminum is fixed one side edge. The specimen is excited by the exciter with the signal of the signal processor within of FFT analyzer. The method of excitation is that it is the change to a sine wave signal of another frequency from a sine wave signal of a certain frequency instantly. In order to investigate the propagation phenomenon of flexural waves, the displacements of vibration at the exciting point and measurement points are measured by Non-contact displacement sensor, respectively. The measurement results are analyzed by personal computer.

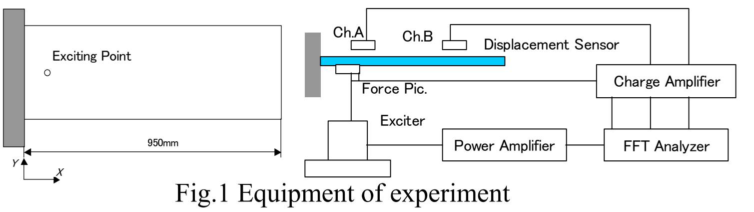


Fig.1 Equipment of experiment

Analysis and results

The used input signal in this experiment is shown in Figure 2. When this input signal is given to the specimen, the displacements such as a vibration response of the specimen are measured at the exciting point and measurement points. In this study, we analyze by using the wavelet transform [3]. In addition, the wavelet analysis and the treatment of experimental results are performed by MATLAB. We detect the time, which is the change frequency of measured signal, by using the wavelet analysis.

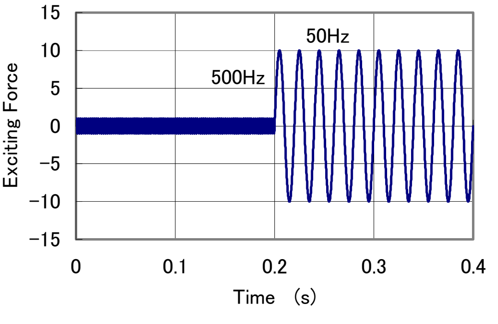
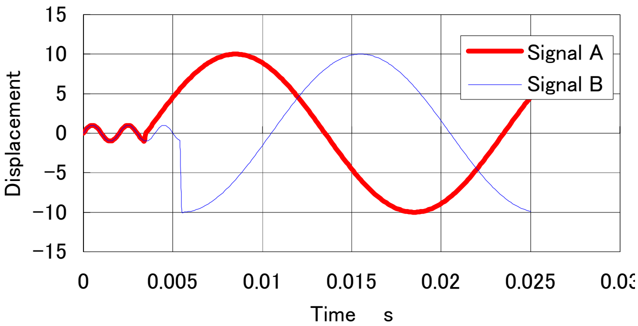


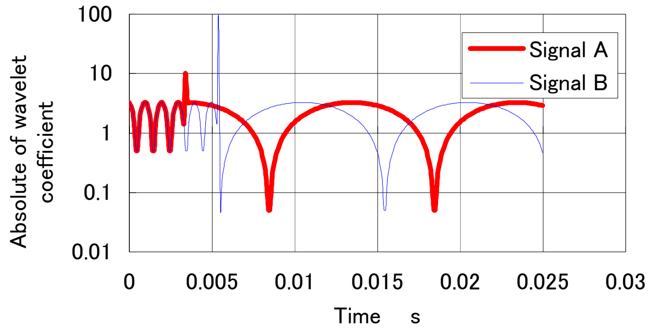
Fig.2 Input signal

These results, which are performed wavelet analysis for signals of various patterns, are shown in Figure 3. Figure 3 (a) shows an original signal before performing wavelet analysis. Figure 3 (b) shows the results, which are preformed wavelet analysis. In addition, the time of change frequency of signal A and B are each moved by 2.0ms. As Figure 3(a) is shown, it is found that it is difficult to detect the time of change frequency. However, as Figure 3(b) is shown, it is found that it is possible to detect the delay time. The delay time of change of frequency is the difference between the signal A and the signal B. Thus the delay time is detected by the wavelet analysis for the measurement result.

In this study, at first, these measurement results at the exciting point and measurement points are analyzed by performing the wavelet analysis. The difference, which is the time of changed frequency, between exciting point and measurement point is decided by cross-correlation function of the wavelet coefficient. And the velocities of the propagation of flexural waves are detected by obtained results and distance form exciting point to measurement point. These analyzed results are shown in Figures 4, 5 and 6. Figure 4 shows the measurement results by the experiment. Figure 5 shows the results of the wavelet analysis performed. Figure 6 shows the results of the velocities of the propagation of flexural waves. In this experiment, the measurement points are 30,60,90,120,150,210,300,450,600mm distant from the exciting point. As these results are shown, it is found that the appropriate result is obtained by performing the wavelet analysis. And the dispersion by distance of the obtained results is very small. The maximum deviation, which is a gap from the mean of the analyzed results, is around 5%. However, The almost deviation is less than 1%. It is found that the analysis of the velocity of the propagation of flexural wave is possible by using proposed method. As the above-mentioned result, it is found that the appropriate velocities of the propagation of flexural waves by using the proposed method, which is the technique with the wavelet analysis, could be acquire. Thus, the health of structures could be investigated by the propagation of flexural waves. In other words, it is found that the propagation of flexural waves could be the effective parameter for the structural health monitoring.



(a) Before wavelet analysis



(b) After wavelet analysis

Fig.3 Results of wavelet analysis for sample signal

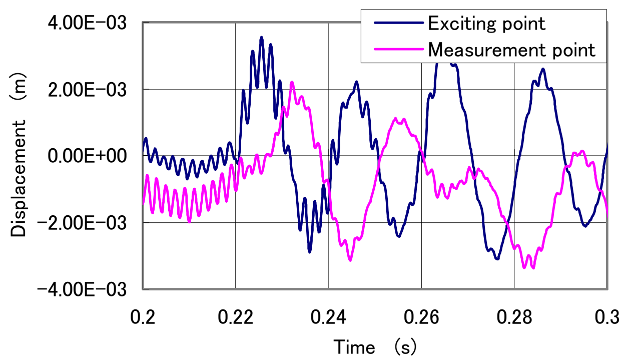


Fig.4 Measurement results

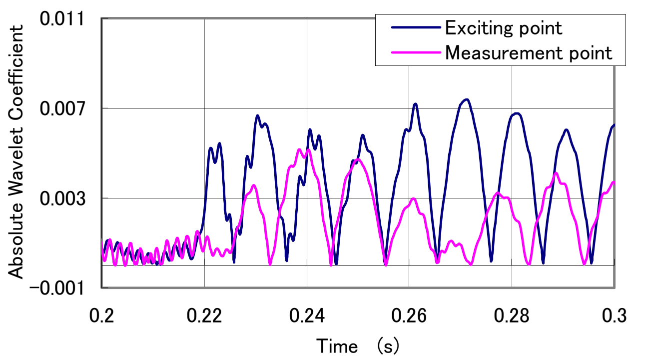


Fig.5 Results after wavelet analysis

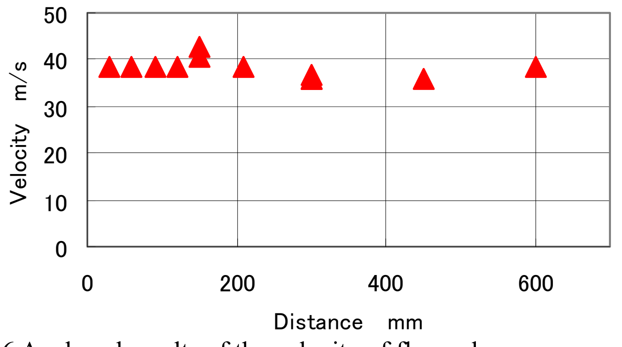


Fig.6 Analyzed results of the velocity of flexural waves propagation

Table 1 Analyzed results of the deviation of the velocity

Distance mm	Velocity m/s	Deviation %
30	38.400	0.893
60	38.400	0.893
90	38.400	0.893
120	38.400	0.893
150	40.421	6.203
210	38.400	0.893
300	35.721	6.146
450	36.000	5.413
600	38.400	0.893

CONCLUSIONS

In this study, we analyzed the propagation phenomenon of wave motion of vibration in the thin plate by using wavelet analysis. The obtained results are as follows. (1) A change of a signal is analyzed almost precisely by using wavelet analysis. (2) The wavelet analysis performs to the measurement results of the exciting point and measurement points. Then, we propose the method, which is investigated the propagation of flexural waves by using correlation of both. In addition, it is found that the investigated results are almost appropriate.

References

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[3] D.E.Newland, Wavelet Analysis of Vibration, *Trans. ASME, J. of Vibration and Acoustics*, 116(1994), 409-417.