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GUIDED WAVE PROPAGATION IN ASYMMETRICAL CORRUGATED PLATE

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ABSTRACT

Research on guided wave propagation in isotropic plates has been quite intensive in the past decade. However, the research on guide wave propagation in corrugated plate limited only to symmetrical type whilst the asymmetrical type has not been determined. Therefore, the behaviour of guided wave in asymmetrical corrugated plates still remains unknown. Hence, in the present study, guided wave dispersion curve for asymmetrical corrugated plates and effects of corrugated dimensions on the dispersion curves are determined. Two-dimensional and infinite plate with isotropic material is modelled by numerical method. Two parameters are affecting the results of dispersion curve which are corrugation height and half wavelength. The results show that the mode shapes are easier to identify if smaller ratio of corrugation height and half wavelength is used. The dispersion curve is reasonably well for small corrugation height but not so good for large corrugation height.

Keywords: *Asymmetrical corrugated plate, dispersion curve*

1.0 INTRODUCTION

A relatively simple geometry such as isotropic plate is considered first in order to understand the behaviour and robustness of the finite element method applied to the solution of guided wave problems [1]. Lord Rayleigh [2] and Lamb [3] are the first treats the Lamb modes in an infinite elastic isotropic plate. Hence, the isotropic plate has its analytical solution that is Rayleigh-Lamb equation [4]. Besides that, the fundamental mathematical modelling of the problem for isotropic material properties was established by Viktorov [5]. He had introduced the concept of angular wave number and derived, decomposed and solved the governing equations.By considering only one curved surface, Viktorov [5] had found the solution for convex and concave cylindrical surfaces. Furthermore, Qu et al. [6] had added the boundary conditions for the second surface in order to obtain the results for curved plates. Hence, he had solved the problem of guided wave propagation in isotropic curved plate.Next, El-Bahrawy [7] had studied the pass bands and stop bands of the Rayleigh- Lamb symmetric modes in sinusoidally corrugated waveguides. Banerjee and Kundu [8] had studied the generalised dispersion equations for periodically corrugated waveguides and presented the solutions for both asymmetric and symmetric modes in sinusoidally corrugated waveguide. The experimentally measured pass band and stop band frequencies in symmetrical corrugated plates had been studied by Banerjee, Kundu and Jata [9].

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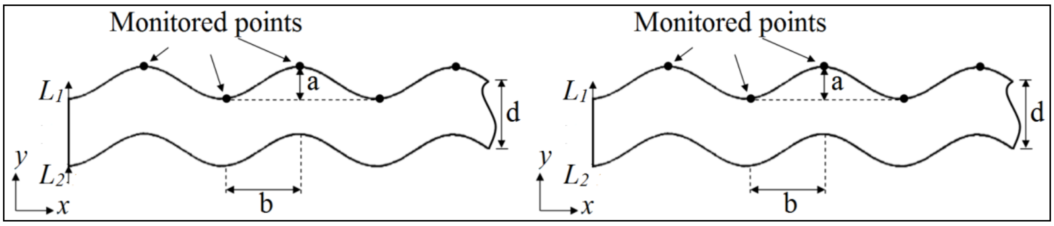
However, the guided wave propagation in asymmetrical corrugated plate is not yet been studied. Therefore, the objectives of this study are to determine guided wave dispersion curves for asymmetrical corrugated plates and to determine effects of corrugated dimensions on the dispersion curves.

2.0 METHODOLOGY

An asymmetrical corrugated plate is shown in Figure 1. It is considered only the thickness, *d* of the plate is 1 mm and the total wavelength of the periodic surface for all different dimension of corrugated plate is 500 mm. The half wavelength of the periodic surface, *b* is 5 mm and the first monitored point is started at 5 mm away from the edge of the corrugated plate, so there are a total of 100 monitored points where the interval of monitored points is 5 mm. The corrugation height, *a* is manipulated to get the ratio a/b is in the range of $0.1<a/b<2$. The dimension of the corrugated plate is shown as Table 1.



(a) (b)

Figure 1: Geometry of corrugated plate:(a) asymmetric mode, and (b) symmetric mode

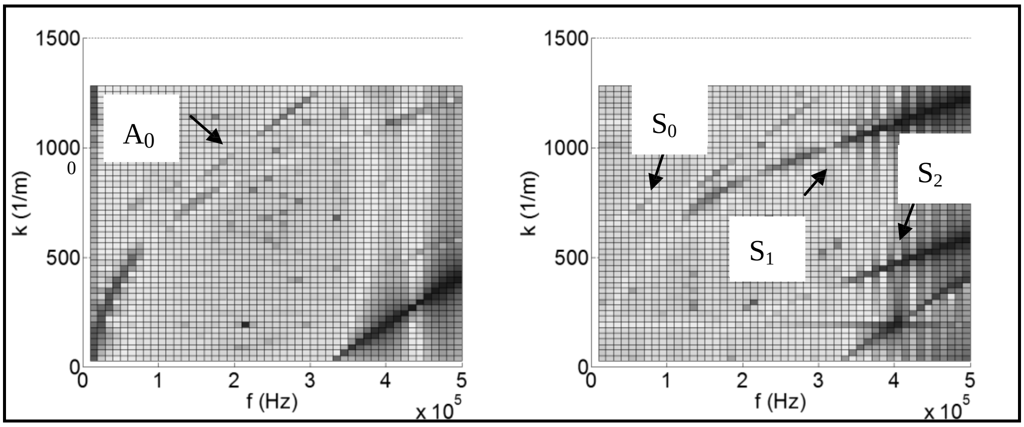
Table 1: Dimension of asymmetrical corrugated plate

Corrugation height, a (mm)	Half wavelength, b (mm)	Ratio of a/b
0.5	5	0.1
5.0	5	1.0
10.0	5	2.0

The boundary condition for both asymmetric and symmetric mode is x-symmetric and located at the edge of the plate. Five cycles tone burst with Hann window at centered frequency 500 kHz is used as the excitation force. The results that compute from ABAQUS are then loaded in MATLAB to get the dispersion curve via Two-dimensional Fast Fourier Transform (2D-FFT). Normally, this method is applied when there is either multi-mode propagation or dispersion [10].

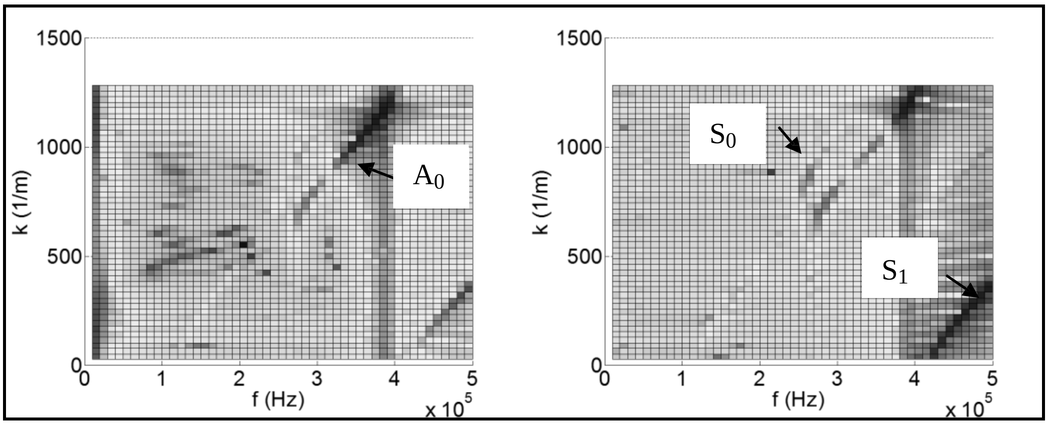
3.0 RESULTS AND DISCUSSIONS

The dispersion curve of asymmetrical corrugated plate with ratio a/b are 0.1, 1 and 2 are shown as Figure 2, Figure 3 and Figure 4 respectively.



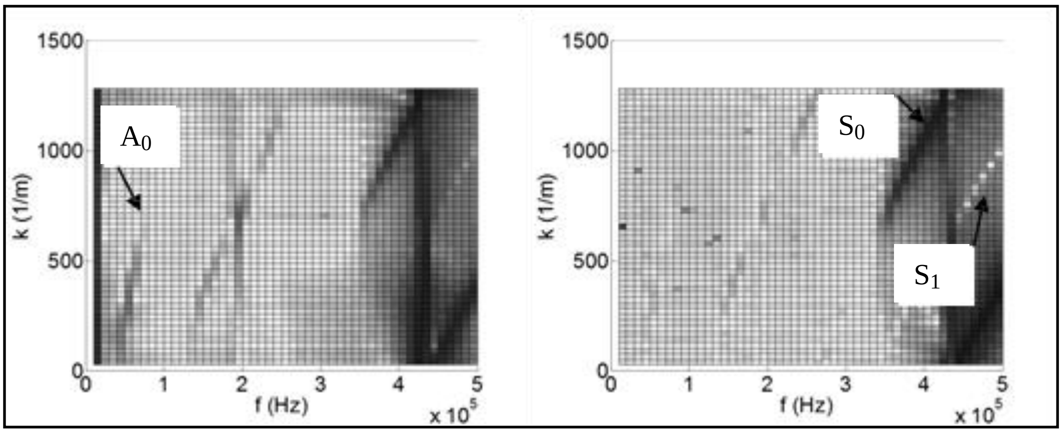
(a) (b)

Figure 2: Dispersion curve of asymmetrical corrugated plate with ratio of a/b = 0.1 a) asymmetric mode, and (b) symmetric mode



(a) (b)

Figure 3: Dispersion curve of asymmetrical corrugated plate with ratio of a/b = 1: (a) asymmetric mode, and (b) symmetric mode



(a) (b)

Figure 4: Dispersion curve of asymmetrical corrugated plate with ratio of a/b = 2: (a) asymmetric mode, and (b) symmetric mode

From the dispersion curves that determined, it is clear to see that the mode is easier to identify when the smaller ratio of a/b is used. Furthermore, there are quasi symmetric modes in the dispersion curve of asymmetric mode and vice versa. This may be due to the geometry of the plate that modelled which is asymmetrical corrugated plate. The dispersive of the centred frequency also affect the results since the plate is corrugated.

Rather than that, there are pass bands and stop bands for the dispersion curve of asymmetrical corrugated plates. Different dimension of asymmetrical corrugated plate will get the different pass bands and stop bands. The stop bands are found to increase with the ratio of a/b. The dispersion curves are good indicating for small corrugation height (easier for mode identification) whilst the dispersion curves are not good indicating for large corrugation height. Moreover, the numbers of modes are different for different dimensions and different ratio of a/b. Aliasing effect is occurred due to large interval between monitored points. Therefore, the interval between monitored points should be as small as possible in order to avoid occurrence of aliasing effect.

4.0 CONCLUSIONS

The guided wave propagation in asymmetrical corrugated plate with different corrugation dimensions are investigated via numerical method. Two parameters which are the corrugation height and the half wavelength of the periodicity are enough for clearly predicting the dispersion curve. The results are reasonably well for small corrugation height whilst the results are not so good for large corrugation height. For further study purpose, the corrugated plate can be developed in three dimensional (3D) so that the effect of directions on the dispersion curves for can be determined.

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