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복합재료 캔틸레버보의 고유진동수에 대한 영향

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The Influence of Natural Frequency of the Cantilevered Composite Materials Beam.

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Abstract: In this paper, the method of vibration analysis for calculating the natural frequency is presented. This method is a simple but exact method of calculating natural frequencies corresponding to the modes of vibration for the cantilevered composite materials beam. As a calculations of the method of vibration analysis, it is noted that the result of the second cycle is only 2.2% away from the 'exact' result. In the case of cantilevered composite materials beam, increase of mass near the support does not significantly affect the vibration characteristics. This method may be extended to stability analysis of complex structural elements.

Key Words: composite materials, vibration analysis, natural frequency, cantilevered beam

1. INTRODUCTION

A method of calculating the natural frequency corresponding to the first mode of vibration of some structural members with plate section is presented herein. This method consists of determining the mode shape by means of successive approximations of iteration and of calculating the natural period corresponding to this method, however, is different from the one usually called "the method of successive approximations."

The originality of this method is open to question and immaterial. This method was found to be the good and reliable one in vibration analysis of laminate plates about vertical load.

2. METHOD OF ANALYSIS

A natural frequency of structure is the frequency under which the deflected mode shape corresponding to this frequency begin to diverge under the resonance condition. If the mode shape, as determined by a process of successive approximations of interaction, is sufficiently accurate, then the relative deflections (maximum) will remain unchanged under the inertia force related with this natural frequency.

Considering only the first mode as a start, the deflection shape of a structural member can be expressed as

$$w = W(x,y)F(t) = W(x,y)\sin\omega t \qquad (1)$$

주요어: 복합신소재, 강성, 고유진동수, 균일한 휨강성

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where, W : maximum amplitude, ω : circular frequency of vibration, t : time

The magnitudes of the maximum deflection at a certain number of points are arbitrarily given as

$$w(i,j)^{(1)} = W(i,j)^{(1)} \tag{2}$$

where (i,j) denotes the point under consideration. This is absolutely arbitrary but educated guessing is good for accelerating convergence. The dynamic force corresponding to this (maximum) amplitude is

$$F(i,j)^{(1)} = \mathrm{m(i,j)}\,[\omega(\mathrm{i,j})^{(1)}]^2 \mathrm{w(i,j)}^{(1)} \tag{3}$$

The “new” deflection caused by this force is a function of F and can be expressed as

$$\mathrm{w(i,j)}^{(2)} = \mathrm{f}[\mathrm{m(k,l)}\,[\omega(\mathrm{i,j})^{(1)}]^2 \mathrm{w(k,l)}^{(1)}]$$
$$\sum_{k,l} \triangle(\mathrm{i,j,k,l})\mathrm{m(k,l)}[\omega(\mathrm{i,j})^{(1)}]^2 \mathrm{w(k,l)}^{(1)} \tag{4}$$

where $\triangle$ is the deflection influence surface.

3. NUMERICAL EXAMPLES

As a numerical example, a cantilevered composite materials beam is considered. The uniform load of 500kg/m is treated as five concentrated loads as shown in Fig. 1.

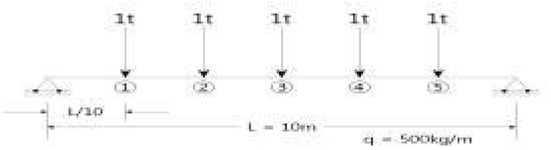


Fig. 1 cantilevered composite materials beam

The set of influence as coefficients is given in Table 1.

Table 1 Influence coefficients for cantilevered composite materials beam

i \ j	1	2	3	4	5
1	0.33	1.33	2.33	3.33	4.33
2	1.33	9.0	18.0	27.0	36.0
3	2.33	18.0	41.33	66.67	91.67
4	3.33	27.0	66.67	114.33	163.33
5	4.33	36.0	91.67	163.33	243.0

The initially guessed maximum amplitude is

$$W(1)^{(1)} = 5,\quad W(2)^{(1)} = 15,\quad W(3)^{(1)} = 50,$$
$$W(4)^{(1)} = 80,\quad W(5)^{(1)} = 100$$

These values are substituted into equations (2) and (3), and from equation (4), the following result is obtained:

$$\mathrm{w}(1)^{(2)} = 829\mathrm{m}(1)[\omega(1)^{(1)}]^2/\mathrm{EI},$$
$$\mathrm{w}(2)^{(2)} = 6809\mathrm{m}(2)[\omega(2)^{(1)}]^2/\mathrm{EI}$$
$$\mathrm{w}(3)^{(2)} = 16865\mathrm{m}(3)[\omega(3)^{(1)}]^2/\mathrm{EI}$$
$$\mathrm{w}(4)^{(2)} = 29235\mathrm{m}(3)[\omega(3)^{(1)}]^2/\mathrm{EI}$$
$$\mathrm{w}(5)^{(2)} = 45845\mathrm{m}(3)[\omega(3)^{(1)}]^2/\mathrm{EI}$$

Letting $\mathrm{w(i)}^{(1)}/\mathrm{w(i)}^{(2)} = 1$, we get

$$w(1)^{(1)} = 0.077A(1),\quad w(2)^{(1)} = 0.0469A(2)$$
$$w(3)^{(1)} = 0.0544A(3),\quad w(4)^{(1)} = 0.052A(4)$$
$$w(5)^{(1)} = 0.0468A(5)$$

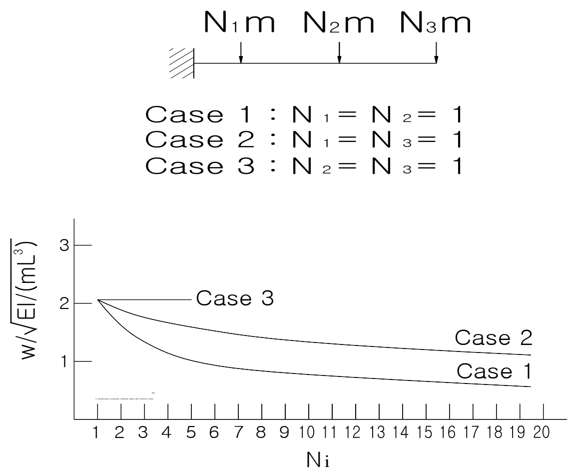
After the second cycle of calculation.

$$w(1)^{(2)} = 0.0494A(1),\quad w(2)^{(2)} = 0.0490A(2)$$
$$w(3)^{(2)} = 0.0494A(3),\quad w(3)^{(2)} = 0.0490A(4)$$
$$w(5)^{(2)} = 0.0507A(5)$$

The result obtained by the 'exact' theory is

$$w = 0.0496A$$

It is noted that the result of the second cycle is good enough for engineering purposes. It w at the point of the maximum deflection, $\mathrm{w}(5)^{(2)}$, is considered, it is only 2.2% away from the ‘exact’ result. This method was used to study the influence of mass distribution and moment of inertia on natural frequencies of cantilevered composite materials beam. The result is shown in Fig.2. In the case of cantilevered composite materials beam, increase of mass near the support does not significantly affect the vibration characteristics in Fig.2.



4. CONCLUSION

A simple but exact method of calculating the natural frequency corresponding to the first mode of vibration of cantilevered composite materials beam is presented. The influence of variable cross section and the effect of neglecting the own mass of the beam as the amount of attached mass varies are thoroughly studied.

For practical design purposes, it is desirable to simplify the vibration analysis procedure. One of the methods is to neglect the weight of the beam. It is hoped that this paper gives some guideline to such practicing engineers. This method extended to two dimensional problems including composite laminated plate.

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