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AN ANALYSIS OF THE VARIATION OF THE MECHANICAL PROPERTIES OF SOME COMPOZITE MATERIALS

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Abstract: *During the manufacture process of a composite and after this, during the use of the material, there exists many way in which the real material can have differences in comparison with the theoretical composite considered as a succession of a repeating cell. Sometime these differences can be great enough and they can have a major influence on the properties of the composite. In the paper we try to present haw these differences can influence the elastic constants of a such material. The resulting behavior of the material will determine what kind of material will be choose to correspond for an particular state of stresses.*

Key words: *composite material, mechanical properties.*

1. Introduction

In the paper the authors have continued to study the formulas for the elastic mechanical constants made in some previous papers [1], [4], [5]. The values obtained will be very important when is necessary to identify the best material for a practical purpose. For this reason the authors have used the results obtained in the mentioned papers and in other papers that have the same subject [2], [3], [6], [7]. The results are presented in a graphical manner in order to be more suggestible.

For some elastic constants a little difference between the theoretical value of some parameters can have a neglected influence but for other constants a little difference for a parameter can produce a great difference for the analyzed coefficient. These differences can be important in same applications and can determine the type of material choose.

A composite material is made by two or more components and he has properties that are different that of each constituent. To obtain the elastic constants for a such material is a very important step in a design process. For this reason are proposed some formulas, depending on the components fraction ratio, on the geometry of the composite structure, on the materials used, etc. The calculus of these properties and the stability of the proposed formulas represent a very important step when we want to find the best material for a practical purpose.

In the paper was analyzed a composite obtained by cylindrical and parallel fibers incorporated in a matrix. The results for the principal engineering mechanical constants used in the following are obtained in the paper [1]…[7].

It exists many formulas proposed for a single constant but the differences between these are not so great and we have used only one formula for each mechanical constant. The aim of the paper is not influenced by this choice.

2. The Poisson's Ratio

For the Poisson's ratio we use the following relations

$$\hat{v}_f \nu_f + \hat{v}_m \nu_m + \frac{(\nu_f - \nu_m)\hat{v}_f \hat{v}_m \left(\frac{1}{k_m} - \frac{1}{k_f} \right)}{\left(\frac{\hat{v}_f}{k_m} + \frac{\hat{v}_m}{k_f} + \frac{1}{m_2} \right)} \le \nu \le \hat{v}_f \nu_f + \hat{v}_m \nu_m + \frac{(\nu_f - \nu_m)\hat{v}_f \hat{v}_m \left(\frac{1}{k_m} - \frac{1}{k_f} \right)}{\left(\frac{\hat{v}_f}{k_m} + \frac{\hat{v}_m}{k_f} + \frac{1}{m_1} \right)},$$

where was considered: $m_f \ge m_m$.

Figure 1 present the Poisson's ratio for the case nr. 1 characterized by the following values: the matrix has the Young's modulus 0.4 MPa and the Poisson's ratio 0.35; the fiber has the Young's modulus 10.5 MPa and the Poisson's ratio 0.22. For this case we have considered that the Young's modulus of the fiber has a variation between ± 10%. We can see that, in this case, a little variation of this parameter has a neglected influence on the Poisson's ratio. The Poisson's ratio respect, well enough, the law of mixtures.

The other elastic parameter of phases have not essential influence. Fig. 2 present the same parameter for the following case: the matrix has the Young's ratio 2.7 and the Poisson's ratio 0.35 and the fiber has the Young's modulus 72.4 and the Poisson's ratio 0.22.

For the case 2 there are no practical difference on the Poisson's ratio even in the situation when the Young's modulus has a great variation. But, the other properties of the material have a strong dependence by the elastic mechanical constants

A study of the situation when the matrix has the Young's modulus 0.27 show that the results are practical the same like for the case nr.2.

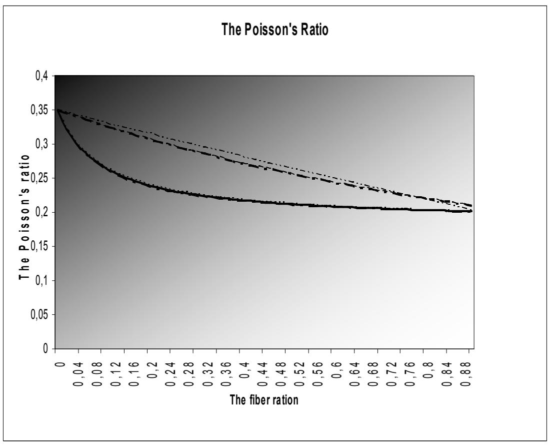

Fig.1. The Poisson's ratio for a variation of ± 10% of the Young's modulus for the case 1

If we consider that there exists a variation of ± 1% of the Young's modulus it easy to see that there is practical no variation of the Poisson's ratio. A graphical representation of the Poisson's ratio in this case look like the Figure 2.

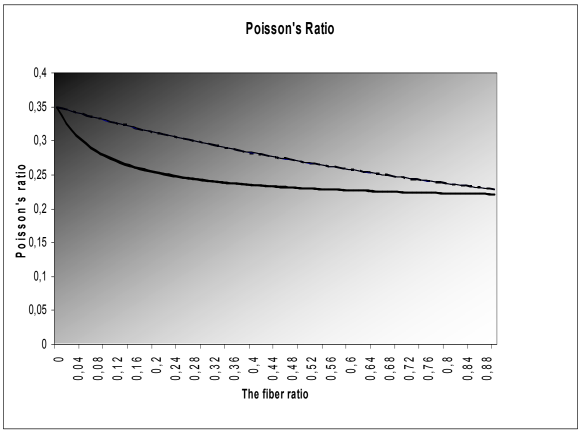

Fig.2. The Poisson's ratio for a variation of ± 10% of the Young's modulus for the case 2

3. The Bulk Modulus

The upper and lower bounds for the bulk modulus used in this paper are:

$$k^- = k_m + \frac{\hat{v}_f}{\frac{1}{k_f - k_m} + \frac{\hat{v}_m}{k_m + G_m}},$$

$$k^+ = k_f + \frac{\hat{v}_m}{\frac{1}{k_m - k_f} + \frac{\hat{v}_f}{k_f + G_f}}.$$

If we study the variation of the bulk modulus when the we have a variation of the Young's modulus between ± 10% we can see that the variation of the obtained values are small enough. We can made the observation that the variation of the Young's modulus in this case has a small influence on the bulk modulus. Figure 3 present this situation.

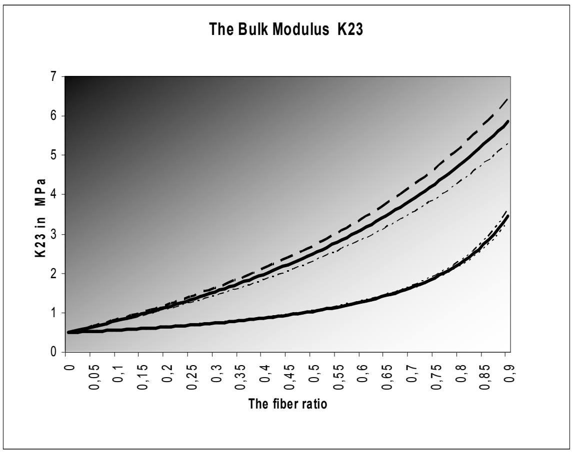

Fig. 3. The bulk modulus for a variation of ± 10% of the Young's fiber modulus for the case 1

If we consider only a variation of ± 1% we can see that, practically, the values for the bulk modulus, when we have small variations are the same (Figure 4).

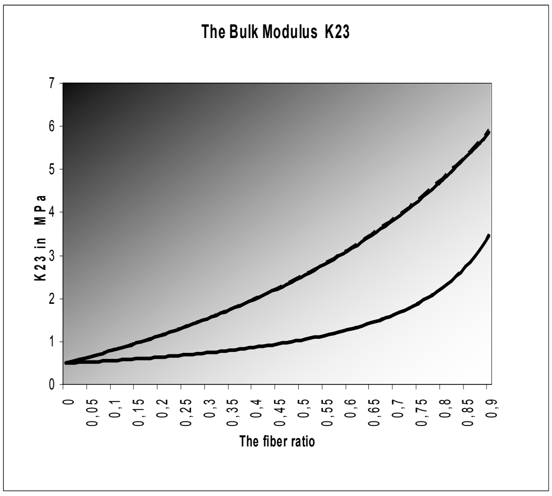

Fig. 4 The bulk modulus for a variation of ± 1% of the Young's fiber modulus for the case 1

4. The Young's Modulus

For the Young modulus we have:

$$\hat{v}_f E_f + \hat{v}_m E_m + \frac{4\hat{v}_f \hat{v}_m (\nu_f - \nu_m)^2}{(\frac{\hat{v}_f}{k_m} + \frac{\hat{v}_m}{k_f} + \frac{1}{m_m})} \leq E \leq$$

$$\leq \hat{v}_f E_f + \hat{v}_m E_m + \frac{4\hat{v}_f \hat{v}_m (\nu_f - \nu_m)^2}{(\frac{\hat{v}_f}{k_m} + \frac{\hat{v}_m}{k_f} + \frac{1}{m_f})},$$

where: $m_f \geq m_m$.

In this case because the Young's modulus formula respect very well the law of mixture a variation of the modulus for the fiber offer a variation practical the same for the composite. This conclusion is very well represented in Figure 5 and 6.

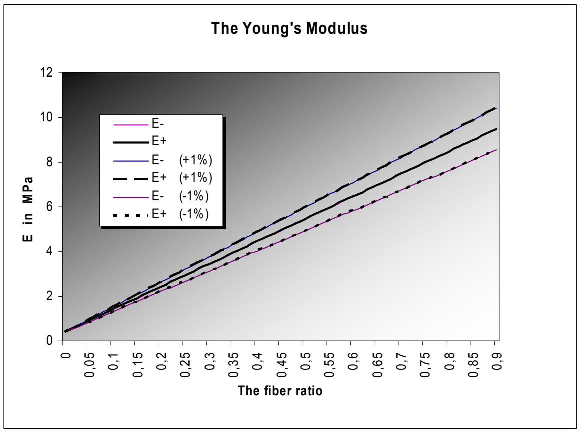

Fig.5. The Young's modulus for a variation of ± 10% of the Young's fiber modulus for the case 1

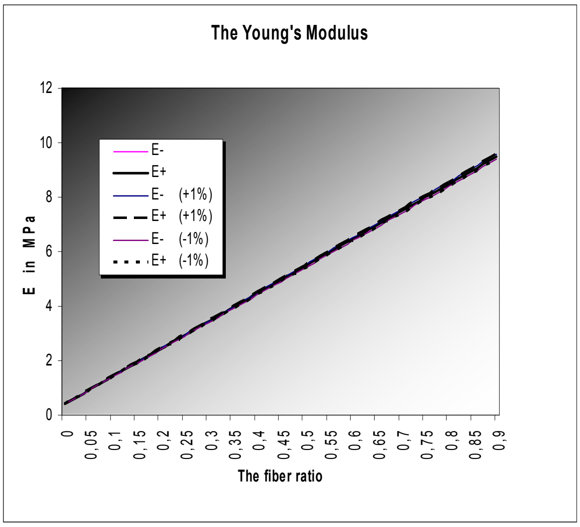

Fig. 6. The Young's modulus for a variation of ± 1% of the Young's fiber modulus for the case 1

5. The Shear Modulus

The lower and the upper bounds for the shear modulus are obtained via the relations:

$$m^{-} = G_m + \frac{\hat{v}_f}{\dfrac{1}{G_f - G_m} + \dfrac{(k_m + 2G_m)\hat{v}_m}{2G_m(k_m + G_m)}},$$

$$m^{+} = G_f + \frac{\hat{v}_m}{\dfrac{1}{G_m - G_f} + \dfrac{(k_f + 2G_f)\hat{v}_f}{2G_f(k_f + G_f)}}.$$

The shear modulus is represented in Figure 7 when we have a variation of ± 10% of the Young's fiber modulus and in fig. 8 the same modulus when the variation is only of ± 1%. We can the that for the upper value the variation has an influence but for the lower value the influence can be neglected.

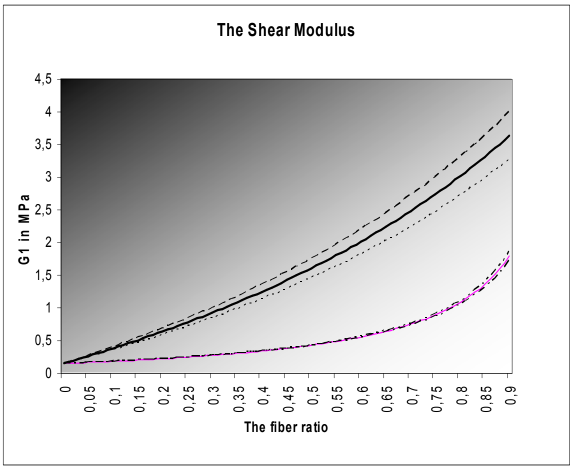

Fig. 7. The shear modulus for a variation of ± 10% of the Young's fiber modulus for the case 1

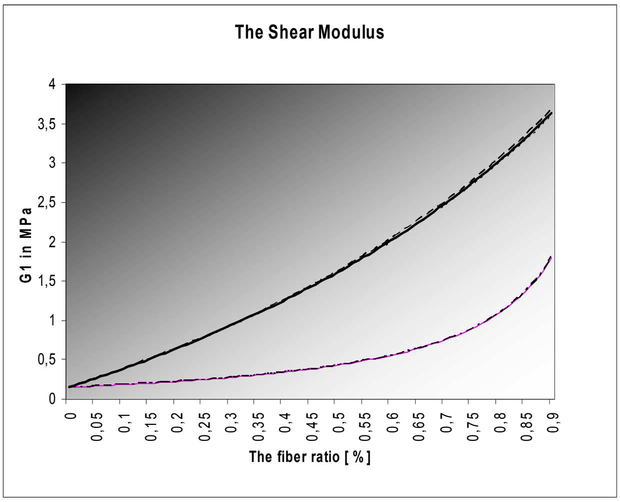

Fig. 8. The shear modulus for a variation of ± 1% of the Young's fiber modulus for the case 1

6. Conclusion

After an analysis of the influence of the variation of some parameters on the elastic constants we can conclude that can exists for some constants great variations. For this reason when we must to determine the values of elastic parameter for a composite it is very important to know the differences between the theoretical model of the material and the real shape and dimensions of this.

The properties in the longitudinal direction for a composite with aligned fibers (the Young's modulus and the bulk modulus), described by formulas that respect well the law of mixture, have practical the same variations like the variation of the Young's modulus. The Poisson's coefficient is very little influenced by these variation.

The properties in the transverse direction are strong influenced by the variations previously presented.

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