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# **Prepared Discussion Contribution** by L. Salmén after paper of D.H. Page, R.S. Seth and F. El-Hosseiny **"Strength and Chemical Composition of Wood Pulp Fibres"**

Dr. Page, I must congratulate you for being able to put some order into all these scattered data on fibre strength. However, I think you have made your analysis too simple by totally neglecting any contribution from the hemicelluloses. If we make an exhaustive model calculation starting from the molecular properties and including all the different fibre wall layers, we may estimate the contribution from the hemicelluloses. In your paper, you have used relations for the modulus of the fibre as an indication of its strength. For comparative purposes, I have adopted the same simplified approach, since the calculations are more straight forward. The model I am using has been presented elsewhere (1,2) and involves the fibre wall layers $S_1$, $S_2$ and $S_3$. It has been shown to give a good estimate of the modulus of fibres (1,2).

Figure 1 shows data for wood fibres with a cellulose content of 40% for different fibril angles of the $S_2$ wall. The solid line represents the case in which the hemicelluloses are contributing to the modulus, while the broken line represents the case in which the action of the hemicelluloses have been neglected, and only the cellulose contributes to the modulus. It is obvious that even at a fibril angle of $0^o$ the hemicelluloses are responsible for about 10% of the modulus. As expected, the influence of the hemicelluloses also increases with increasing fibril angle. This behaviour is supported by experimental evidence, which shows that the modulus of the fibre drops as the hemicelluloses are softened by the sorption of water.

We may now estimate the effect of decreasing the yield, that is increasing the relative cellulose content. In Figure 2, the modulus for fibres of different fibril angle is plotted as a function of increasing cellulose content. Evidently, the higher the $S_2$ fibril angle, the more concave is the relationship. In the literature, the data for the mechanical properties of fibres is reported over a limited interval of composition - typically 40%-80% cellulose content - and exhibits a high degree of scatter. If the data in the figure are considered over a similar interval, it can be seen that straight lines through the origin can be fitted with good precision (thin lines). This can detract from the true relationship, and is applicable to fibre strength as well as modulus.

Thus, what I want to point out is firstly that hemicellulose contributes to the mechanical properties of the fibre. Secondly, I agree that the modulus and strength of fibres are mainly governed by the properties of the cellulose. However, due to the large scatter in fibre properties, it is dangerous to assess the contribution of cellulose by relations such as the dependence of modulus and strength on cellulose content.

## REFERENCES


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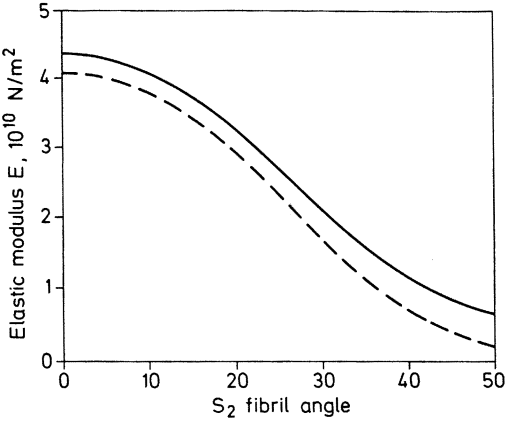


**Fig 1**—The elastic modulus of wood fibres containing 40% cellulose versus the $S_2$ fibril angle. Solid lines represent the case in which the hemicelluloses contribute to the modulus, broken lines represents the case when only the cellulose contributes.

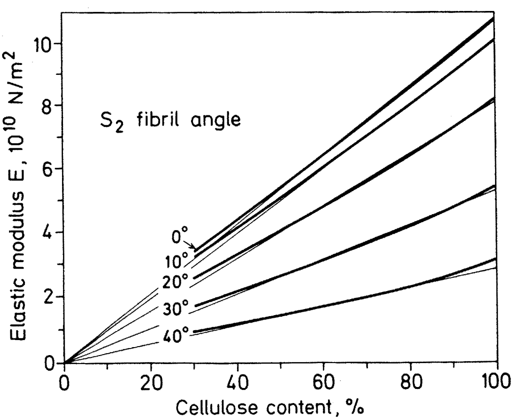


**Fig 2**—The elastic modulus of pulp fibres of different $S_2$ fibril angle as a function of cellulose content. Thin lines represent a relationship when only cellulose contributes to the modulus and are arbitrarily drawn through the origin to fit the curves in the region of 40 to 80% cellulose content.