Letter

Comments on "Elastic Stiffness and the Economics of Fibre-Reinforced Plastics" by J. Scanlan, J. Materials Sci. **3** *(1968) 339*

Scanlan confines his investigation to "situations where weight-saving . . . cannot justify a premium". We feel that this important qualification should be repeated under "Conclusions" which, as they stand, appear to forecast a very limited future for high-modulus reinforcing fibres. In comparing different materials for almost any engineering component there is some premium on saving of weight or, more fundamentally, of mass - difficult as that premium may be to quantify.

In fact when fibre-reinforced plastics replace metals the factor by which mass is reduced will frequently be several times the factor by which price is increased. Take as example an application where "it is not appropriate to increase the depth of a beam to increase its stiffness as overall dimensions are settled by other design factors" and where the volume fraction of fibre is about 0.7. Such high values both best exploit the stiffness of the fibres, as is shown by extending the abscissa in Scanlan's fig. 2, and can be successfully realised in practice with carbon and boron [1]. Then, where C and e are each much greater than 1,

$$\frac{\text{Cost of reinforced plastic}}{\text{Cost of un-reinforced plastic}} \simeq \frac{C}{e} .$$

Assuming the fibre to be used unidirectionally and using the data quoted in table III of the paper,

$$e = \frac{6 \times 10^7}{3 \times 10^5} = 200 .$$

So, for the case of the most relatively expensive fibres $C = 20{:}1$,

$$\frac{C}{e} = 0.1 .$$

Examination of fig. 2 shows that here the reinforced plastic is only some 40% more expensive than aluminium.

Now compare the masses of such reinforced-plastic and aluminium beams. Since

$$e \times \text{thickness} = \text{constant},$$

and for beams of equal width, and of mass M, specific gravity ρ,

$$\frac{M}{\text{thickness}} = \text{constant},$$

$$\text{(i)} \qquad \frac{M_c}{M_{Al}} = \frac{\rho_c \times E_{Al}}{\rho_{Al} \times E_e} .$$

For large values of ϕ and $E_r \gg E_m$ Scanlan's equation 1 approximates to

$$\text{(ii)} \qquad E_c = \phi\, E_r .$$

The corresponding equation for specific gravity is

$$\text{(iii)} \qquad \rho_c = (1 - \phi)\, \rho_m + \phi \rho_r .$$

Taking $\phi = 0.7$, $\rho_r = 2.0$ and using other data quoted in the paper, equations (i), (ii) and (iii) give

$$\frac{M_c}{M_{Al}} = 0.15 .$$

Thus the composite beam is some 600% lighter than the aluminium equivalent but costs only about 40% more.

Reference

1. H. D. BLAKELOCK and D. R. LOVELL, paper to be read at 24th S.P.I. Conference (Washington, D.C., USA, February, 1969).

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