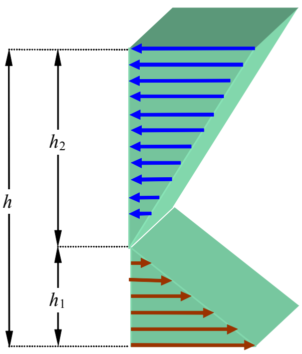
FLEXURE TESTS FOR DETERMINING TENSILE AND COMPRESSIVE MODULUS

F. Mujika[1] and I. Mondragon[2]
[1]Mechanical Engineering Department, [2] Chemical and Environmental Engineering Department
Polythecnichal University College, University of the Basque Country
Plaza de Europa 1, 20018 San Sebastian, Spain

U.P.V. E.H.U.



INTRODUCTION

Usually, no difference between tensile and compressive modulus is considered in the analysis of bending of unidirectional composites, in spite of tensile and compressive tests bring different values of modulus

In the present work, considering the difference between modulus, an experimental method in order to obtain tensile, compressive and flexure modulus using bending tests is proposed

E_t: Tensile modulus

E_c: Compressive modulus

$$\lambda = \frac{E_t}{E_c}$$

ε_t: Strain in the outer face (tensile)

ε_c : Strain in the inner face (compressive)

ρ: curvature radius

According to Classical Beam Theory

$$\varepsilon = \frac{y}{\rho} \Longrightarrow \varepsilon_t = \frac{h_1}{\rho} \qquad \varepsilon_c = \frac{h_2}{\rho}$$

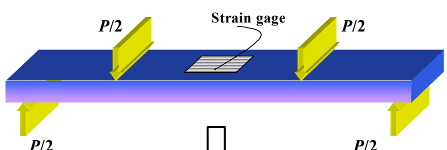
Provided that resultant force is 0

$$\int_A \sigma dA = 0 \Rightarrow \begin{cases} h_1 = \dfrac{h}{1+\sqrt{\lambda}} \\ h_2 = \dfrac{h\sqrt{\lambda}}{1+\sqrt{\lambda}} \end{cases}$$

Provided that resultant moment is M

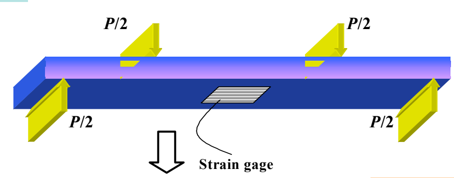
$$\int_A \sigma y dA = M \Rightarrow \begin{cases} M = \dfrac{E_f I}{\rho} \\ E_f = \beta E_t \text{ where } \beta = \dfrac{4}{\left(1+\sqrt{\lambda}\right)^2} \end{cases}$$

EXPERIMENTAL PROCEDURE



The same specimen

Maximum test load is much lesser than the failure load



Strain gage at compressive side
Slope of load-strain curve

$$\Longrightarrow m_c = \frac{P}{\varepsilon_c} = \frac{P\rho}{h_2}$$

Strain gage at tensile side
Slope of load-strain curve

$$\Longrightarrow m_t = \frac{P}{\varepsilon_t} = \frac{P\rho}{h_1}$$

As long as for the same load P the curvature radius is the same, λ and β are obtained

$$\Longrightarrow \frac{m_t}{m_c} = \frac{h_2}{h_1} = \sqrt{\lambda} \Longrightarrow \beta = \frac{4}{\left(1+\sqrt{\lambda}\right)^2}$$

Flexure modulus E_f is determined in the same specimen from the slope of load-displacement curve of a 3-point or 4-point bending test

Having determined E_f and knowing β, E_t is calculated

$$\Longrightarrow E_t = \frac{E_f}{\beta}$$

Finally, knowing E_t and λ, E_c is calculated

$$\Longrightarrow E_c = \frac{E_t}{\lambda}$$

Experimental results for 3 carbon fiber/epoxy matrix unidirectional composite materials tested in longitudinal bending

Material	Strain gage position	P/ε (N)	E_f (MPa)	λ	E_t (MPa)	E_c (MPa)
AS4/3501-6	Tension	44,922	117,900	1.193	123,300	103,400
	Compression	41,134				
AS4/8552	Tension	94,394	131,200	1.209	137,600	113,800
	Compression	85,864				
IM7/8552	Tension	188,916	150,000	1.198	157,100	131,100
	Compression	172,595				

ACKNOWLEDGMET

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