LMAF Laboratoire de mécanique appliquée et analyse de fiabilité

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Transverse Evolution of Residual Stresses in Notched Epoxy Cylinders using the OLCR Technique and Embedded FBG Sensors

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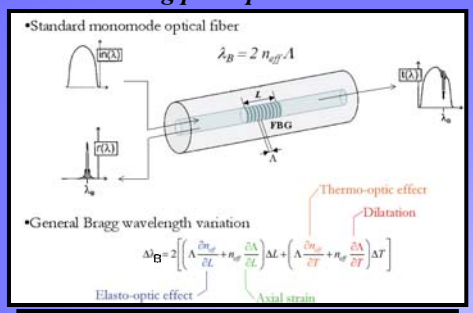
FBG working principles

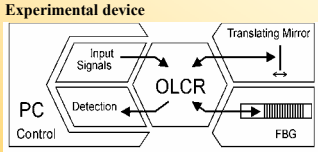


$$\frac{\Delta\lambda_B}{\lambda_B} = \left(1 - \frac{1}{2} n_0^2 P_{12}\right)\varepsilon_z - \frac{1}{4} n_0^2 (P_{11} + P_{12})\varepsilon_r + \alpha\Delta T$$

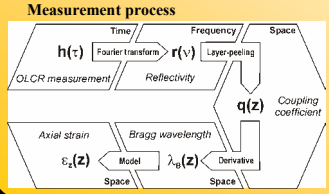
P_{11} and P_{12} are the strain-optic constants

OLCR technique

Experimental device



Measurement process



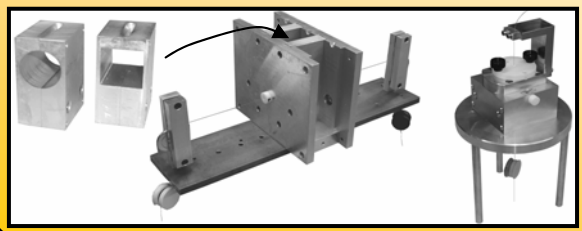
h(τ)= Complex impulse response

r(ν)= Complex spectral response

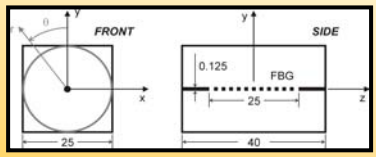
q(z)= Complex coupling coefficient

Materials and experimental methods

Specimen mould

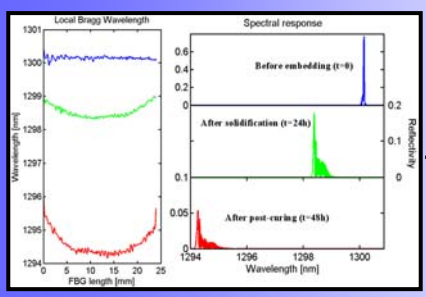


Geometrical specifications



An optical fibre is embedded in an large epoxy block /cylinder and contains a FBG sensor, which is a powerful tool to detect the non-uniform residual strain build-up during the matrix shrinkage. The grating response is analyzed by the OLCR technique, which allows one to retrieve the corresponding strain field along the fibre core without any assumption

OLCR measurements



Analysis

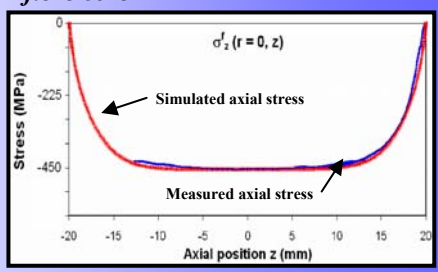
RESIDUAL STRAIN MODELING

- **Axisymmetric deformation mode**
- **Equivalent thermo-elastic approach (CTE ⇒ Shrinkage function $s_m(r,z)$)**

FINITE ELEMENT ANALYSIS

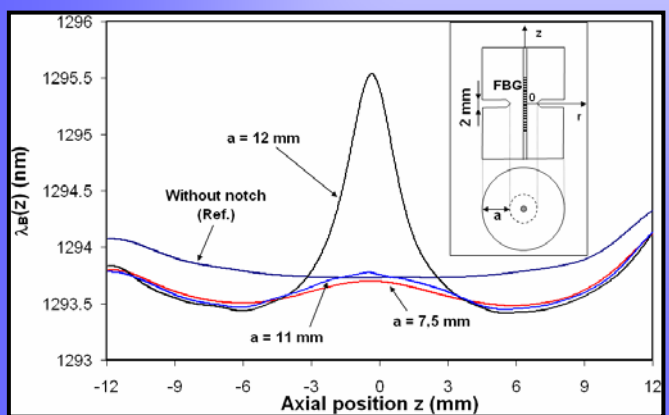
- **Solid parabolic axisymmetric elements**
- **Matrix /fibre domain: 200x100/200x30 elements**
- **Strong fibre-matrix interface**

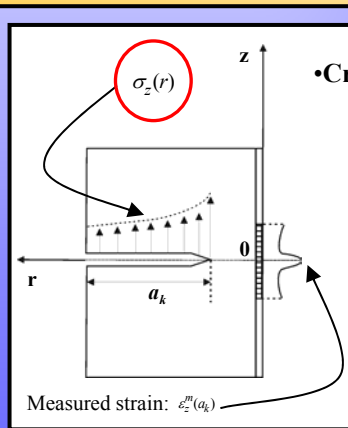
Residual stress evolution along the fibre core



Transverse evolution of residual stresses

To investigate the radial dependence of the residual stress, the Crack Compliance Method is adapted to the cylindrical geometry by measuring strains with the FBG, as a function of a circumferential crack length





•Crack Compliance Method

$$\sigma_z(r) = \sigma_0(r) = \sum_{i=0}^{n} A_i P_i(r)$$

P_i= Legendre polynomials

A_i = *non-dimensional coefficients*

$$\varepsilon_z^c(a_k) = \varepsilon_0^c(a_k) = \sum_{i=0}^{n} A_i C_i(a_k)$$

C_i= Computed Compliance

k = number of cuts

n+1 = series order

Preliminary results

- **Determination of the zone of influence of the reinforcing fibre**
- **The effect of the presence of the mechanically induced crack on the specimen**