



### Science Arts & Métiers (SAM)

is an open access repository that collects the work of Arts et Métiers Institute of Technology researchers and makes it freely available over the web where possible.

This is an author-deposited version published in: <https://sam.ensam.eu>  
Handle ID: <http://hdl.handle.net/10985/9920>

#### To cite this version :

Marco MONTEMURRO - Corrigendum to "An extension of the polar method to the First-order Shear Deformation Theory of laminates" [Compos. Struct. 127 (2015) 328-339] - Composite Structures - Vol. 131, p.1143-1144 - 2015

Any correspondence concerning this service should be sent to the repository

Administrator : [archiveouverte@ensam.eu](mailto:archiveouverte@ensam.eu)



Corrigendum

Corrigendum to “An extension of the polar method to the First-order Shear Deformation Theory of laminates” [Compos. Struct. 127 (2015) 328–339]

Marco Montemurro\*

Arts et Métiers ParisTech, I2M CNRS UMR 5295, F-33400 Talence, France

The author regrets to inform that, after the publication of the paper, he found an error about the transformation law of Eq. (20) concerning the lamina transverse shear stiffness matrix when passing from the local material frame of the ply  $\Gamma$  to the global frame of the laminate  $\Gamma^1$ . Indeed, the components of this matrix behave like those of a second-rank symmetric plane tensor with the local frame turned clockwise by an angle  $\delta_k$  around the  $x_3$  axis. Therefore, the correct relationship is:

$$\begin{aligned} \widehat{Q}_{qq} &= T + R \cos 2(\Phi - \delta_k), \\ \widehat{Q}_{qr} &= R \sin 2(\Phi - \delta_k), \\ \widehat{Q}_{rr} &= T - R \cos 2(\Phi - \delta_k). \end{aligned} \tag{20}$$

Unfortunately, this error sign causes a similar error in Eqs. (25), (26), (A.7) and (A.9) whose correct form is:

$$T_{H^*} = \begin{cases} T & \text{(basic),} \\ 2T & \text{(modified),} \end{cases}$$

$$R_{H^*} e^{i2\Phi_{H^*}} = \begin{cases} \frac{1}{n} R e^{i2\Phi} \sum_{k=1}^n e^{-i2\delta_k} & \text{(basic),} \\ \frac{1}{n^3} R e^{i2\Phi} \sum_{k=1}^n (3n^2 - d_k) e^{-i2\delta_k} & \text{(modified),} \end{cases} \tag{25}$$

$$R_{H^*} e^{i2\Phi_{H^*}} = \begin{cases} R_{1A^*} \frac{R}{R_1} e^{i2(\Phi + \Phi_1 - \Phi_{1A^*})} & \text{(basic),} \\ \frac{R}{R_1} e^{i2(\Phi + \Phi_1)} (3R_{1A^*} e^{-i2\Phi_{1A^*}} - R_{1D^*} e^{-i2\Phi_{1D^*}}) & \text{(modified),} \end{cases} \tag{26}$$

$$R_{H^*} e^{i2\Phi_{H^*}} = \begin{cases} \frac{1}{n} \sum_{k=1}^n [R \cos 2(\Phi - \delta_k) + iR \sin 2(\Phi - \delta_k)] & \text{(basic),} \\ \frac{1}{n^3} \sum_{k=1}^n (3n^2 - d_k) [R \cos 2(\Phi - \delta_k) + iR \sin 2(\Phi - \delta_k)] & \text{(modified),} \end{cases} \tag{A.7}$$

$$R_{H^*} e^{i2\Phi_{H^*}} = \begin{cases} \frac{1}{n} R e^{i2\Phi} \sum_{k=1}^n e^{-i2\delta_k} & \text{(basic),} \\ \frac{1}{n^3} R e^{i2\Phi} \sum_{k=1}^n (3n^2 - d_k) e^{-i2\delta_k} & \text{(modified).} \end{cases} \tag{A.9}$$

On the other hand, this error gives rise to a modification of the proof (given in Appendix B) for obtaining the correct form of Eq. (26). The correct proof is given here below.

In order to analytically derive the link between the deviatoric part of matrix  $[H^*]$  and the second anisotropic polar modulus  $R_1$  and the related polar angle  $\Phi_1$  of matrices  $[A^*]$  and  $[D^*]$ , let us consider the expression of quantities  $\sum_{k=1}^n e^{-i2\delta_k}$  and  $\sum_{k=1}^n (3n^2 - d_k) e^{-i2\delta_k}$  appearing in Eq. (A.9). These quantities actually depend upon the polar parameters of the membrane and bending stiffness matrices of the laminate. To derive these relationships let us consider the following property of complex numbers:

$$\overline{\alpha z + \beta w} = \alpha \bar{z} + \beta \bar{w}; \quad \text{with } z, w \in \mathbb{C} \quad \text{and } \alpha, \beta \in \mathbb{R}, \tag{B.0}$$

where  $\bar{z}$  is the complex conjugate of  $z$ . By using property (B.0) and considering Eqs. (22) and (24) we have:

$$\begin{aligned} \sum_{k=1}^n e^{-i2\delta_k} &= \sum_{k=1}^n \overline{e^{i2\delta_k}} = \sum_{k=1}^n \overline{e^{i2\delta_k}} = n \frac{R_{1A^*}}{R_1} \overline{e^{i2(\Phi_{1A^*} - \Phi_1)}} \\ &= n \frac{R_{1A^*}}{R_1} e^{i2(\Phi_1 - \Phi_{1A^*})}, \end{aligned} \tag{B.1}$$

$$\begin{aligned} \sum_{k=1}^n d_k e^{-i2\delta_k} &= \sum_{k=1}^n \overline{d_k e^{i2\delta_k}} = \sum_{k=1}^n \overline{d_k e^{i2\delta_k}} = n^3 \frac{R_{1D^*}}{R_1} \overline{e^{i2(\Phi_{1D^*} - \Phi_1)}} \\ &= n^3 \frac{R_{1D^*}}{R_1} e^{i2(\Phi_1 - \Phi_{1D^*})}. \end{aligned} \tag{B.2}$$

The expression of quantity  $\sum_{k=1}^n (3n^2 - d_k) e^{-i2\delta_k}$  can be obtained by combining Eqs. (B.1) and (B.2) as follows:

$$\begin{aligned} \sum_{k=1}^n (3n^2 - d_k) e^{-i2\delta_k} &= 3n^2 \sum_{k=1}^n e^{-i2\delta_k} - \sum_{k=1}^n d_k e^{-i2\delta_k} \\ &= \frac{n^3}{R_1} e^{i2\Phi_1} (3R_{1A^*} e^{-i2\Phi_{1A^*}} - R_{1D^*} e^{-i2\Phi_{1D^*}}). \end{aligned} \tag{B.3}$$

DOI of original article: <http://dx.doi.org/10.1016/j.compstruct.2015.03.025>

\* Tel.: +33 55 68 45 422; fax: +33 54 00 06 964.

E-mail addresses: [marco.montemurro@ensam.eu](mailto:marco.montemurro@ensam.eu), [marco.montemurro@u-bordeaux1.fr](mailto:marco.montemurro@u-bordeaux1.fr)

Finally, by substituting Eqs. (B.1) and (B.3) into Eq. (A.9) (and after some standard passages) it is possible to obtain the desired result:

$$R_H e^{i2\phi_H} = \begin{cases} \frac{1}{n} R e^{i2\phi} n \frac{R_{1A^*}}{R_1} e^{i2(\phi_1 - \phi_{1A^*})} = R_{1A^*} \frac{R}{R_1} e^{i2(\phi + \phi_1 - \phi_{1A^*})} & \text{(basic),} \\ \frac{1}{n^3} R e^{i2\phi} \frac{n^3}{R_1} e^{i2\phi_1} (3R_{1A^*} e^{-i2\phi_{1A^*}} - R_{1D^*} e^{-i2\phi_{1D^*}}) \\ \quad = \frac{R}{R_1} e^{i2(\phi + \phi_1)} (3R_{1A^*} e^{-i2\phi_{1A^*}} - R_{1D^*} e^{-i2\phi_{1D^*}}) & \text{(modified).} \end{cases} \quad (\text{B.4})$$

Nevertheless, the mentioned error does not affect at all nor the numerical results presented in the paper neither the conclusions, since the above relationships were correctly implemented into the numerical code employed to carry out all of the calculations.

The author would like to apologise for any inconvenience caused.