Brazilian test for the characterization of adhesively bonded joints

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In the present work, we propose the use of the Brazilian test on a adhesively bonded disk for the characterization of adhesion properties of the adhesive. The main advantage of this test is that any combination of shear and normal loading can be achieved by appropriate choice of the bonding inclination angle with respect to the loading direction. A closed-form full-field solution is presented for stresses and displacement in a circular disk containing a diametrical adhesive thin layer induced by two opposite compressive loads acting along an arbitrary diametrical direction. For the sake of simplicity, the adhesive layer is treated as a tangential displacement discontinuity between the two disk halves. The problem is split into symmetric and skew symmetric loading conditions. No contribution is expected from the layer for the symmetric problem. For the skew-symmetric loading condition, a general integral solution in bipolar coordinates has been assumed for the Airy stress function in the form of a Fourier sine transform [1, 2]. The imposition of the boundary conditions then allows us to reduce the problem to a Fredholm integral equation of the first kind defined on the half-line or equivalently to a singular integro-differential equation defined on a bounded interval. A preliminary asymptotic analysis of the stress and displacement fields at the edges of the adhesive thin layer shows that the stress field is regular therein, but the rotation displays a logarithmic singularity [3]. A numerical solution of the singular integro-differential equation is then provided by assuming a power series expansion for the shear stress distribution, whose coefficients are found by means of a collocation method. An approximate closed-form solution is also derived by exploiting a perturbation method that assumes the ratio between the shear modulus of the disk material and the shear stiffness of the adhesive thin layer as small parameter [4]. The shear stress distribution along the thin layer turns out to be more and more uniform as the adhesive shear stiffness decreases. In order to validate the analytical results, FE investigations and also experimental results obtained by using Digital Image Correlation (DIC) techniques are presented for varying loading orientation and material parameters. The present investigation thus provides some fundamental understandings of the effects of adhesive compliance on the distribution of the shear stress along the adhesive bonding. The analytical solution presented here may be considered particularly valuable, since it allows for the validation of numerical methods as well as for a preliminary design of adhesively bonded connections employed in many structural engineering applications.

References

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