A variationally consistent membrane wrinkling model based on spectral decomposition of the strain and stress tensors

Lecture of

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We present a variationally consistent membrane wrinkling model based on spectral decomposition of the strain and stress tensors and on the mixed wrinkling criterion, which can accurately capture the different membrane states (taut, wrinkled, slack) in arbitrary deformation states. Separating the principal strains and stresses into tension and compression, the strain energy is split into tensile and compressive parts, and the compressive strain energy is removed or degraded to a small amount, offering modeling flexibility. Retaining a small amount of compressive stiffness helps preventing element interpenetration and allows for slack states, thereby enhancing the robustness of the method. From this modified energy functional, the whole formulation is derived in a variationally consistent manner. The formulation is simple, it requires only the determination of principal strains and stresses. Assuming isotropic material, everything can even be expressed in terms of the principal strains only, making the model perfectly suited for any displacement-based finite element analysis scheme. The model employs the mixed wrinkling criterion, formulations employing the strain- and stress-based wrinkling criteria can be obtained by minor modifications. We use this fact for performing a comparison of the different criteria, which confirms that only the mixed criterion can accurately predict the membrane wrinkling behavior in arbitrary deformation states. Extensive validation through analytical, numerical, and experimental benchmark tests highlights the accuracy, robustness and effciency of the model.

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