On virtual elements for Kirchhoff-Love plates and shells

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The virtual element method is based on an ansatz space in which the ansatz is only defined at the boundary. This feature permits to revisit the construction of Kirchhoff-Love (KL) plate elements of arbitrary shape. The C1-continuity condition is much easier to handle in the VEM framework than in the traditional finite element methodology. We will show various VEM elements suitable for KL plates which are much simpler than the well-known TUBA finite elements. Based on a geometrically exact thin KL shell models we will construct virtual elements for large deflections and compare these with a similar formulation for TUBA elements. The formulation contains new ideas and different approaches for the stabilization needed in a virtual element setting. In the case of C1-continuous elements it is crucial to use an efficient stabilization, otherwise the rank deficiency of the stiffness matrix associated with the projected part of the test function is more pronounced than for C0-continuous elements. In this contribution we demonstrate how to construct simple and efficient virtual plate elements for isotropic and anisotropic materials.

The formulation will then be extended to geometrically exact shell elements. Various benchmark examples and convergence studies demonstrate the accuracy of the resulting VEM elements.

Finally, reduction of virtual plate elements to triangular and quadrilateral elements with 3 and 4 nodes, respectively, yields finite element like plate elements which are much simpler than TUBA elements. It will be shown that these C1-continuous elements can be easily incorporated in legacy codes and demonstrate an efficiency and accuracy that is much higher than provided by traditional finite elements for thin plates and shells.