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STABILIZED FINITE ELEMENT FORMULATION FOR CONVECTIVE TRANSPORT PROBLEMS WITH SHARP GRADIENTS VIA HIGHER ORDER FINITE CALCULUS

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ABSTRACT

We present an enhanced stabilized finite element (FEM) formulation for convective transport problems using a higher order finite calculus (FIC) formulation. The FIC-FEM approach is based on solving a modified set of governing differential equations obtained by expressing the equations for balance of fluxes in a domain of finite size [1-3]. The proposed method retains higher order terms in the standard Taylor expansions leading to a modified set of governing equations accounting for the second derivatives of the standard residual terms. The weighted residual form is obtained using modified non-load test functions which are consistent with the new governing differential equations. The FIC terms in the discretized equations via the standard FEM introduce the necessary stability to accurately model sharp gradient of the solution in boundary layers and also in the interior of the analysis domain typical of convection-diffusion-reaction problems. The paper explains the procedure to compute the higher order FIC terms in the discretized integral expressions involving second derivatives of the unknowns using patches of linear triangles and tetrahedra. A key advantage of the new FIC-FEM method is that it allows to obtain accurate stabilized problems in a single solution step. Examples of the good performance of the FIC-FEM method proposed are shown for a number of convection-diffusion problems with arbitrary sharp gradients

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