

## **Simultaneous shape and material optimization of functionally graded structures using a generalized isogeometrical analysis approach**

In this paper we introduce a new methodology in the framework of isogeometric analysis for simultaneously shape optimization and material design of functionally graded structures. The proposed method which employs an improved form of the standard isogeometric analysis method allows gradation of material properties through the patches. The gradation of material properties are considered as imaginary surfaces over the computational domain and captured in a fully isoparametric formulation using the same NURBS basis functions employed for construction of the geometry and approximation of the solution. Subsequently, the coordinates of the control points defining the design boundary surface as well as the imaginary heights of all the control points that define the variations of material properties are considered as the design variables of the optimization problem. A mathematical programming algorithm is then employed to find the design variables so that simultaneously reach the optimum shape and volume fraction distributions of the material constituents. It is shown that the proposed method considerably alleviates the difficulties of the existent methods. Some examples of 2D elasticity problems with stress constraints are presented to demonstrate the performance of the proposed method. It will be shown that the obtained results with this concurrent method have much better performance compared to the optimal results of the consequent shape and material distribution.

### **Keywords:**

Generalized Isogeometric Analysis, Shape Optimization, Material Distribution, Functionally Graded Materials.