Revisiting Size Scale Effects in Phase-field

Pavan Kumar Asur VK [1]*, Kairul Anam[1], Jose Reinoso[2] Heinz E. Pettermann[1]

[1] Institute of Lightweight Design and Structural Biomechanics, Technische Universität Wien, Getreidemarkt 9, 1060 Vienna, Austria. pavan.kumar@ilsb.tuwien.ac.at

[2] Elasticity and Strength of Materials Group, School of Engineering, University of Seville, Camino de los Descubrimientos s/n, 41092, Seville, Spain

The study of size scale effects on fracture in materials science is a complex and ongoing challenge. Despite numerous advances in computational modeling, there is still much to be learned about how the size and shape of a material influences its fracture behavior. This is a critical area of research, as a thorough understanding of size scale effects is essential for accurately predicting and improving the mechanical properties of materials. As noted by Bazant, "If scaling is not understood, the theory itself is not understood" [1]. With the recent development of phase field theory, there is a renewed focus on understanding the size effects on fracture and how they impact material behavior.

This research introduces a geometrical scaling framework to capture the geometric transformation relationship between material models and scaling. The framework utilizes a scaling matrix that defines the transformation between the original and scaled domains and adjusts the gradient operator accordingly without loosing variational formulation, allowing it to handle various scaling scenarios including lateral expansion, horizontal expansion, symmetric scaling, and rotations. The proposed framework has been applied to AT1, AT2 [3], and PFCZM [4] models and has been successful in mimicking the original and scaled models without the need for additional model development or computational resources. The model is solved using both variational inequality (fenicsx) and ABAQUS (UEL) to ensure unbiased results. Furthermore, the model has the ability to recover size scale laws and structural bifurcations with constant computational time for any scaling within the framework. Moreover, mesh issues concerning phase field are addressed.

As an example, a plate with a notch is studied using a scaled model of dimension (1×1) to represent the results of the original model $(x \times y)$. Figure 1a shows the scaling of the symmetrical model while Figure

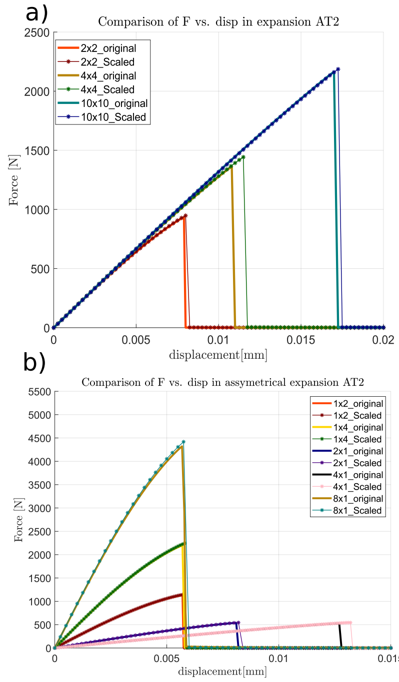

Figure 1: a) Comparison of Symmetrical, and b) asymmetrical loading on AT2 model with scaled and original model [2].

1b presents the lateral and horizontal scaling on the AT2 model, with a comparison between the scaled and original models.

References

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