World Academy of Science, Engineering and Technology
International Journal of Mechanical and Industrial Engineering
Vol:17, No:07, 2023

Breaking Stress Criterion that Changes Everything We Know About Materials Failure

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Abstract : Background: The perennial deficiencies of the failure models in the materials field have profoundly and significantly impacted all associated technical fields that depend on accurate failure predictions. Many preeminent and well-known scientists from an earlier era of groundbreaking discoveries attempted to solve the issue of material failure. However, a thorough understanding of material failure has been frustratingly elusive. Objective: The heart of this study is the presentation of a methodology that identifies a newly derived one-parameter criterion as the only general failure theory for noncompressible, homogeneous, and isotropic materials subjected to multiaxial states of stress and various boundary conditions, providing the solution to this longstanding problem. This theory is the counterpart and companion piece to the theory of elasticity and is in a formalism that is suitable for broad application. Methods: Utilizing advanced finite-element analysis, the maximum internal breaking stress corresponding to the maximum applied external force is identified as a unified and universal material failure criterion for determining the structural capacity of any system, regardless of its geometry or architecture. Results: A comparison between the proposed criterion and methodology against design codes reveals that current provisions may underestimate the structural capacity by 2.17 times or overestimate the capacity by 2.096 times. It also shows that existing standards may underestimate the structural capacity by 1.4 times or overestimate the capacity by 2.49 times. Conclusion: The proposed failure criterion and methodology will pave the way for a new era in designing unconventional structural systems composed of unconventional materials.

Keywords : failure criteria, strength theory, failure mechanics, materials mechanics, rock mechanics, concrete strength, finite-element analysis, mechanical engineering, aeronautical engineering, civil engineering
Conference Title : ICSMFEA 2023 : International Conference on Solid Mechanics and Finite Element Analysis
Conference Location : Toronto, Canada
Conference Dates : July 10-11, 2023