Path Instability Criterion for Non-Potential Problems in Rate-Independent Plasticity

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Instabilities in plastically deformed solids can manifest themselves in various ways. In general, instabilities can be of a dynamic, geometric or material type, sometimes simultaneously. They can be treated in a unified manner by referring to the energy criterion of path stability, as demonstrated in a long series of works initiated by the author in 1982. This leads to a computational approach that uses incremental energy minimization and has become more popular in the past two decades. This approach, however, is limited to the incremental problems that admit an energy-based potential.

In this lecture, the incremental energy minimization is extended to a broad class of non-potential rate-independent problems. It is based on the recently proposed [1] quasi-extremal energy principle (QEP) which can be applied when ordinary stationarity or minimum principles fail. The key point is that the minimized energy function then depends not only on the variables undergoing variations but also on an unknown solution as a parameter.

The energy criterion of path stability, built into the QEP, provides a method for selecting a solution among many alternatives. In this way, the post-critical deformation branch can be selected automatically during the computation and tracked to examine a series of successive instabilities. This is shown by examples of large deformation of a fcc metal crystal with lattice rotations and associated multiple changes of active slip-systems. Application of the QEP to gradient plasticity is also discussed.

References

[1] Petryk, H., A quasi-extremal energy principle for non-potential problems in rate-independent plasticity, *J. Mech. Phys. Solids* 136, 103691 (2020).