Direct computation of failure boundaries

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Abstract

Predicting the behaviour of a structure when subjected to an earthquake is an important problem from Civil Engineering. Here, we consider a planar post-tensioned frame, which can be modelled as a two-degree-of-freedom system that is equivalent to the analytical model of a tied rocking block on an elastic foundation. The frame remains structurally sound as long as the tilt angle of the frame does not exceed a certain maximal angle. A standard approach to studying the dynamics would be to run simulations, where it is assumed that the earthquake is a pure sine wave with varying frequency and amplitude. Such a brute-force approach establishes a region in the frequency-amplitude plane for which the structural stability of the frame eventually fails. We propose a novel approach that calculates the failure region in a much more efficient way by determining the failure boundary directly. Our method is based on continuation of a suitable two-point boundary value problem. Our computations demonstrate that the failure boundary is only piecewise smooth and the results highlight further interesting details of how the dynamics is organised in the frequency-amplitude plane.

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