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Researcher: Ken Gavin **University:** Delft University of Technology
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Nonlinear dynamic load-displacement response of foundation piles under progressive damage

Soil supporting foundations for infrastructural assets such as bridges are repeatedly subjected to dynamic loading from passing traffic.

The load-displacement characteristics are nonlinear at even small to medium strains, however this effect is mostly modelled using secant stiffness models with effective linear stiffness. This simplification enables a pseudo linear model to encapsulate the effects of a nonlinear system with some accuracy.

Linear models have a frequency related to the amplitude of the load used to specify the secant stiffness.

Nonlinear models, however, have a range of frequencies due to the changing stiffness of the system resulting from the amplitude of the input load. There is growing uncertainty surrounding the response of foundation systems to damage effects. In particular scour erosion, which is the term used to describe removal of soil from around foundation elements by hydraulic action, presents a significant hazard to infrastructure and is becoming more prevalent with increased flooding risk due to climate change effects. This research describes a numerical framework to incorporate a basis for nonlinearities in the load-displacement response modelling of pile foundations.

The Newmark-Beta nonlinear integration solver is implemented in the study. A case study is presented of a pile foundation subjected to a range of load types and progressive scour damage, and the calculated response from the various conditions is evaluated. Periodic loads of varying amplitude are implemented. Effective linear models are developed based on the secant stiffness approach and compared to the nonlinear systems •