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STRUCTURAL OPTIMIZATION OF ELASTOPLASTIC STRUCTURES UNDER SHAKEDOWN CONDITIONS

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ABSTRACT

First, it is outlined that common structural shape optimization methods (e.g. weight minimization for static loads) are problematic in case of elasto-plastic deformations combined with load spaces. This is because the growth of plastic deformations for a given n-dimensional load space with an arbitrary number of load cycles can only be modeled by an adequate shakedown theorem (or more refined theorem), in this paper by Melan's static shakedown theorem for linear unlimited kinematic hardening material behavior. Herein, no aging by micro- or meso-damage is considered, allowing for an infinite number of load cycles within the given load space [1], see also [2, 3].

An adequate formulation of the structural optimization problem, including shakedown analysis, requires variations of residuals, objectives, and constraints, which is presented briefly [1].

2D problems are discretized with isoparametric finite elements, yielding the 'tangent stiffness matrix' and the 'tangent sensitivity matrix' as well as the corresponding matrices for the variation of the Langrangian functional. The computer implementation is discussed, and the efficiency of the proposed algorithm is shown by examples.

Important effects of shakedown conditions in shape optimization with elasto-plastic deformations are highlighted, comparing the results for optimized systems with elastic and elasto-plastic material behavior, from which the necessity of shape optimization under shakedown conditions for elasto-plastic material deformations and n-dimensional load spaces is deduced, i.e. for guaranteeing structural safety.

The following example, Fig. 1, of a plate with a hole in plane stress state shows three different resulting optimized shapes for (i) elastic deformations, (ii) one-cycle elasto-plastic deformations (load point) and (iii) kinematically hardening elasto-plastic deformations for an unlimited number of load cycles in the given load domain.

Finally, the question of the necessity of shakedown investigations instead of using only

ultimate load theorems in common civil-engineering structures is discussed.

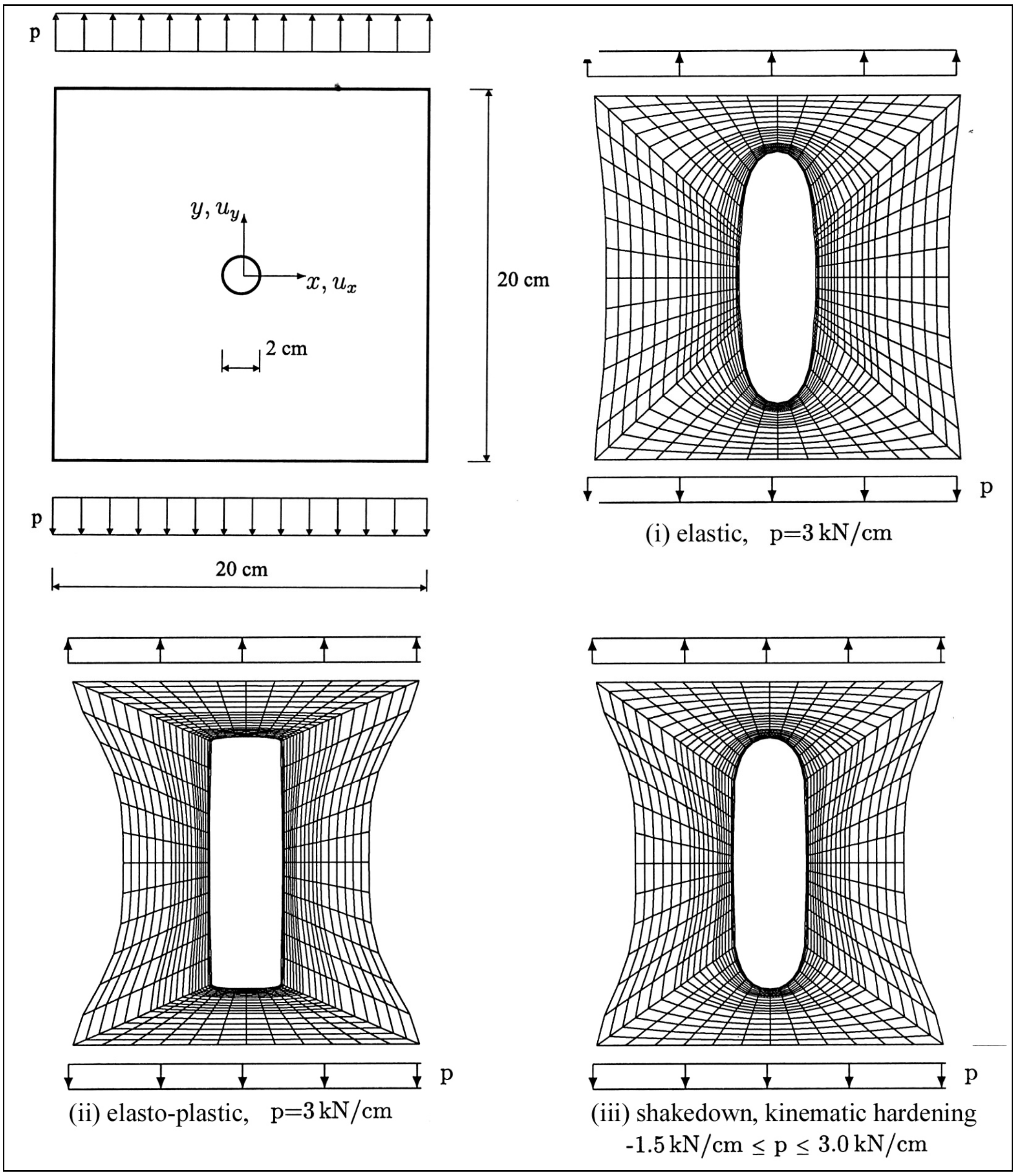

Figure 1: Shape optimization of a plate with a hole in plane stress state with three types of material behavior and two types of loading

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