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# Direct determination of initial imperfections: The most unfavourable and most favourable initial shape

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## ABSTRACT

The paper presents an optimization method for direct determination of the most unfavourable imperfection of structures by means of ultimate limit states. When analyzing imperfection sensitive structures it turns out that the choice of the shape and size of initial imperfections has a major influence on the response of the structure and its ultimate state. Within the optimization algorithm the objective function is constructed by means of a fully nonlinear direct and first order sensitivity analysis ([3], [4], [5], [6]). The method is not limited to small imperfections or a linear fundamental path based on Koiters asymptotical theory ([1], [2]) and also allows the imposition of "technological" constraints on the shape of the imperfection, thus making it possible to avoid unrealistically low ultimate loads. When carefully constructed, the objective function and constraints remain linear enabling the use of numerically efficient and readily available linear programming algorithms.

The most unfavourable initial imperfection shape with a specified amplitude has to represent a change in the geometry of a structure in the most unfavourable way so that the ultimate load of the imperfect structure is the smallest possible. The evaluated imperfection shape is unique under the given circumstances and can not be determined intuitionally as this can be the case when using more simple theories, where for example the lowest load of a structure can be achieved with considering its lowest buckling mode as the initial imperfection. In the same manner, the most favourable imperfection can be evaluated where the limit load is the highest possible at a certain imperfection amplitude. The imperfections are represented as a linear combination of the chosen base shapes within the amplitude prescribed by the principle of equivalent geometrical imperfections. Base shapes can be chosen arbitrary. The most convenient set of shapes is the set of buckling shapes which can be extended by eigenshapes, empirically known worst shapes or deformation shapes.

Despite of the intensive research on theoretical, experimental and numerical aspects of stability limit of imperfection-sensible structures, there is still no consensus on how the ultimate state should be evaluated, owing to numerous difficulties which arise. In complex structures where intuitive determination of initial most unfavourable imperfections is not possible or where there is a lack of known empirically obtained worst imperfections, the use of a method for determining the worst initial shape is essential.

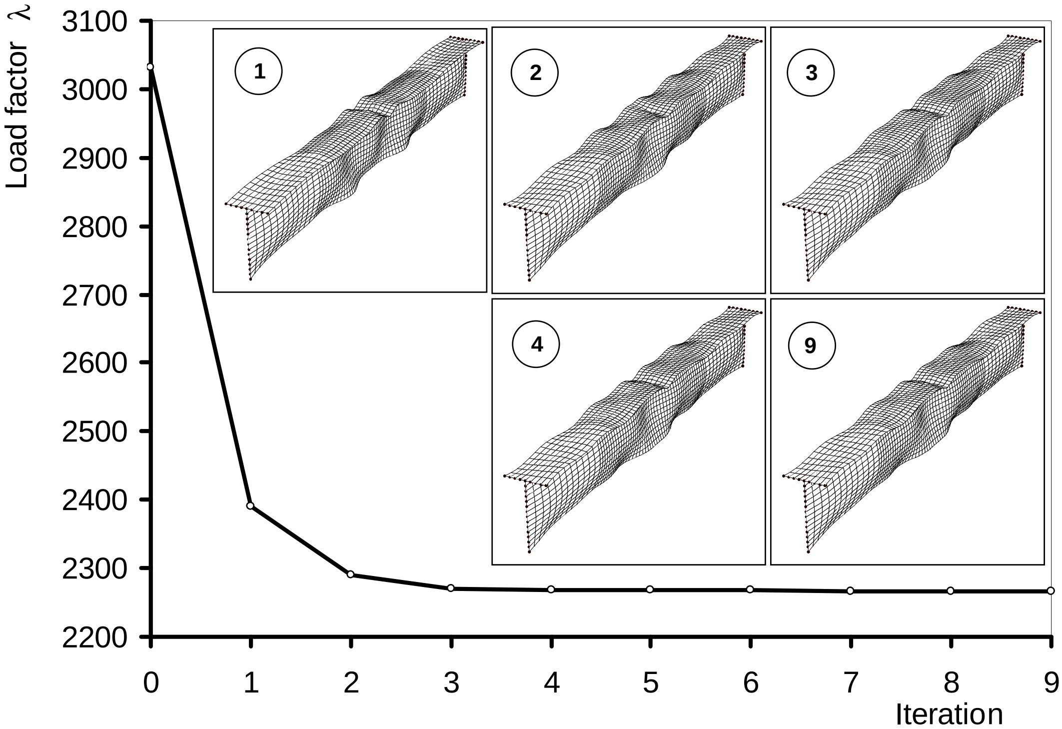


Figure 1: Example showing the convergence of the global iterative optimization process of finding the most unfavorable imperfection shape of a T cross-section thin walled beam with considering 52 base shapes. The most unfavourable initial imperfection is achieved within engineering tolerances in the $9^{th}$ iteration.

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