Discussion on Problems in Buckling Analysis of a Continua

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Abstract. In linear buckling analysis the eigenvalue problem, that constitutes the background for estimating critical buckling load, is

\[ ([S_0] + \lambda[S_\sigma])\{\Delta\} = \{0\} \]  \hspace{1cm} (1)

where \([S_0]\) is the initial global stiffness matrix and \([S_\sigma]\) is the stress stiffness matrix that is part of the tangential stiffness matrix, both obtained based on linear elasticity. The matrix \([S_\sigma]\) is obtained by a reference load vector \(\{\bar{A}\}\) and a factor on \(\{\bar{A}\}\) implies the same factor on \([S_\sigma]\). The estimated critical buckling load vector is \(\{A\}_C = \lambda_1\{\bar{A}\}\) where \(\lambda_1\) is the lowest eigenvalue for the eigenvalue problem (1). From the assumption of linearity between \(\{\bar{A}\}\) and \([S_\sigma]\) follows directly, that the critical buckling load vector \(\{A\}_C\) is independent of the size(norm) of \(\{\bar{A}\}\). This implies uncertainty in linear buckling analysis, and this is illustrated by applying geometrical non-linear displacement analysis, that shows that buckling load also depends on the norm of \(\{\bar{A}\}\). The relations between the individual stress components in a finite element are unchanged for linear buckling analysis. However, with geometrical non-linear displacement analysis this is not the case, even assuming material linear elasticity. This also give doubts to the estimated buckling load, obtained by linear buckling analysis. The geometrical non-linear buckling analysis is based on the full tangential stiffness matrix \([\bar{S}_t]\) that is separated in a gamma stiffness matrix \([\bar{S}_\gamma]\) and a stress stiffness matrix \([\bar{S}_\sigma]\). These matrices depend on a reference load \(\{\bar{A}\}\) and therefore the stiffness matrices contain a bar notation and must be determined by iteration. The eigenvalue problem for non-linear buckling analysis is interpreted as an extrapolation along the tangential stiffness matrix

\[ ([\bar{S}_t] + \lambda[\bar{S}_\sigma])\{\Delta\} = \{0\} \]  \hspace{1cm} (2)

Applying this approach for estimating non-linear buckling analysis, comparison to (1) is used to show errors from linear buckling analysis, i.e., for initial uniform and unchanged design the buckling load as a function of the size(norm) of reference load \(\{\bar{A}\}\) is shown not to be constant. A cantilever beam-column and a frame of two beam-columns are used as examples.