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Physics-based initial guess of conjugate gradient method for solid element analysis

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Physics-based initial guess of Conjugate Gradient (CG) method for solid element analysis is proposed by using the meta-modeling theory which allocates structural mechanics as a mathematical approximation of continuum mechanics. Based on the meta-modeling theory, the finite element analysis can be readily classified as the solid element analysis which is the most accurate and the structural element analysis which is an approximation of solid element analysis.

The basic idea of this study is to use an approximate solid element solution which is converted from a beam element solution, as the initial solution (initial guess) of the CG method for solid element analysis. The meta-modeling theory ensures that the most suitable beam element solution is the closest to the solid element solution since a distance between them is rigorously defined in a function space of continuum mechanics the improved CG method has the capability to significantly reduce the computational cost that is needed for solid element analysis. Therefore, this study promotes the use of solid element analysis in engineering problems. Displacement controlled static analysis of a frame structure is considered the numerical example of the proposed CG method. The results show that the number of iterations is drastically reduced in the proposed CG method compared to the ordinary CG method. There is hope that this reduction of computational cost of solid element analysis will be more significant with the magnitude of the problem targeted.

In the future, authors are planning to develop a physics-based preconditioning for the CG method which is more effective than the physics-based initial guess of the CG method. While there are numerous mathematical studies about pre-conditioning for the CG method, as far as the authors have studied, there is some possibility for physics-based preconditioning which employs the meta-modeling theory, and authors are presently working on it.