Numerical Investigation of Dynamic Contact Problems using Finite Element Method

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1. Introduction

There is a great interest towards the examination of dynamic contact and impact problems [1] due to their widespread applicability. The proper solution of these kinds of problems can be especially momentous in such fields like cogwheel drives and cutting metalwork. Contact and impact problems are hard to handle as a substantial nonlinearity occurs in the displacement field. The main problem is that due to the spatial discretization a spurious high frequency oscillation emerges in the resulting functions, which can easily cause divergence in the contact algorithm. Thus, in our study we focused on the best possible elimination of these oscillations by which the choice of the proper numerical method has a great importance.

2. Results and Discussion

When assessing the developed method, a simple one-dimensional problem is reviewed (see Fig. 1) which contains an elastic rod moving towards a rigid wall with a constant $\boldsymbol{v_0}$ velocity. In the literature, this 1D example is regarded as a standard test problem in which the exact solution have not been accurately reproduced yet using numerical methods. It emerges in many recent publications such as in the paper by Kim [2] showing that it is still actual to deal with this problem.

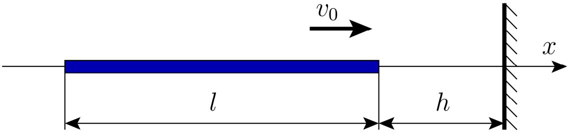

Fig. 1. The mechanical model of the examined 1D problem

After the spatial discretization using the finite element method [3], the equation of motion can be written in the form of

$$\mathbf{M}\ddot{\mathbf{u}} + \mathbf{C}\dot{\mathbf{u}} + \mathbf{K}\mathbf{u} + \mathbf{G}^{\mathrm{T}}\lambda = \mathbf{f} \tag{1}$$

where **M** is the mass matrix, **C** is the damping matrix, **K** is the stiffness matrix, **G** is the contact constraint matrix, **f** is the load vector, **u** is the nodal displacement vector and λ denotes the contact pressure. In the solution of the contact problem, the Lagrange multiplier technique was applied using the method published by Carpenter et al. [4]. The time integration of equation (1) was performed applying our newly developed forward increment method. In order to obtain the effectiveness of the proposed method, other solutions are also considered using well-known time integration methods like the backward Euler method, the Newmark method [5] and the HHT-α method [6] (see Fig. 2). Further details will be provided in the presentation.

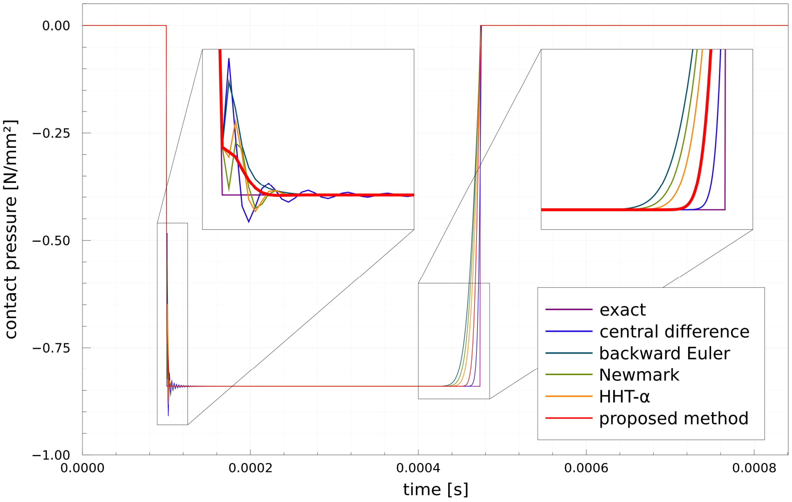

Fig. 2. Time evolution of contact pressure

3. Concluding Remarks

Compared to other widely used methods, our novel approach yields a significantly better solution for the examined model. The considered 1D contact problem is very simplistic, but the phenomena observed here have similar characteristics in higher dimension cases. Thereby, the proposed method must be applicable for more complex problems.

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