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A New Family of Integration Methods for Nonlinear Dynamic Analysis

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Abstract : A new family of structure-dependent integration methods, whose coefficients of the difference equation for displacement increment are functions of the initial structural properties and the step size for time integration, is proposed in this work. This family method can simultaneously integrate the controllable numerical dissipation, explicit formulation and unconditional stability together. In general, its numerical dissipation can be continuously controlled by a parameter and it is possible to achieve zero damping. In addition, it can have high-frequency damping to suppress or even remove the spurious oscillations high frequency modes. Whereas, the low frequency modes can be very accurately integrated due to the almost zero damping for these low frequency modes. It is shown herein that the proposed family method can have exactly the same numerical properties as those of HHT-α method for linear elastic systems. In addition, it still preserves the most important property of a structure-dependent integration method, which is an explicit formulation for each time step. Consequently, it can save a huge computational efforts in solving inertial problems when compared to the HHT-α method. In fact, it is revealed by numerical experiments that the CPU time consumed by the proposed family method is only about 1.6% of that consumed by the HHT-α method for the 125-DOF system while it reduces to be 0.16% for the 1000-DOF system. Apparently, the saving of computational efforts is very significant.

Keywords : structure-dependent integration method, nonlinear dynamic analysis, unconditional stability, numerical dissipation, accuracy
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