ON THE ADEQUACY OF THE STEP SIZES RECOMMENDED FOR TIME INTEGRATION IN LINEAR TRANSIENT ANALYSIS OF MID-RISE BUILDINGS

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Time history analysis is the most powerful analysis approach to study the seismic behaviours of structural systems, and time integration is the most versatile tool for time history analysis, especially in cases with nonlinearity, close natural frequency, and non-classical damping (Chopra, 1995; Chung and Hulbert, 1994; Clough and Penzien, 1993). The parameter of time integration, i.e. the integration step size, is effectual both in the accuracy and the computational cost, in reverse manners (Belytschko and Hughes, 1993; Soroushian, 2008). Hence, the value to be assigned to the integration step size need to be set reasonably, considering practical requirements and restrictions.

Towards enhancement of the comments existing on integration step size selection, taking into account the social importance of mid-rise buildings (Stafford Smith and Coull, 1991), and the fact that buildings design codes generally do not require nonlinear dynamic analyses (BCJ, 2001; BHRC, 2007; ICC, 2003; NZS, 2004), the adequacy of the conventional engineering comments (Bathe, 1996; Clough and Penzien, 1993; Soroushian, 2008), i.e.

$$\Delta t \leq \mathrm{Min}\left(\frac{T}{10}, h_s, {}_f\Delta t\right) \tag{1}$$

is studied in this paper, in linear transient analysis of mid-rise buildings, from the points of view of accuracy and computational cost (T stands for the smallest dominant period of the response; h_s implies the maximum step size preventing integration instability, and ${}_f\Delta t$ denotes the size of steps, by which, the strong ground motion is digitized). After theoretical discussion, about twenty-five buildings are taken into account, from a past study on optimum design of residential buildings (Soroushian, 1995).

As the consequence (though not still finalized), it is demonstrated that, for regular mid-rise residential buildings, designed according to the national codes of Iran (INBR, 1993), the most broadly accepted comment for the integration step size selection (stated above), even when applied precisely, does not correspond to specific ranges of computational errors, and even more, large computational errors are probable. The observations are then explained theoretically. The issue is completely different for computational cost and with a definition based on the memory and run time, the computational cost is precisely determinate, in linear analyses, depending on the computational facilities at hand.

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