Evaluation of the performance of u–p formulation-based analysis by the u–w–p formulation-based analysis in oscillation problem

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ABSTRACT

Soil-water coupled analysis for saturated soil is generally based on ***u***–*p* formulation. However, the ***u***–*p* analysis which assumes the static permeation of pore water fails for the highly-permeable soils or the sufficiently small time increment [1]. Then, the authors have developed the full formulation (***u***–***w***–*p* formulation)-based analysis code [2], [3].

To investigate the effect of the ***u***–*p* assumption, we systematically conducted the one-dimensional elastic oscillation analysis with the harmonic load application changing permeability coefficient k, angular velocity of the harmonic load ω, and the time increment Δt. The analysis was conducted based on both the ***u***–*p* and ***u***–***w***–*p* formulations for examining the applicability of the ***u***–*p* analysis and for confirming the correspondence of the ***u***–*p* and ***u***–***w***–*p* analysis results.

As a consequence, we confirmed the satisfaction of the $\gamma_{\theta 1}$ criterion [1] derived from the physical meaning of the soil-water coupling equation did not mean the satisfaction of the ***u***–*p* assumption. Furthermore, we found that the ***u***–*p* analysis tended to fail when the ***u***–***w***–*p* calculation exhibited (1) unignorable magnitude of relative acceleration ($|\mathrm{D}_f \boldsymbol{v}_f - \mathrm{D}_s \boldsymbol{v}_s| \neq 0$), (2) significant violation of the ***u***–*p* assumption ($|\mathrm{D}_f \boldsymbol{v}_f - \mathrm{D}_s \boldsymbol{v}_s| \ll |\mathrm{D}_s \boldsymbol{v}_s|$), and (3) indispensable magnitude of relative convective term ($|\mathrm{D}_f \boldsymbol{v}_f - \mathrm{D}_s \boldsymbol{v}_f| \ll |\mathrm{D}_s \boldsymbol{v}_s|$).

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