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2.5D MODELING OF SOIL-STRUCTURE INTERACTION USING A COUPLED MFS-FEM FORMULATION

Paulo Amado-Mendes[1]*, Luís M.C. Godinho[2] and Pedro Alves Costa[3]

[1] CICC, Dept. Civil Engineering, University of Coimbra, 3030-788 Coimbra, Portugal,
pamendes@dec.uc.pt, http://www.uc.pt/fctuc/dec

[2] CICC, Dept. Civil Engineering, University of Coimbra, 3030-788 Coimbra, Portugal,
lgodinho@dec.uc.pt, http://www.uc.pt/fctuc/dec

[3] Dept. Civil Engineering, Faculty of Engineering of the University of Porto, Porto, Portugal,
pacosta@fe.up.pt, http://www.fe.up.pt

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Soil-structure interaction dynamic problems have been tackled by researchers using a variety of methods, ranging from analytical solutions (valid only for simple configurations) to complex numerical strategies, including coupled formulations between different numerical methods. An extensive review of such techniques can be found in review papers such as the recent one by Clouteau et al. [1].

Some recent contributions found in the literature, such as the ones by Godinho et al. [2] or by Alves-Costa et al. [3], propose the use of the FEM coupled with either the MFS or the BEM to efficiently and accurately model vibration propagation originated in a structure located within an infinite or semi-infinite elastic medium. These models allow incorporating all the physics of the linear propagation problem while keeping a quite elegant mathematical description of the physical system. The possibility of simulating long-distance wave propagation contrasts with other computationally alternatives, such as the use of FEM approaches [4].

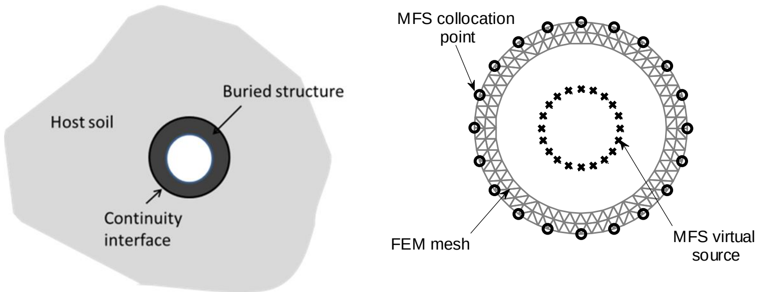

Figure 1 – Schematic representation of the problem and its discretization.

An extension of the work presented by Godinho et al. [2] is now developed, presenting a coupled MFS-FEM formulation for the 2.5D soil-structure dynamic problem. For that case, assuming null initial conditions, the frequency domain wave equation can be written as

$$(\lambda+2\mu)\nabla\nabla\cdot\mathbf{u}-\mu\,\nabla\times\nabla\times\mathbf{u}+\omega^2\rho\,\mathbf{u}=0\,, \qquad (1)$$

where λ and μ are Lamé constants and ρ is the density of the elastic medium, and β is its shear wave velocity. Besides satisfying this governing equation at all points of the structure and of the soil, the adequate continuity and equilibrium conditions between these two parts of the model must be imposed (see Figure 1). To couple the two methods, the continuity conditions are imposed at the boundary nodes as

$$\mathbf{u}_{FEM}(X\ ,\omega)-\mathbf{u}_{MFS}(X\ ,\omega)=0 \qquad (2)$$

$$\mathbf{F}_{FEM}(X\ ,\omega)-\mathbf{F}_{MFS}(X\ ,\omega)=0\,. \qquad (3)$$

The proposed method is here verified by comparing its results with those provided by the fundamental solutions available for the case of a homogeneous medium, and then performing a comparison with the ones given by a FEM model with a PML [4]. Some sample results are presented in Figure 2, considering a homogeneous soil with $E=3.09\times10^{8}$ Pa, $\nu=0.3$ and $\rho=1900\ \mathrm{kg/m^3}$, for a frequency of 40 Hz and for different values of the axial wavenumber (k1).

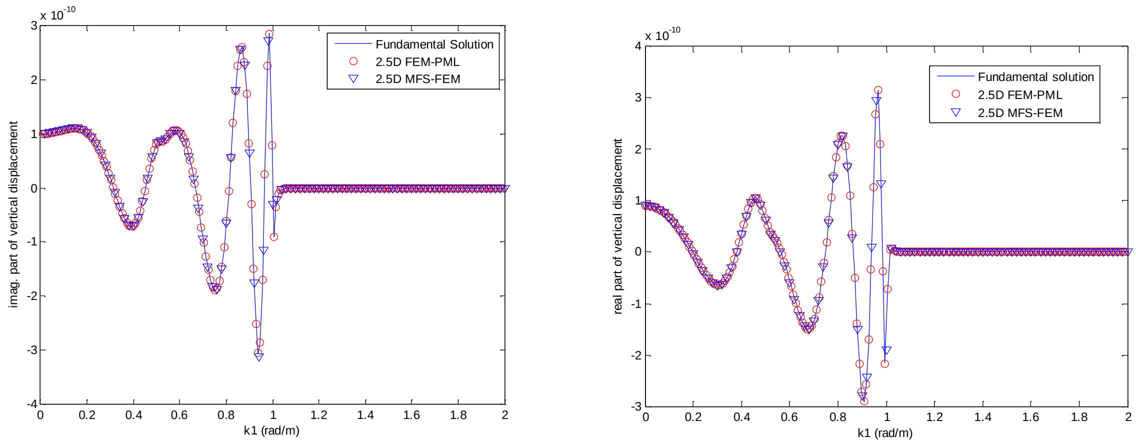

Figure 2 – Comparison against the fundamental solution for a homogeneous medium.

Finally, it should be mentioned that the proposed method is quite simple to implement, and proved to be accurate and computationally efficient, and thus the authors believe that it can be a promising tool in the analysis of soil-structure interaction dynamic problems.

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