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TRANSIENT ANALYSIS OF DAM-RESERVOIR INTERACTION BASED ON SBFEM AND FEM

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In this paper, the time-domain response of a two-dimensional dam-reservoir system was analysed by using the scaled boundary finite element method (SBFEM) and finite elment method (FEM). The reservoir was considered as an acoustic medium and truncated into two parts as shown in Fig.1. One is the near field with arbitrary geometry, and the other is the far field with uniform cross section. The near field and the dam was modelled by the traditional FEM, while far-field was modelled by SBFEM. Cross sections of Far field are uniform at any position. Its SBFEM discretization mesh is plotted in Fig.1, in which each element at Interface 2 represents a sub-domain (i.e. sub-semi-infinite layered medium), so that the whole Far field is represented by an assemblage of elements at Interface 2.

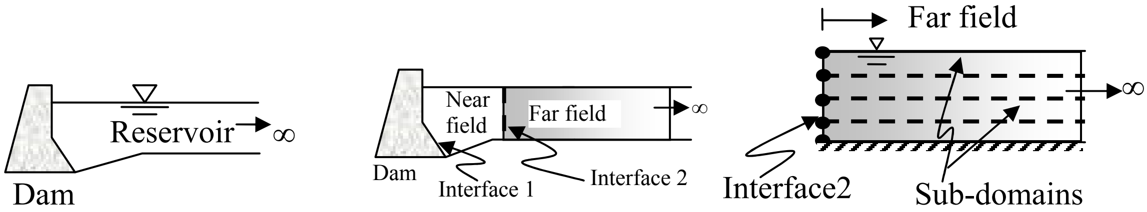


Fig.1 Dam-reservoir system and SBFEM mesh of far field

According to the SBFEM theory [1], the dynamic stiffness matrix $\mathbf{S}^{\infty}(\omega)$ of Far field is written as [2] in the frequency domain

$$\mathbf{S}^{\infty}(\omega)=\sqrt{\left(\mathbf{E}^{2}-\omega^{2}\mathbf{M}^{0}\right)\mathbf{E}^{0-1}}\mathbf{E}^{0}=\mathbf{X}^{-T}\mathbf{diag}\left(\sqrt{\lambda_{i}-\left(\frac{\omega H}{c}\right)^{2}}\right)\mathbf{X}^{-1} \tag{1}$$

where $\mathbf{E}^0$, $\mathbf{E}^2$, $\mathbf{M}^0$, $\mathbf{X}$ are coefficient matrices; c , H , ω , λ_i denotes wave speed in fluid, reservoir height, circular frequency and eigenvalue, and **diag** denotes a diagonal matrix. Details about them can be founded in the literature [2]. Rewriting Eq.(1) as

$$\mathbf{S}^{\infty}(\omega)=\mathbf{X}^{-T}\mathbf{diag}\left(i\frac{\omega H}{c}\right)\mathbf{X}^{-1}+\mathbf{X}^{-T}\mathbf{diag}\left(\sqrt{\lambda_{i}-\left(\frac{\omega H}{c}\right)^{2}}-i\frac{\omega H}{c}\right)\mathbf{X}^{-1} \tag{2}$$

Appling the inverse Fourier transform to Eq.(2) leads to the following formulation in the time domain.

$$\mathbf{S}^{\infty}(t)=\mathbf{X}^{-T}\mathbf{diag}\left(\frac{H}{c}\right)\mathbf{X}^{-1}\dot{\delta}(t)+\mathbf{X}^{-T}\mathbf{diag}\left(\frac{\sqrt{\lambda_{i}}}{t}J_{1}\left(\frac{c\sqrt{\lambda_{i}}}{H}t\right)\right)\mathbf{X}^{-1} \tag{3}$$

where $J_1(t)$ is the the Bessel function of the first kind and of the first order and $\dot{\delta}(t)$ is the first deravtive of step funtion with respect to time. Through coupling Equation (3) and FE equations of near field and dam, the transient response of dam-reservoir system subjected to horizontal ground motions can be obtained.

In order to check the accurate of Equation (3) for modeling infinite acoustic medium with uniform cross section, a gravity dam-reservoir system as shown in Fig.2 was considered. The pressure at the heel caused by the ground acceleration Fig.3 was plotted in Fig.4. Results from the presented SBFEM-FEM coupling method were very close to solutions from other methods [3]. Good agreements were found.

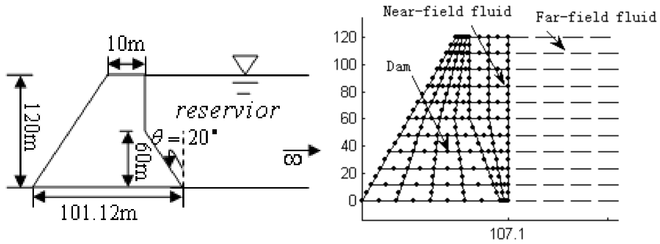


Fig.2 Gravity dam-reservoir system and its FEM-SBFEM mesh

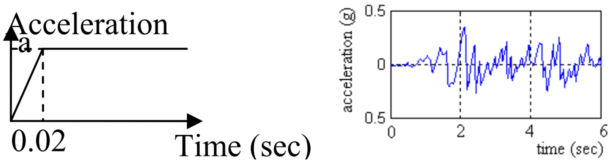
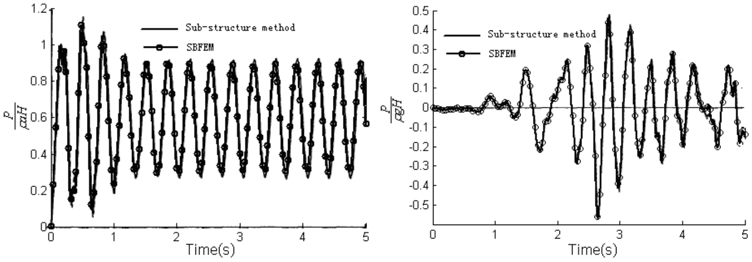


Fig.3 Horizontal ground acceleration (Left: Ramped, Right: El Centro N-S)



(a) Ramped acceleration (b)El Centro acceleration

Fig.4 Pressure at the heel of gravity dam subjected to horizontal acceleration

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