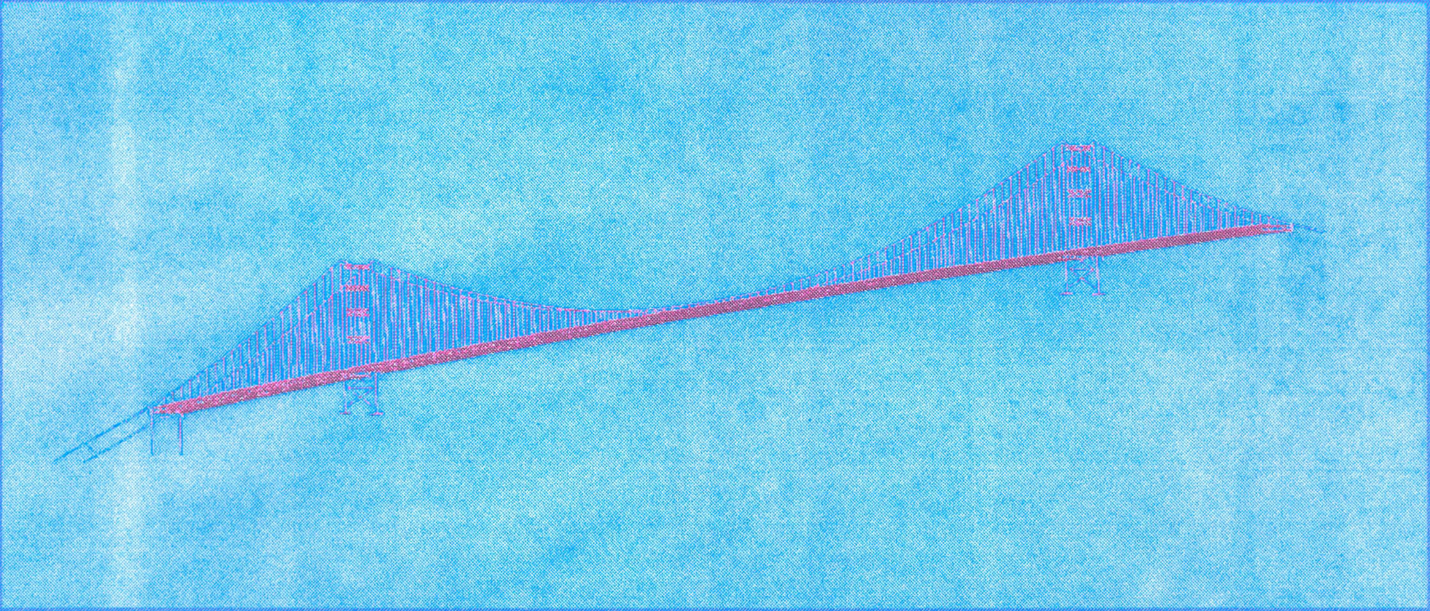
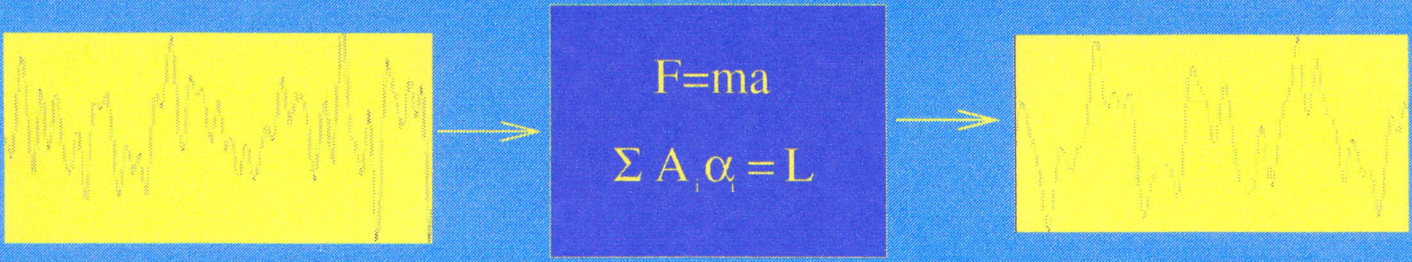
13th ASCE Engineering Mechanics Conference

The Johns Hopkins University
Baltimore MD, USA
June 13-16, 1999





Edited by:

Nick Jones
Roger Ghanem

Technical Program
13th Engineering Mechanics Conference
The Johns Hopkins University

Technical Sessions

Monday							
8:30-9:30	**9:30-10**	**10-12**	**12-1**	**1-3**	**3-3:30**	**3:30-5:30**	**6pm-9pm**
Keynote Lecture 1	*Coffee Break*	M1A BEM I	*Lunch*	M2A BEM II	*Coffee Break*	M3A BEM III	Ice Breaker
		M1B Damage Mechanics in materials with Microstructure I		M2B Damage Mechanics in materials with Microstructure II		M3B Structural Dynamics	
		M1C Reliability of Aerospace Structures I		M2C Reliability of Aerospace Structures II		M3C Probabilistic Methods for Earthquake Dynamic Response	
		M1D Soil-Structure Interaction and Seismic Wave Propagation: I		M2D Soil-Structure Interaction and Seismic Wave Propagation: II		M3D Soil-Structure Interaction and Seismic Wave Propagation: III	
		M1E Durability Mechanics I: Diffusion, Percolation and Dissolution		M2E Durability Mechanics II: Chemo-Hydral Swelling of Materials		M3E Durability Mechanics III: Coupled Problems in Durability Mechanics	
		M1F Phenomenological Approaches to Constitutive Modeling		M2F Neural Network-Based Modeling		M3F Flow and Mechanical Properties of Soils	
		M1G Environmental Fluid Mechanics		M2G Major Issues in Civil Infrastructural Systems		M3G Structural Control and System Identification	
		M1H Probabilistic and Computational Fatigue and Fracture: I		M2H Probabilistic and Computational Fatigue and Fracture: II		M3H Probabilistic Mechanics	

Session: M3D
Title: Soil-Structure Interaction and Seismic Wave Propagation: III
Date: Monday 3:30pm-5:30pm
Room: Shaffer 100
Chair: John Tassoulas and Dimitris Rizzos
Committee: Dynamics

Paper	Authors	Title
1	X. Zeng and R.K.N.D. Rajapakse	Vertical Vibrations of Buried Circular Foundations in Poroelastic Soils
2	Dan M. Ghiocel and Roger G. Ghanem	A Computational SSI Study on Nonsynchroneous Motion Effects for Structures with Torsional Eccentricities
3	X.M. Zhao and K.H. Ha	Dynamic Soil-Structure Interaction of Friction Damped Braced Frame
4	O. Maeso, J.J. Aznares and J. Domínguez	A 3-D Model for the Seismic Analysis of Concrete Dams Including Poroelastic Sediment Effects
5	Bang-Fuh Chen and Hsuen-Weng Chiang	Complete Two-Dimensional and Fully Nonlinear Analysis of Seismic Waves Induced Sloshing Fluid in a Rigid Tank; Real Fluid
6	B. B. Guzina and A. Lu	Full Waveform Analysis in Site and Material Characterization by Seismic Methods

A 3-D Model For The Seismic Analysis Of Concrete Dams Including Poroelastic Sediment Effects

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In spite of the great progress in the knowledge of the earthquake behavior of arch dams achieved in recent years, some important effects which can greatly influence this behavior are not yet well evaluated. The existing analytical and numerical models for earthquake analysis of arch dams include substantial simplifications which may lead to some non realistic results. One of the factors which has not been properly considered in the past is the effect of porous bottom sediments. In a recent paper, Domínguez et al. (JEM, April 1997) presented a 2-D model for the seismic analysis of gravity dams taking into account the porous bottom sediment effects.

In the present paper, a 3-D boundary-element approach for the seismic analysis of arch dams including the effects of porous bottom sediments is presented. The model includes different zones: the dam as a viscoelastic solid, the soil as a viscoelastic solid with different regions and which may have a rigid bedrock or a uniform viscoelastic half-space at the bottom, the water reservoir, and the bottom sediments. These sediments are represented using Biot's theory of poroelastic materials. All the regions considered may have any arbitrary shape and the dynamic interaction between then is rigorously represented.

The effects of sediment on the seismic response of arch dams are evaluated. The influence of the degree of saturation and the thickness of bottom sediment are studied.

A 3-D Model for the Seismic Analysis of Concrete Dams Including Poroelastic Sediment Effects

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1 Introduction

In spite of the great progress in the knowledge of earthquake behavior of arch dams achieved in recent years, some important effects which may influence this behavior are not well evaluated yet. The existing analytical and numerical models for earthquake analysis of arch dams include substantial simplifications which may lead to non realistic results.

One of the important matters which require some additional research effort is the effect of porous bottom sediments on the seismic response.

Fenves and Chopra (1985) were the first to present a two-dimensional model including reservoir bottom absorption for the seismic analysis of gravity dams. They used an approximate boundary condition characterized by a wave-reflection coefficient. Some other simple models which represent the sediment as a single-phase medium have been presented in the last decade.

There are also more realistic models where the sediment is represented as a two-phase poroelastic material. Cheng (1986) concluded, from a one-dimensional study including a poroelastic medium, that partially saturated sediments may significantly affect the hydrodynamic force on the dam. Bougacha and Tassoulas (1991) presented a two-dimensional Finite Element model for gravity dams including the effects of two-phase poroeslastic sediments . In a recent paper, Domínguez et al. (1997) presented a two-dimensional Boundary Element model for the seismic analysis of gravity dams taking into account the poroelastic bottom sediment effects.

In the current paper a three-dimensional B.E. model for the seismic analysis of arch dams is presented. The effect of the bottom sediment is taken into account using a rigorous representation of it. The sediment is considered as a fluid-filled poroelastic material whose behavior is governed by Biot's equations. The subsequent boundary integral formulation of the problem includes all the material parameters as the added density and the dissipation coefficient. The dynamic behavior of the water, the dam and the foundation are also represented in the same Boundary Element model as done by Domínguez and Maeso (1993). Interaction among different materials is accounted for.

2 Boundary Element Model

The Boundary Element representation of a typical geometry of the problem at hand is shown in Figure 1. It corresponds to the Morrow Point dam which has been previously studied by several authors. There are regions of three types in the model: water, viscoelastic solids and poroelastic sediments. The water is assumed to be a compressible inviscid fluid. The reservoir can be easily represented by the B.E. mesh and a boundless canyon geometry can be included if required. The dam is represented as a viscoelastic solid as it is the foundation which may have sub-regions and extend to infinity. The B.E. representation of the sediment corresponds to a poroelastic material as mentioned above. All the B.E. are quadratic nine or six node elements. The interaction between regions of different type is rigorously considered by enforcing the corresponding equilibrium and compatibility conditions over the interfaces.

These interfaces between different regions can be seen in Figure 2, which corresponds to one half of the model used for the analysis of Morrow Point dam. The region on the lower part of the reservoir corresponds to the porous sediment.

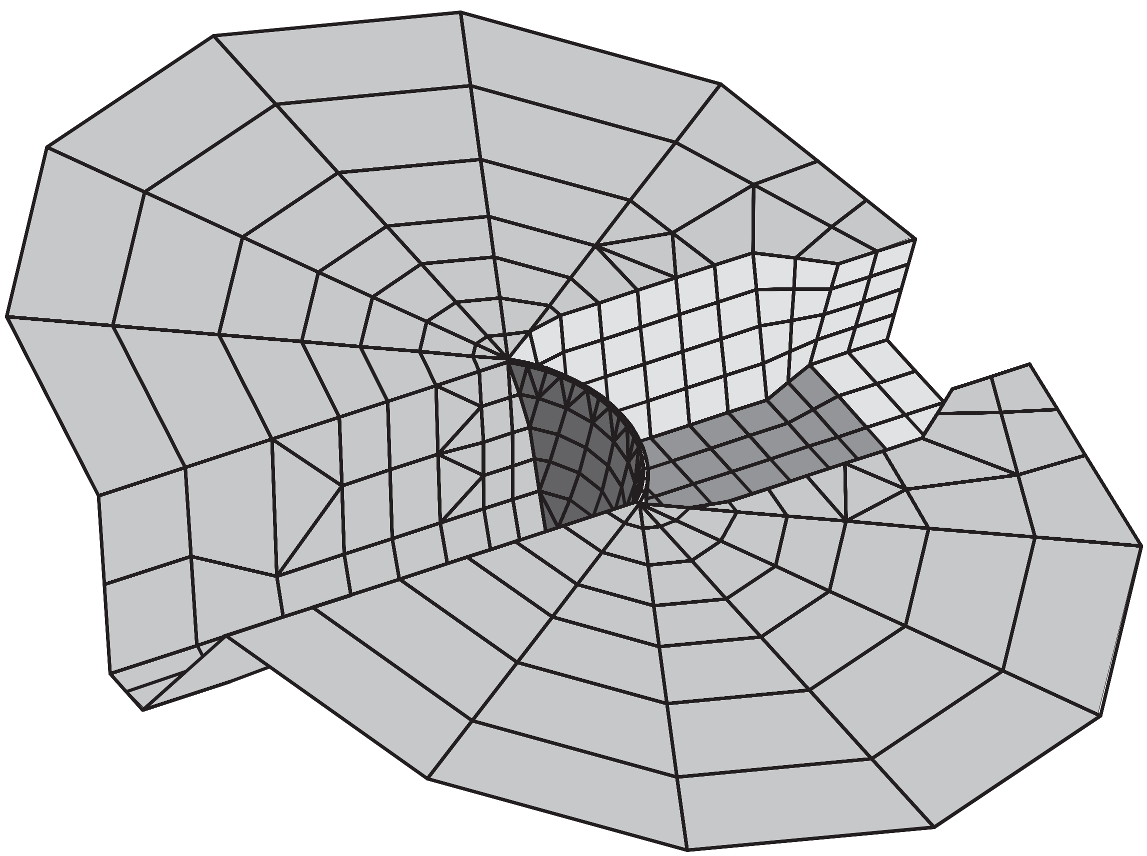

Figure 1: Boundary Element model including bottom sediments.

3 Results and Conclusion

The effect of porous sediment on the seismic response of arch dams is studied by comparison of the dam motion for cases with sediment and wthout it. It can be concluded from the results that the effect is important and depends on the sediment properties and thickness.

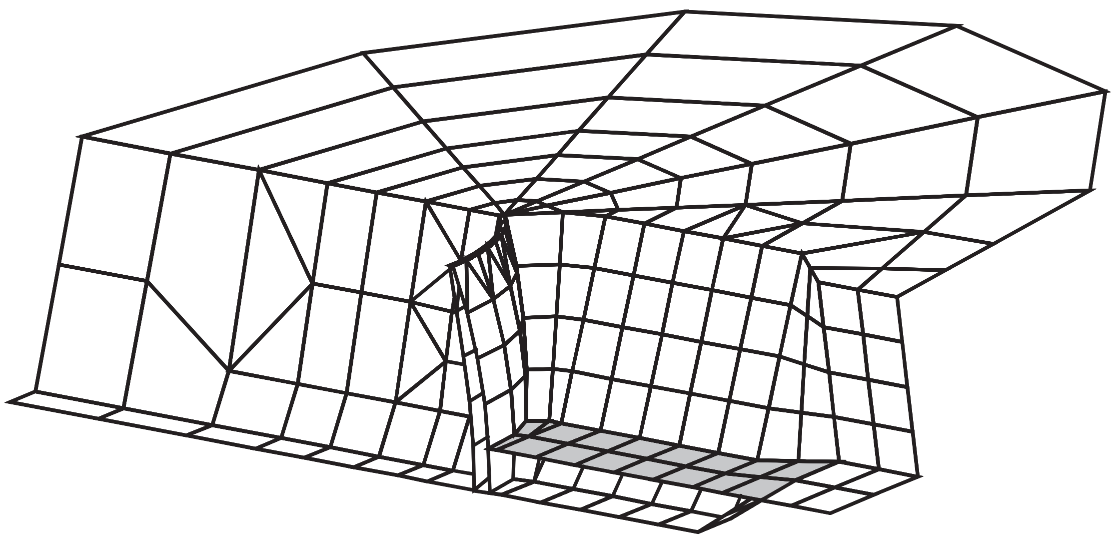

Figure 2: Upstream section showing different subregions.

4 Acknowledgments

This work was supported by the Comisión Interministerial de Ciencia y Tecnología of Spain. (PB96-1380 and PB96-1322-C03-01). The financial support is gratefully acknowledged.

5 References

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