FOUNDATION-DAM INTERACTION AND SPATIAL VARIATION IN GROUND MOTION

by

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SYNOPSIS

Using high order finite elements with very few degrees of free dom, mathematical models are established for a large earth dam from the eigen value study. Spatial variation of ground acceleration along the base of dam is investigated and compared with that of constant ground acceleration. Dam-foundation interaction is studied. A direct numerical integration of the equations of motions is performed. Natural frequencies and time history of displacement curves are presented.

INTRODUCTION

Large earth dams and many structure-foundation systems require consideration of large physical dimensions. As a result, the spatial variation in the ground motion due to earthquake as well as foundation interaction effect must be considered in the dynamic response of such structures.

The dam considered in this study is a 300-foot-high symmetric triangular earth dam, with side slopes 3:1. It has a width of 1,800 feet at the base. For an elastic modulus of 81,300 psi, Poisson's ratio of 0.45 and a unit weight of 130 pcf, the corresponding shear wave velocity is 1,000 fps (1). Thus, it takes 1.8 seconds for a wave front to travel across the base of dam, causing points along the path to experience different accelerations at a given instant of time.

The dynamic response of structures is affected by the properties of the foundations on which the structure stands. This is very significant in gravity dams where the Young's modules of dam and foundation are very nearly the same (2).

Spatial variations in the ground acceleration and dam-foundation interaction on the response of dam are studied in this paper.

NUMERICAL STUDY

The numerical work utilizes high order finite elements (3,4) to formulate the stiffness and the consistent mass matrices of the dam. Three mathematical models are considered as shown in Fig. 1a, b, and c. They are made of 4, 2, and 1 8-modal-point isoparametric elements respectively. The list below gives the first five natural frequencies for each of the model as well as Ref. (1) results for comparison.

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Mode No.	Const. Stress Δr Elem(1) 100 Elem. 66 N.P.	8 N.P. Isoparametric Elem. 4 Elem 23 N.P.	2 Elem 13 N.P.	1 Elem 8 N.P.
1	7.16	7.46	7.14 (7.34)	8.39
2	10.77	11.69	13.15 (13.71)	9.40
3	13.31	14.62	16.46 (18.02)	21.92
4	15.33	15.83	17.69 (21.92)	27.83
5	15.76	16.42	18.14 (22.99)	28.58

The above figures were obtained by *dropping* the off-diagonal terms of the consistent mass matrix except for the figures in brackets where they were retained. Dropping the off-diagonal terms improved results.

The three models, plus a dam-foundation interaction model of same modulus shown in Fig. d, are subjected to the first 7.15 seconds of El Centro (May 18, 1940, NS) accelerogram. The time history of the lateral displacement of the dam vertex relative to the base perpendicularly below are shown plotted in Fig. 1 for zero damping.

CONCLUSIONS

1. Dropping of the off-diagonal terms of the consistent mass matrix improved the natural frequencies.

2. With constant acceleration input, except for the dam-foundation interaction case, the model with the greatest number of elements showed the greatest relative lateral displacement response of the vertex. Also, the first mode dominated the response.

3. Varying acceleration input substantially altered and reduced the displacement response and caused 2 and 4 element models to respond similarly.

4. Dam-foundation interaction had very noticeable effect on the response of the dam.

5. This study seems to demonstrate that high order finite elements with consistent mass and few degrees of freedom are well suited for dynamic response study of large structures.

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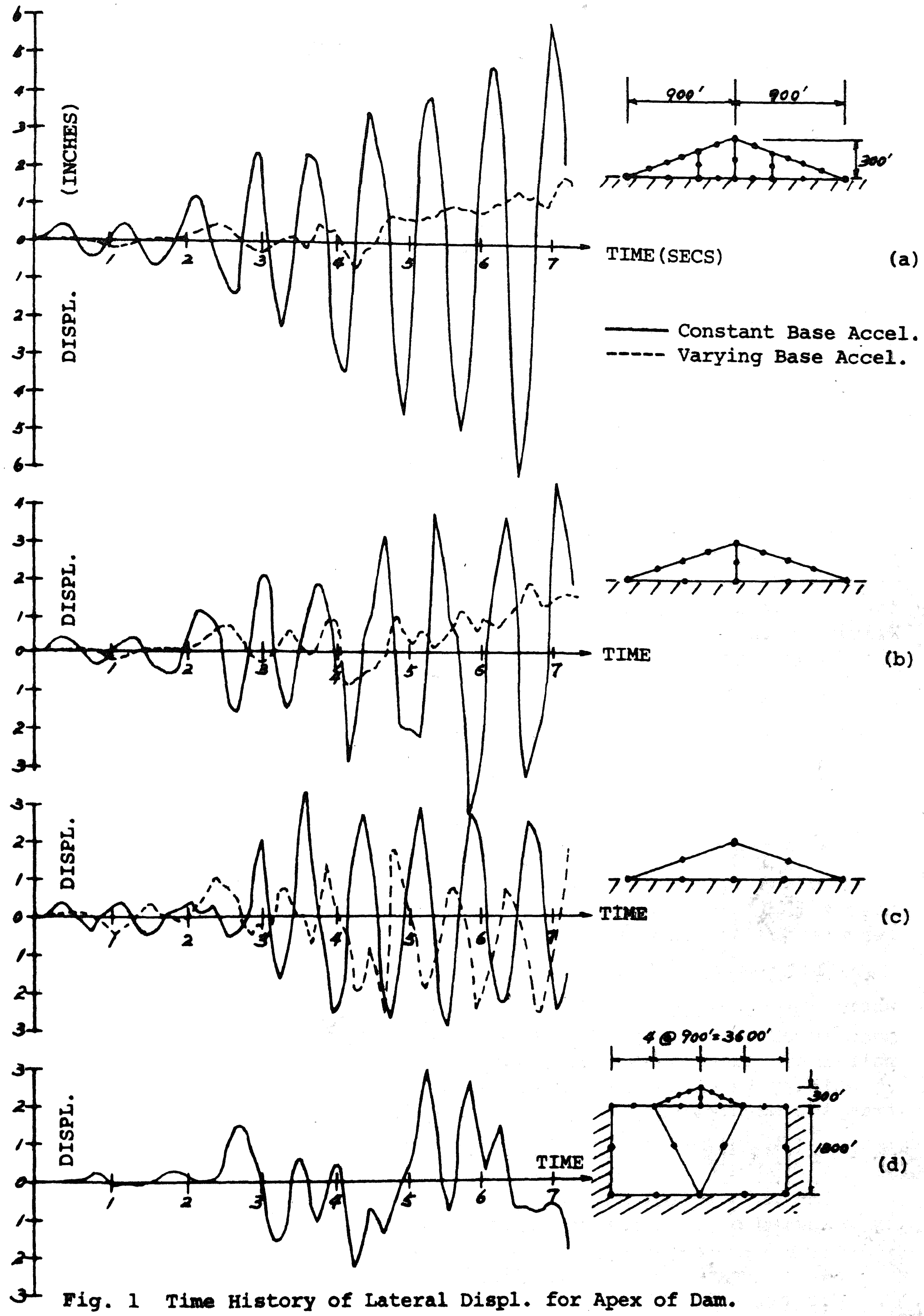

Fig. 1 Time History of Lateral Displ. for Apex of Dam.