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Time dependent earthquake modeling of an earth dam

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Abstract

In accordance with new French regulations, new dams in seismic areas have to be justified for earthquake solicitation by coupled poro-mechanical modeling. Allowable displacement thresholds are thus given by these regulations. This paper presents the first phase of a real time dependent modeling using a finite difference software for an earth dam in Guadeloupe (French West Indies) for a 7.5 magnitude earthquake.

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Keywords: earth dam; seismic sollicitations; dynamic modeling; displacements.

1. Introduction

Water supply for agriculture activities in Guadeloupe (French West Indies) requires the construction of several new dams all around Basse-Terre Island. These dams are generally made with earth, using the local clayey material which covers the hilly areas at the base of the volcano chain.

As the region is highly seismic due to the subsidence of the Atlantic plate under the Caribbean plate, dam design has to take into account earthquake solicitations. Different methods exist for this design but the French Authorities request that the new project dams are justified with poro-mechanical coupled modeling. The use of time-dependent modeling based on real accelerogram is thus needed. This paper will present the modeling of a dam in such geotechnical conditions. Computations are made using FLAC software [1], which uses the explicit finite difference method.

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2. Description of the geotechnical context and the project

2.1. Geotechnical context

At this time, two geotechnical surveys were carried out on the site with different types of boreholes and measurements: core sampling, CPT, DPT, PMT and laboratory tests. The geological and geotechnical analysis allows to define five main strata below the ground level:

- H1 - muddy clay in the valley axis. This compressible material will be totally removed;
- H2 - ocher silty clay;
- H3 - grey silty clay (volcanic ashes), found as a lens below a half part of the dam;
- H4- weathered conglomerate at a depth of about 10 m;
- H5 - conglomerate (thickness potentially higher than 100m).

The material H2 will be used for the backfilling but there is still a huge uncertainty about the water conductivity k_h and k_v of this material after compaction and thus its availability for an impervious core.

Table 1. Geotechnical parameters.

Parameters Stratigraphy	ρ_h (g/cm^3)	E_{dyn} (MPa)	ν	C_u (kPa)	ϕ_u (°)	C' (kPa)	ϕ' (°)	k_h (m/s)	k_v (m/s)
Filling	1.7	150	0.35			10	32	5.E^{-7}	1.E^{-7}
H2 – ocher silty clay	1.6	100	0.45	100	2			5.E^{-6}	5.E^{-7}
H3 – grey silty clay	1.6	100	0.45	100	2			5.E^{-6}	5.E^{-7}
H4 – weathered conglomerate	1.7	400	0.45	180	2			5.E^{-5}	1.E^{-5}
H5 - conglomerate	1.7	900	0.45	200	2			5.E^{-8}	1.E^{-8}

The stratigraphy and soil parameters are given in Table 1.

Computations under dynamic solicitation are done with drained parameters for the dam filling (non saturated soils) and undrained shear strength for the foundation (saturated soils), using Plastic-Hardening (PH) model.

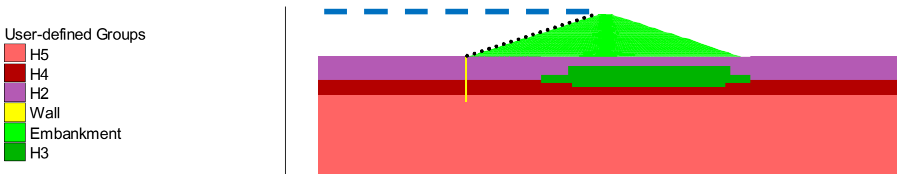

Fig. 1. Lithology of the dam used for modelling.

2.2. Dam

Considering the natural topography of the valley, the dam will be 20m high and 400m long. The upstream and downstream slopes are about 19° (3H for 1V). The crest width is 5m. As described before (see Table 1), the lack of material with low hydraulic conductivity ($k_h \leq 1.10^{-9}$ m/s) generates a specific design with an upstream sealing using a geomembrane (black dotted line) and a slim grouted curtain wall in the foundation (yellow area in Figure 1).

2.3. Design thresholds

In accordance with French recommendations [2, 3], two different types of earthquake have to be taken into