SEISMIC ANALYSIS OF GRAVITY DAM SUBJUCTED TO NEAR-FIELD PULSE-LIKE GROUND MOTIONS

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ABSTRACT:
Recently a great deal of near-field strong seismographic records is obtained. Because these earthquakes lead severe hazards to near field area, more and more researchers begin to study effects of near-field ground motions to structures. In order to effectively investigate the different seismic response of the dam, a typical near-field pulse-like ground motion and an artificial ground motion are selected to input. The seismic respond of a concrete gravity dam is obtained using linear time history analysis. The results indicated that near-field pulse-like ground motions will remarkably effect on the concrete gravity dam, which cannot be neglected in the design of RC gravity dam.

KEY WORDS:
gravity dam, pulse-like ground motions, linear time history analysis

1. FORWORD

Dams are important lifeline engineering which can induce catastrophic hazards when earthquakes happen. So the design of dam is a worthy attention issue in our country where earthquakes often occur.

Recently more and more near-field strong seismographic records are obtained, such as in 1995 Kobe earthquake（Mw7.2）, in 1999 Kocaeli earthquake（Mw7.4）, in 1999 Chi-Chi earthquake（Mw7.6）, and these earthquakes lead severe hazards to near field area. Near-field seismic ground motions are frequently characterized by intense velocity, displacement pulses of relatively long period and great vertical ground accelerate of relatively short period that clearly distinguish them from typical far-field ground motions, and such characteristics should be seriously took into account in design of dams.

In order to effectively investigate the different seismic response of the dam, a typical near-field pulse-like strong seismographic record and an artificial ground motion are selected as the input of ground motions, and the seismic respond of a RC gravity dam is obtained using linear time history analysis. The results indicated that near-field pulse-like ground motions will remarkably effect on the RC gravity dam, which cannot be neglected in the design of RC gravity dam.

2. COMPUTATIONAL MODEL

The RC gravity dam model consists of such parts: dam body, right and left banks, dam underside. The characters of concrete below 100 meter on the dam body as follow: the modulus of elasticity of is 3.25 e10pa, the Poisson ratio is 0.2, and the density is 2400kg/m^3. The characters of concrete above 100 meter on the dam body as follow: the modulus of elasticity of is 3.00 e10pa, the Poisson ratio is 0.2, and the density is 2400kg/m^3. The characters of the rock as follow: the modulus of elasticity of is 2.9e10pa, the Poisson ratio is 0.3, and the density is 2600kg/m^3.

The dam is 180m high. The upriver surface is vertical, but the downstream surface is oblique (m=0.75). The upriver water level is 100m, and the downstream level is 80m. The upriver bank is 270m, and the downstream is 360m. The dam foundation depth is 360m. The length of dam crest is 270m, and the width is 18m. The dam model consists of 10977 nodes and 8944 elements.

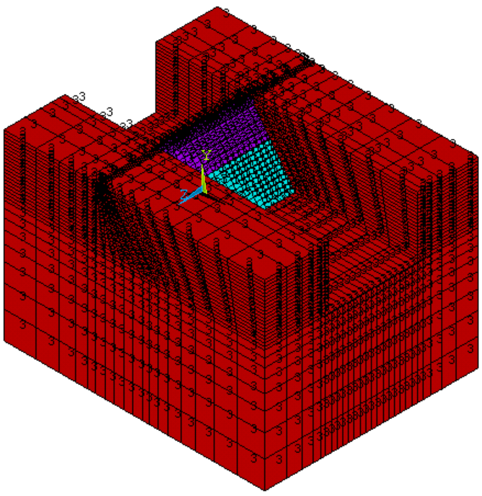


Figure1 Computation model

3. COMPUTE RESULT AND ANALYSIS

3.1 The select of the ground motions

In this paper we select a ground motion from 1999 Chi-Chi earthquake, registered by TCU036 instrument, and the direction is EW. This ground motion has obvious pulse-like velocity, which is the typical character of near-field ground motion. We adjust the PGA to 70cm/s^2 which corresponds to small earthquake of 7 anti-seismic grades in actual criterion, the v_{max}=86.2cm/s. Figure 2 is the TCU036EW ground motion acceleration and velocity time-history.

We simulate a ground motion which has the same PGA and the similar response spectra with TCU036EW ground motion. But it has not pulse-like velocity, the v_{max}=61.9 cm/s. Figure 3 is the artificial ground motion acceleration and velocity time-history.

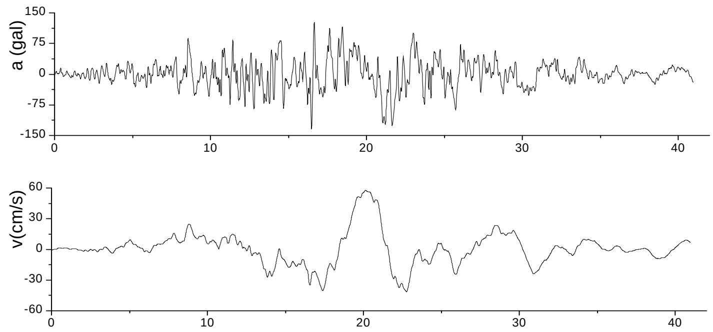


Figure2 TCU036EW ground motion acceleration and velocity time-history

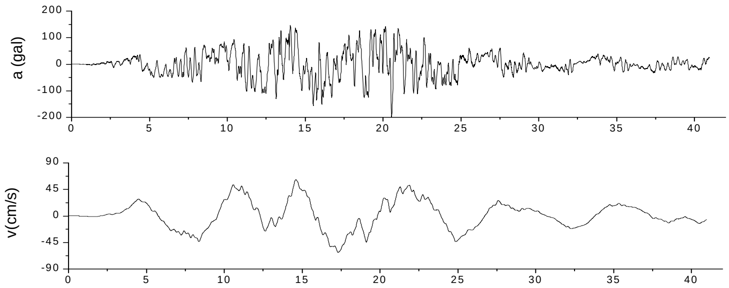


Figure3 Artificial ground motion acceleration and velocity time-history

3.2 The result of computing

Input the above two ground motions into the RC gravity dam model respectively and carry through dynamic time history analysis. The RC gravity dam under load of gravity, hydrostatic pressure, ground motion, wave pressure and uplift pressure. The direction of ground motions is same with the river direction. The damping factor is 0.05.

At different highness select several characteristic points for analysis. There are 12 characteristic points: 2 are on the underside of dam (the highness is 0 meter), 4 are at the middle of the dam (the highness is 108 meter), 2 are at the shoulder of the dam (the highness is 162 meter), and 4 are at the top of the dam (the highness is 180 meter).

For comparing the effects of the two ground motions we analyze the principal stress and displacement of the characteristic points under the two ground motions.

3.2.1 The difference of principal stress under the two ground motions

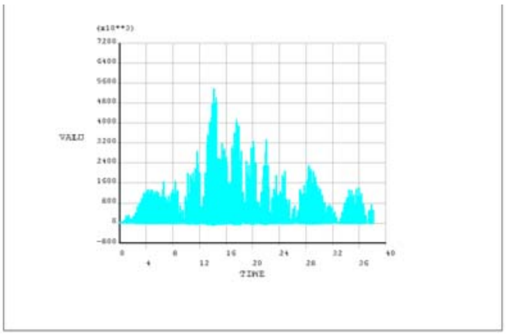
The stress status of dam is reflected by the stress time history. We analyze the principal stress of the characteristic points under the two ground motions. We select characteristic point 1 at the top of dam (the highness is 180 meter) for example to compare the effect of the two ground motions. The stress time history of characteristic point 1 is shown as figure 4.

From figure 4 we can see that under the pulse-like ground motion load the maximum 1 principal stress of characteristic point 1 is 5.38Mpa at 14.19s, while under the artificial ground motion load the maximum 1 principal stress of characteristic point 1 is 4.46Mpa at 20.41s.Under the pulse-like ground motion load the minimum 3 principal stress of characteristic point 1 is -5.25Mpa at 14.34s, while under the artificial ground motion load the minimum 3 principal stress of characteristic point 1 is -4.41Mpa at 20.59s.

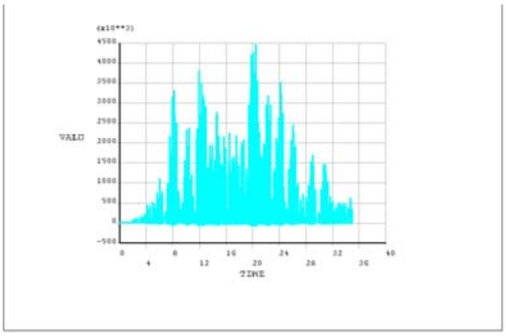
From the comparing the principal stress of the two ground motions we can gain following conclusion:

1) Through comparing the principal stress of 4 characteristic points at the middle of the dam, 2 characteristic points at the shoulder of the dam, and 4 characteristic points at the top of the dam, the value of stress under the pulse-like ground motion is bigger than the corresponding one.

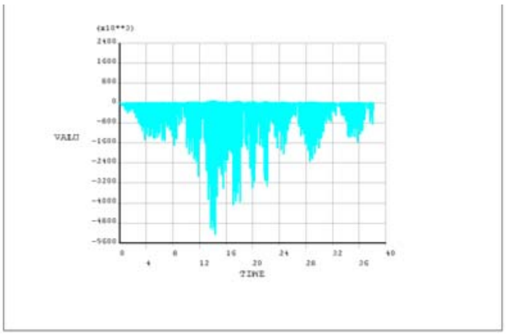
2) According to the principal stress time history, we can find that under the pulse-like ground motion the most disadvantage time is 14.19s or14.34s, but under the artificial ground motion the most disadvantage time is 20.41s or 20.59s.



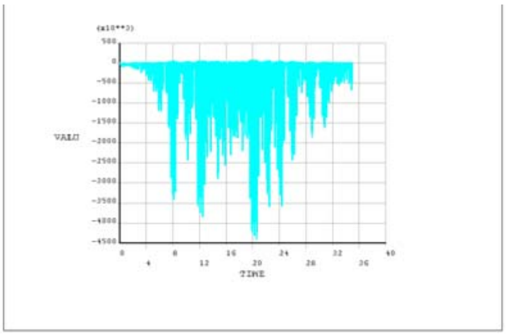
(a) 1 principal stress under pulse-like ground motion



(b) 1 principal stress under the artificial ground motion



(c) 3 principal stress under pulse-like ground motion



(d) 3 principal stress under the artificial ground motion

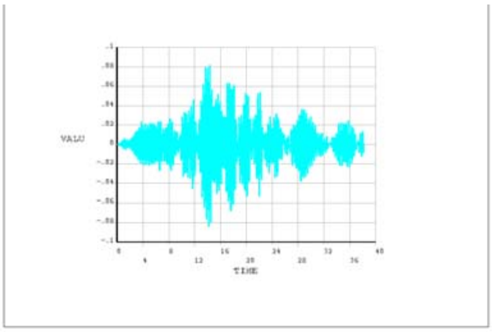
Figure4 Principal stress of the characteristic point 1

3.2.2 The difference of displacements under the two ground motions

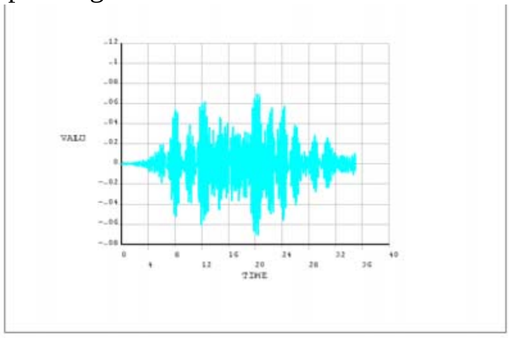
The level displacement of dam is reflected by the particles displacement time history. We analyze the displacement of the characteristic points under the two ground motions. We select characteristic point 2 at the top of dam (the highness is 180 meter) for example to compare the effect of the two ground motions. The displacement time history of characteristic point 2 is shown as figure 5.

From figure 5 we can see that under the pulse-like ground motion load the maximum displacement of characteristic point 2 is 8.17cm at 14.34s, while under the artificial ground motion load the maximum displacement of characteristic point 2 is 6.91cm at 20.42s. Under the pulse-like ground motion load the minimum displacement of characteristic point 2 is －8.42cm at 14.19s, while under the artificial ground motion load the minimum displacement of characteristic point 2 is －7.09cm at 20.42s.

Through comparing the displacement of 2 characteristic points at the underside of the dam, 2 characteristic points at the shoulder of the dam, and 4 characteristic points at the top of the dam, the value of displacement under the pulse-like ground motion is bigger than the corresponding one.



(a) Displacement under pulse-like ground motion



(b) Displacement under the artificial ground motion

Figure5 Displacement of the characteristic point 1

4 CONCLUSION AND DISCUSS

In this paper we select a ground motion from 1999 Chi-Chi earthquake, which has obvious pulse-like velocity. We simulating fit a ground motion which has the same PGA and the similar response spectra with above ground motion, but it has not pulse-like velocity. Input the above two ground motions into the RC gravity dam model respectively and carry through dynamic time history analysis. According to calculating and analysis we gain following primary conclusion: Principal stress and displacement of all the characteristic points under pulse-like ground motion is bigger than no pulse-like velocity ground motion. Moreover, the extrema of principal stress and displacements occur at different time. So we can learn that the pulse-like ground motion will remarkably effect on the RC gravity dam.

In this paper we only select two ground motions to research, so the conclusion may be unilateral. We should collect more ground motions to checkout the conclusion. Moreover, we can't conclude these differences of results brought by the pulse-like velocity because near-field ground motions have many other obvious characters. More embedded research about this should carry through.

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