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Evaluation of the Behavior of Concrete Gravity Dams under Shock Waves Resulted from the Explosion in the Reservoir

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ABSTRACT: The present study evaluates the behavior of concrete gravity dam structures against the hydrodynamic pressure of the shock wave produced by the explosion in the dam reservoir. To this end, several arbitrary points are selected as lower, middle, upper elevations at the height of the dam, and the explosives are placed at 10, 20 and 30 meters' horizontal distances. Numerical analysis was carried out under various explosive locations in the dam reservoir. Finally, the cracking profiles of the dam were extracted and the probable cracking areas of the dam under various explosive loads were determined By comparing the crack profile obtained from the analysis of the various states of the explosive loads. It was concluded that the shock wave from the explosion in the middle elevations and near the floor of the dam had more destructive effects on the location of explosives at altitudes close to the dam of the crest dam so that at the height of zero, the dam floor and the horizontal distance of 10 meters are the most dam failure, as well the areas susceptible to cracks in the heel and neck of the dam are detected. After the explosion is completed, the effects of the explosion remain, and the resulting waves can damage the body of the dam for the next few seconds. The more explosive materials are located at an altitude lower than the bottom of the dam, the change in the crown of the dam was increased so that the rate of change of the displacement of the crest by placing explosives on the floor of the reservoir, i.e. the zero level, as well as the level of 27, is the highest compared to other levels Altitude shows.

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1. INTRODUCTION

The increase in deliberate accidents caused by explosions or unexpected explosions occurring in structures has led to such incidents becoming a potential threat to huge infrastructure and structures, which, if not carefully analyzed, would be irreparable damage to national and vital interests One country arrives. Due to a large number of concrete gravity dams and the number of these dams is increasing, the study of the condition of damage and explosive performance of dams under explosive loading is a critical issue. The prediction of damages to structures under explosive charges in recent years has been affected by a large number of accidental events and deliberate explosions on the safety of structural engineering. Many studies were conducted on the behavior of various structures under explosive loads

2. INTRODUCING UNDERWATER EXPLOSION EQUATION

In order to determine the shock wave created by the submarine explosion, the pressure-time relationship is used in the form of experimental Eq. (1). Symbol W is the weight of the TNT in kilograms, S is the horizontal distance of each point of the explosion in the meter and θ is the maximum shock wave in microseconds [1].

$$P_t = P_m e^{\left(\frac{-t}{\theta}\right)} \tag{1}$$

$$P_m = 52.16\left(\frac{W^{\frac{1}{3}}}{S}\right)^{1.13} \tag{2}$$

$$\theta = 96.5(W^{\frac{1}{3}})\left(\frac{W^{\frac{1}{3}}}{S}\right)^{-0.22} \tag{3}$$

3. CASE STUDY

Two-dimensional modeling of the Pineflat Dam and its reservoir have been used by Abaqus software. The finite element model used for the dam body and part of the reservoir is shown in Figure 2. Specifications of concrete materials used in the dam body, as well as its reservoir, are listed in Table 1.

The reservoir height was assumed to be 116.88 m. The amount of fracture energy for concrete materials was about 400 Nm/m. The nonlinear behavior of dam concrete materials was modeled in the analysis of compressive waves from the explosion in a dam reservoir using a concrete

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Table 1. Specifications of concrete and water used for analysis

Material parameter	Value
Undamaged Young's modulus, (GPa)	30
Poisson's ratio	0.2
Density (Kg/m3)	2400
Tensile failure (MPa) stress	2.9
Compressive yield (MPa) stress	30
Water density (Kg/m3)	1000
Water Bulk Modulus (GPa)	2.07

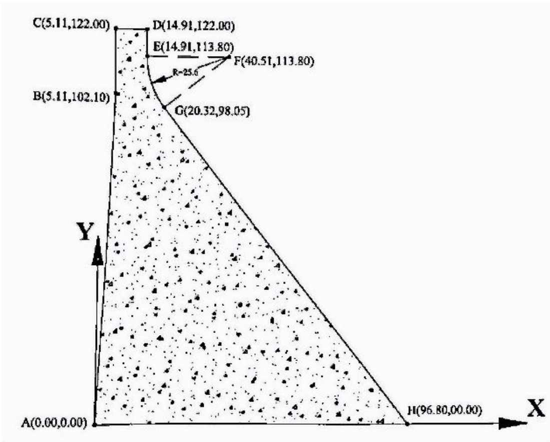

Fig. 1. Two-dimensional profile of Pine Flat Dam [2]

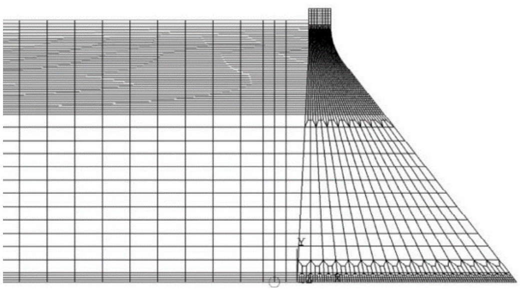

Fig. 2. Finite Element Pineflat Dam

damaged plasticity approach. A concrete dam was considered homogeneous.

4. LOADING UNDERWATER EXPLOSION

In this research, in order to determine the nonlinear behavior of the body of the dam under the submarine explosion loading, explosive materials at 10, 20 and 30 meters' horizontal distance from the upstream of the dam in

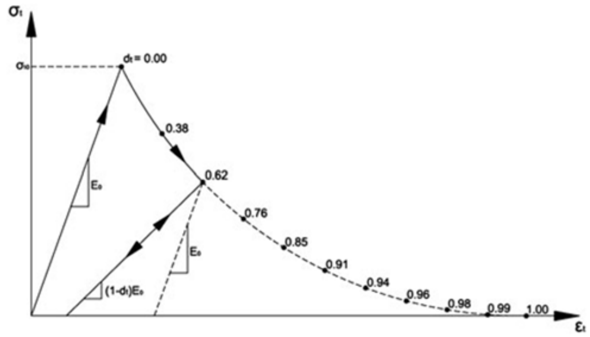

Fig. 3. Concrete constitutive behavior in uniaxial tension [2]

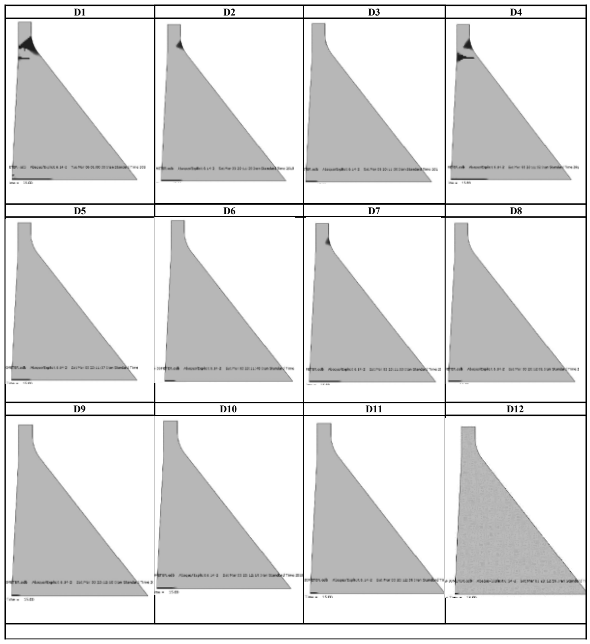

Fig. 4. Damage profiles under the analytical states D1-D12

the reservoir in four points at different altitudes of 0 (reservoir bottom), 27, 69 and 102 meters. Explosive load analyzes with titles U1 to U12 are named for 500kg TNT and D1 to D12 for 1000kg TNT.

CONCLUSIONS

By measuring the hydrodynamic pressure at the nearest points to the explosion site, it was observed that the hydrodynamic pressure at the explosion site was higher in all cases than in other places and reached the peak at the explosion and then the values were decreased, and also after the effects of the explosion still remain after the explosion has occurred, and the resulting waves can damage the body of the dam in the next few seconds. The explosion was started from a small radial and gradually grew larger. With the increase of TNT from 500 kg to 1000 kg, the crest displacement of dam was increased in all conditions, and as expected, the crest displacement of dam was gradually increased with increasing horizontal distance, but when it occurred at a height of 102 meters near the crest of dam the explosion This process is

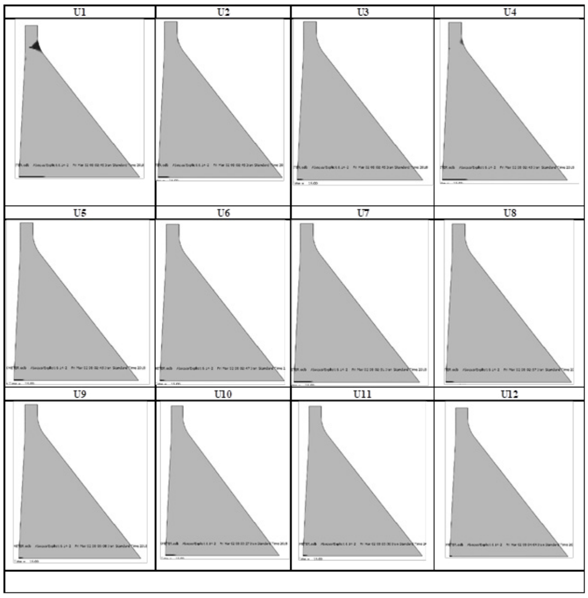

Fig. 5. Damage profiles under the analytical states U1-U12

reversed so that as far away as the explosion dam occurs, less displacement is reported. As shown in Figures 4 and 5, the crack profile of the dam was created under the explosive loads in the heel and neck of the dam, and the areas susceptible to cracks in the heel and neck of the dam were detected.

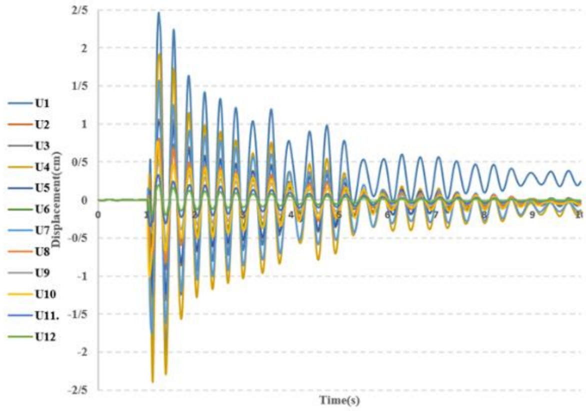

Fig. 6. Relative Crest Displacement in U1 to U12 Analysis Modes

REFERENCES

[1] Rajendran R., Narasimhan K. (2006) "Deformation and Fracture Behaviour of Plate Specimens Subjected to Underwater Explosion: A review", Impact Engineering, 2006.

[2] Alembagheri, M., & Ghaemian, M. (2012) "Seismic Assessment of Concrete Gravity Dams Using Capacity Estimation and Damage Indexes", Earthquake Engineering and Structural Dynamics, Vol. 42, pp. 123-144.

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