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HYDRODYNAMIC PRESSURE ON INCLINED SURFACE

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INTRODUCTION

In the early 1950's, professor Zanger[1] simulated the behaviors of hydrodynamic pressure on inclined surfaces with electric analogy method. But the conclusions drawn from that experiment have not been verified by any numerical method up to now. So in this paper the problem is to be investigated with the finite difference method for three dimensional reservoirs in time domain.

STATEMENT OF THE PROBLEM

Suppose the sloping upstream face of a dam is of a angle ψ with the vertical degree. The model of the reservoir connecting with the dam should be like Fig.1 (a). The reservoir water is assumed to be compressible and non-coherent. Its motion should obey the hyperbolic equation. The boundary conditions are supposed to be:

1. At reservoir bottom and the two side banks the potential function satisfys the condition given by Hatano[2].
2. At free surface water particles move with gravity wave.
3. At the upstream end the dashpot boundary condition presented by the authors[3] is used.

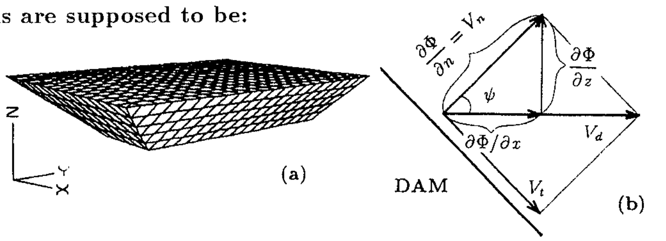

Fig. 1 Analytical Model

4. At the end connectting with dam; The dam is supposed to be rigid and moves with harmonic waves in horizontal direction. The velocity of the dam body should be separated as normal and tangental components i.e. V_n and V_t (Fig.1 (b)). Since water under above assumptions can not transmit shear wave, only the normal velocity component generates pressure on dam face. The water particles will move with the same velocity as V_n in the normal direction. For the reservoirs of different depths and the upstream faces of different angles, a systematical investigation is made.

RESULTS AND ANALYSIS

Here, as a example, the maximum values and the distribution forms got from a reservoir of a depth of 120 meters and a inclined upstream surface with the angles of 0^0, $15^0, 30^0, 45^0, 60^0$ and 75^0 are to be shown.

Fig.2 shows the isobaric lines of hydrodynamic pressure on the dam face where the sloping angle is 45^0 and when the pressure on dam surface reached at its maximum value. The distributions along the central lines of the dam faces are displayed in Fig.3 which are normalized with the maximum values. It is clear that following facts exist:

1. The hydrodynamic pressure on the inclined surface is usually less than that on the vertical surface, and as the angle ψ gets bigger and bigger the pressure gets less and less.

2. The distribution on the whole surface is near a paraboloid. In both the horizontal section(parallel to x-y plane) and the vertical section(parallel to y-z plane) the distribution forms are near parabolic lines, but the maximum values and their positions depend on many factors, for instance, the angle of the surface, the topographic features of the two side banks, the vibrating frequencies and the impedance ratio between the reservoir bottom and water. In the vertical section, the maximum value usually is not at reservoir bottom but at a upper position with a certain distance apart from the bottom.

3. When the angle of a inclined surface from the vertical degree is less than 10^0 the maximum difference of the hydrodynamic pressure with that on the vertical surface is less than 13%.

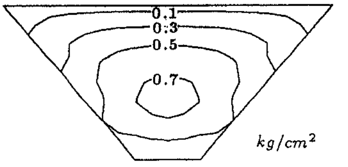

Fig.2 Isobaric Lines of Hydro. Pressure on Dam Face

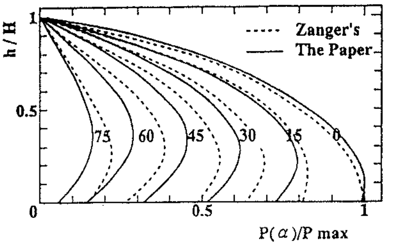

Fig.3 Distr. on Central Line of Dam Face

4. Comparing with the results of Zanger's experiments(Fig.3), it can be found that the general trend of the distributions is similar with each other, but the value near reservoir bottom is different to a certain extent. It may be due to that in Zanger's experiment copper wires were used and generated electric potential to a certain value. The hydrodynamic pressure determined by measuring the potential contour lines with electric bridge may be larger than normal case. Any way, the hydrodynamic pressure on the sloping face of a ordinary earth dam or rockfill dam under horizontal vibration condition is estimatable by Zanger's experimental formula if the dam can be assumed as rigid one. But it may results in a conservative design.

CONCLUSION

First. In the case of rigid dam, the hydrodynamic pressure on inclined surface is usually less than that on vertical surface. The gentler the surface, the less the pressure.

Second. The distribution form on dam surface is near a paraboloid. In the vertical section the maximum value usually is not at reservoir bottom but at upper position with a distance apart from the bottom.

Third. The hydrodynamic pressure on earth dam or rockfill dam is affected by many factors. For important dam designs the hydrodynamic pressure on dam facing should be evaluated not only by Zanger's experimental formula but also by numerical caculation.

REFERENCES

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