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Khosrojerdi, Amir; Galle-Dari, Neda

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Application of pressure fluctuations on Stilling Basin

Amir Khosrojerdi, Neda Galle-Dari

Because of pressure fluctuations, flow can make damages on the bottom and walls of Stilling Basin. Eddies are set up within the basin and vortices are formed. Thus under higher velocity flow conditions, cavitations can occur near bottom and walls by fluctuations. In addition of cavitations the pressure fluctuation can make impacts on the structure too. This hydraulic phenomenon can be occurred with serious damages.

In this research, experimental data are analyzed based on measuring pressure fluctuation by pressure transducer under an experimental model of stilling basin (Galabar Dam against one of main branch of Ghezel Ozen river, Iran) with scale of 1:30, which has built and taken place in laboratory of Water Research Institute(WRI) in Tehran. Pressure fluctuations were measured under seven piezometers along the basin for three discharges (592.9, 355.8 and 221.7 m³/sec). Dimension of the stilling basin is 20m by 86m (length by width). Also elevation of the stilling basin floor is 1641 meter from sea level and elevation of walls crest is 1655 meter (from sea level).

The results were analyzed and presented for both basin floor and walls: 1- Pressure coefficients on floor and walls, 2- Cavitations Index in the floor and 3- Statistical levels of pressures (0.1%, 1%, 5%, 95%, 99% and 99.9%).

1 Introduction

When flow velocity in part of hydraulically structure increase from allowed value, the structure expose to cavitation damage. Concrete rough surface that create in build time and then, make changing in flow line and pressure decrease in some location. If this pressure decrease due to velocity increase, creating cavitation phenomenon be started [1].

Narayanan in 1980 with some calculations showed relation between pressure fluctuations and cavitation phenomenon in stilling basin [2]. Narayanan calculations on stilling basin in model and prototype be admission with Loprado and his team in 1982 and 1988. This calculation shown that cavitation possibility because of severe pressure fluctuations in stilling basin, probable although pressure cannot be under of haze water pressure [4,5]. Also Narayanan
in 1984 with some experiment on slot shown severe pressure fluctuations increase cavitation possibility and most cavitation possibility, reported from cut layer separated from up edge[5]. Narayanan and Loprado compare pressure fluctuation and cavitation occur probably in model and prototype on stilling basin and say cavitation bubbles crate depend on durability of pressure fluctuation be under of haze water pressure as if temporary pressure more than 0.2% of examine time be under haze water pressure, cavitation may occur. Also for calculate average time for cavitation bubbles crate under haze water pressure Blazjewski in 1980 had some calculations [6].

Kavianpour experience results in 1997 and 2000 on the chute spillway and steeps downstream and close channel shown air inject in flow decrease pressure fluctuation and also pressure fluctuation average, increase therefore cavitation occur risk decrease a lot. Kavianpour experience shown increase value of air inject in flow more than 0.5% on steeps downstream and close channel, increase pressure fluctuation[3,7]. Similar examine by Mohamadi on spillway steeps downstream shown with increase air inject in flow from 15% to 20%, pressure fluctuation increase.

2 Research Method

Measuring data on stilling basin of Galabar dam in three 221.6, 355.8 and 592.9 m³/s discharge on prototype be used on this research. In plan 1 shows plan and section of spillway dam model and its water surface profile along Chute and stilling basin has shown.

Plan 1 Plan and Profile of Galabar Chute Spillway Model.
Pressure fluctuations measuring contain record data form temporary pressure on specified time and location, accomplish by pressure transducer, amplifier, filter, record and show equipment. Because of dynamic pressure due to turbulent flow in hydraulically structure is accident phenomenon type, can examine pressures and cavitation phenomenon on different part of structure base on statistical method.

For examine impact flow on structure $C'_p$ + dimensionless coefficient shown as below:

$$C'_p = \frac{P_{\text{max}} - P_{\text{mean}}}{V_i^2 \sqrt{2g}}$$

Where:

$V_i^2 \over 2g$ is velocity height measured in entrance flow on stilling basin in different discharge

$P_{\text{max}}$ is maximum pressure measured on specified point

$P_{\text{mean}}$ is average pressure measured on specified point

Figure 1 to 3 shown $C'_p$ value that be dimensionless by dividing on RMS (pressure squares) in stilling basin in three 221.7, 355.8 and 592.9 m/s discharge base on froud number.

In these figures horizontal axis, express dimensionless relation $x/L$ where $x$ is horizontal distant of consider point from spillway edge in dam and $L$ is horizontal distant of spillway edge from end of stilling basin and vertical axis express $C'_p$ +.

Also for examine structure behavior for cavitation and relation between cavitation and pressure fluctuation, calculate pressures probably base on 0.1%,1%,5%,95%,99% and 99.9%. with using probably table, calculate $P'\%$ values that equal a specified occur probably from average value in specified point and then be dimensionless by dividing to RMS.cavitation occur risk range be recommended 1% probably base on toso opinion and 0.1% probably base on Loprado opinion.

Cavitation potential is evaluated base on $P'\%$ for 0.1 % possibility and RMS estimate on specified points. With put $P'\%$ values base on absolute pressure and
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$P_v$ equivalent haze water pressure and V equivalent flow velocity in specific location, cavitation index ($\delta$) determine by below relation:

$$\delta = \frac{P - P_v}{\nu^2}$$

Cavitation index result shown by figure 4 to 6 in stilling basin on walls and bottom.

3 Results

In flow impact ($C'_{f,+}$) examine on stilling basin in different discharge, in start of stilling basin in all discharge coefficient value is maximum, in the other word flow impact on structure in start of stilling basin is maximum and with moving flow on stilling basin impact value decrease until be minimum in end of stilling basin (figure 1). Actually in end of stilling basin flow impact on structure is about nothing (figure 1).

Also base on figure 1 seem that with increase discharge, impact flow values on stilling basin be increase. Flow behavior on right wall is similar stilling basin bottom (figure 2) but on left wall for unsymmetrical on building stilling basin model and geometrical wrong and measuring equipment wrong, flow behavior is different thus in front of stilling basin this coefficient is minimum and then immediately coefficient value be maximum therefore maximum flow impact will happened in second measuring point on stilling basin then with moving flow gradationally impact value decrease (figure 3). Also in left wall similar right wall and bottom with discharge increase, flow impact increases (figure 3).

In examine cavitation phenomenon seem that first point of stilling basin because of maximum flow velocity and maximum flow energy have minimum cavitation index (figure 4, 5) therefore have maximum occur cavitation possibility and with moving flow on stilling basin and flow energy depreciation, the cavitation occur possibility be little until in penultimate piezometer be minimum because of energy depreciation stairway structure after penultimate piezometer that flow energy value and consequently cavitation occur possibility decrease (figures 4, 5). Like $C'_{f,+}$ coefficient analyze on left wall for unsymmetrical on building stilling basin model and geometrical wrong and measuring equipment wrong, flow behavior is different and second piezometer have minimum cavitation index (figure 6).

In end of stilling basin for increase height bottom values, cavitation index again decrease but this decrease is so little and cannot be occur cavitation therefore
entrance flow section on stilling basin is the critical section on occur cavitation phenomeno(figuers4,5,6).

As seem, in walls and bottom on stilling basin, with discharge increase cavitation index decrease therefore cavitation occur possibility increase (figuers4,5,6) so in 592.9 $m^3/s$ discharge in entrance section on stilling basin cavitation index is minimum and therefore in this section cavitation maybe occur.

Also seem cavitation Index values in walls and bottom in specified section in same discharge are similar and have not so difference therefore cavitation occur possibility in walls and bottom is similar and in 592.9 $m^3/s$ discharge in start of stilling basin on right wall because of too decrease cavitation index certainly cavitation be occur(figuer5).

![Figure 1](image1.png)  
**Figure 1** Variations of the $C_{p'}$ coefficient in different discharges on stilling basin bottom

![Figure 2](image2.png)  
**Figure 2** Variations of the $C_{p'}$ coefficient in different discharges on stilling basin right wall
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Figure 3 Variations of the $C_{P}^\prime$ coefficient in different discharges on stilling basin left wall

Figure 4: Variations of the cavitation index base on 0.1 percent probably in different discharges on stilling basin bottom

Figure 5 Variations of the cavitation index base on 0.1 percent probably in different discharges on stilling basin right wall
Figure 6  Variations of the cavitation index base on 0.1 percent probably in different discharges on stilling basin left wall

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Authors:

Amir Khosrojerdi
Water Engineering Dep.,
Science and Research Branch,
Islamic Azad University,
Tehran, Iran,
khosrojerdi@srbiau.ac.ir

Neda Galle-Dari
M.S. Student, Azad University,
Center of Tehran Branch,
Tehran, Iran