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*Extended Abstract (Technical Note)*

# Experimental Study of Vortex Flow Phenomena in Orifice Spillways (Case study: Karun III Dam)

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## Introduction

In dam reservoirs whirlpools cause problems such as increased energy loss, decreased discharge coefficient, increased noise, and vibration at intakes (Knauss,1987). Hecker (1981) divided vortices based on visual classification from weaker to stronger into 6 types. For a powerhouse tunnel intake it is assumed that in vortex type 5 debris and some air bubbles are entrained to the tunnel and in the strongest vortex (type 6) a stable air core from water surface is formed in the center of the vortex and air is entrained into the power tunnel steadily. By reducing the submergence depth in power intakes, the strength of vortices increase regarding to the unchanging discharge. However in orifice spillways, the discharge is a function of submergence depth and by decreasing it, the discharge will decrease.

## Objectives

In the present study the changing strength and the stability of vortices are analyzed against changing discharge and submergence depth using a physical model of orifice spillway. In addition, the effect of the vortex on the discharge coefficient and local loss was estimated.

## Methodology

Karun III dam is a double arch concrete dam 205m high from the foundation and is constructed on the Karun River in southwestern Iran.

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The dam has four orifice spillways which are placed on the half elevation of the dam body with a maximum discharge capacity equal to 5740 $m^3/s$. A partial model of one orifice with a scale of 1:33.33 was constructed.

## Discussion and Results

Experiments showed that as the water level lowered in the reservoir the strength of vortices increased, such as vortex type 6 which was formed in S/D 3.1 till 3.7. From S/D equal 1.8 to 2.4, the strength of vortices decreased. In S/D=1.2 all vortices were eliminated (Figure 1). It is shown that by moving from vortex type 2 to type 6, the energy loss caused by the vortex increased. By increasing the water level vortices gradually disappeared. Therefore in Fr=1.9 the energy loss was less than the loss in Fr=1.7 which can be the effect of the vortex. This effect again was observed in Froude Number between 2.1 and 2.2 where vortices were eliminated. Also the formation of strong vortices of type 6 can reduce the discharge coefficient of the spillway by 10 percent.

In figure 2, a comparison between the experimental and calculated submerged depth using 8 methods (Gordon (1970), Reddy & Pickford (1972), Knauss (1987), Rohan (Andaroodi, 2006), Chang, Amphlet, Jain, Berge (Daemi, 1998)) is presented. Considering vortex type 5 as a dangerous vortex, relative critical submerged depth read in a real experiment was placed between 3.7 and 4.3. The Gordon (1970) and Knauss (1987) equations estimate critical submerged depth to be about 4 which is in agreement with the experimental data.

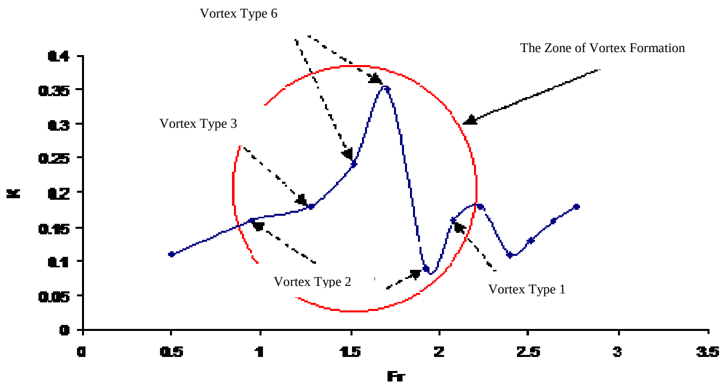


**Figure 1- Froude Number effect and Vortex type on Energy loss coefficient (*K*)**

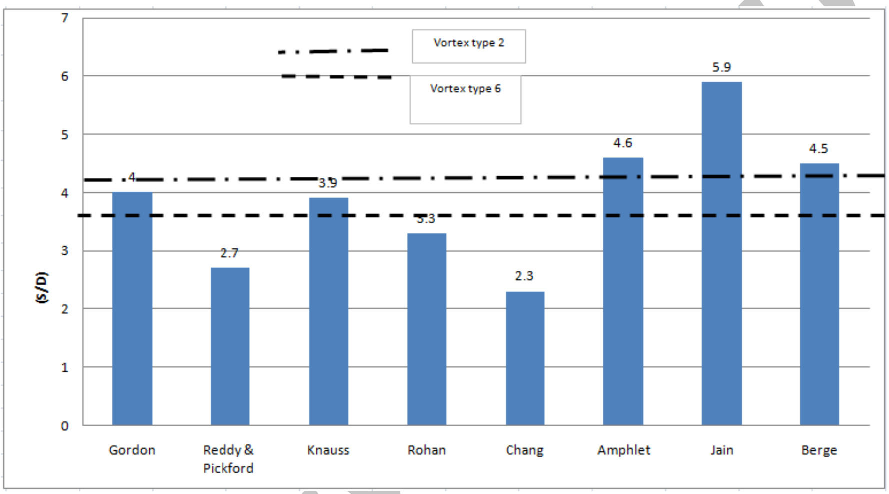


**Figure 2- Comparison of relative critical submerged depth (S/D) between experimental and theoretical results**

## Conclusion

In Orifice spillways the discharge changes with the change in water elevation. Accordingly experiments showed that by decreasing the submerged depth in orifice spillways the strength of vortices first increased up to a maximum value and then decreased. In addition, experiments showed that vortex formation reduce the discharge coefficient of the orifice spillways.

***Keywords:*** Vortex, Orifice Spillway, Karun III dam, Physical Model, Local Loss.

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