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USING PNEUMATIC TUBE FOR REDUCE FORCE OF ICE CLASH AND WAVE HYDRODYNAMICS

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ABSTRACT

In the last decade the climate has been changing and this event has influenced on the reservoir such as decrease in temperature which can build ice covers on reservoirs. Windy weather also causes large waves on the reservoirs. Thus, dams can be influenced by these climate changes. Water waves hit the dam's body and then water tends to pull materials inside. A pneumatic tube (PT) is a kind of long tube which is designed for reducing force of ice, water waves and water wave hydrodynamics. It can be situated on the water surface in the vicinity of the dam. It has some instruments for moving when water level changes. Pneumatic tubes are useful for riprap's or cover's life. They can be assembled when the weather is cold and windy, as it is required.

Keywords: pneumatic tube, water hydrodynamic, ice clash, force reduction, significant wave height (Hs).

INTRODUCTION

In order to present particular problems of water shortages and climatic conditions, water has always been a very valuable material in Iran. Many irrigation systems that use water have existed for several years. The Achaemenid Empire built large dams in the southwest and southern Iran. Dam construction as one of the oldest and the most complex human activities have always been considered by different communities. Climate changes such as windy weather which causes water waves, periods of fall in temperature which produce ice cover, alteration of the amount of reservoir water are factors influencing the water wave height and energy. The water wave hitting the dam’s body has two actions, its impact force on the dam’s body which occurs immediately and then water tends to pull materials inside the reservoir. These events affect the dam’s body. A relatively new technology that is used for surface water control is inflatable dams These dams are basically cylindrical tubes, made of rubberized material, and inflated by air, water, or a combination of the two. The idea of using inflatable dam was first proposed in 1950 by N.M. Imbertson. Since then, over two thousand such dams have been constructed in Japan, the United States, Thailand, and many other countries. A review of published work involving such dams is given in a paper by Hsieh and Plaut (1990), and additional publications include Mika (1981), Wakefield (1987), AbdulRazzak et al. (1988) etc. Inflatable dams can raise the height of existing dams or spillways, impound water for recreational basins, divert water for irrigation or groundwater recharging, prevent river backflows due to high tides, and control water for hydroelectric production. "Inflatable dams and tubes can provide an alternative to levees and sandbags in protecting buildings and towns from flooding" Plaut concludes.

In the present research, it has been attempted to show another practical use of pneumatic tubes for controlling some forces such as ice clashes to the dam’s body or the force of water waves. In contrast to the work of the inflatable dams, the PT (is similar in appearance to the inflatable dams) proposed for the present project was supposed to be filled with air and water together in order to gain higher stability and better controlling of the impact force.

EXPERIMENTAL

Design of pneumatic tubes filled with air and water

In a first experiment a simple pneumatic tube was built from a plastic bottle with about 10 cm diameter and 30 cm length. This tube was used as a simulation of a pneumatic tube. It could be filled with various amounts of water to optimize the volume of water for controlling the floatation of the bottle on the water surface and also its stability. A large tub was filled with enough water to make waves on the water surface. Initially, the empty plastic bottle was floated on the surface of the water present in the tub and waves were induced manually and its stability was assessed. In a second experiment like field experiment which was done nearby the Doroodzan dam reservoir located in Fars. A pneumatic tube was built from a black flexible plastic tube with 4.5 m length and 0.35 m diameter which filled with air and optimized water amount which reached according in the first experiment. A site experiment was chosen near the reservoir margins which look like riprap cover and the black pneumatic tube was there and was fixed with rope while it did not induced motionless tube, it could floating on water surface and water waves motioned it. A little boat was assumed as ice or bough which was moved toward the pneumatic tube with approximately 5 km/h velocity in order the black pneumatic tube experimented in clashing reaction.

Simulation of pneumatic tubes filled with air and water

The PT simulated in this project, as mentioned above, was a plastic bottle filled with air and water. Methods for determining the diameter of the PT is depend on the water waves. The criterion, suggested here, was H_S and other objects such as ice cover and tree trunks that have impact forces on the dam’s body. In fact, the PT tries to reduce the influence of forces mentioned above

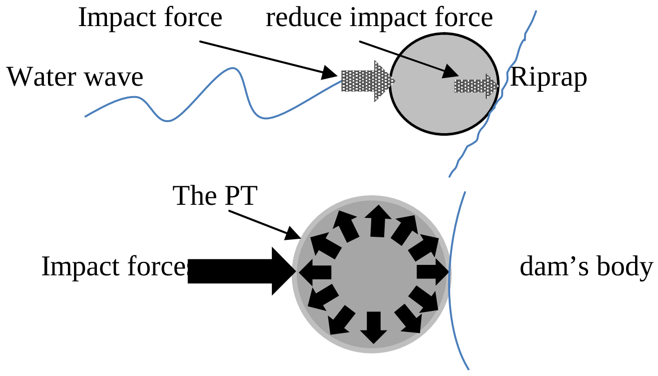

Figure1: Schematic appearance of dam

As seen in Figure 1, the PT is able to distribute the stress in itself to prevent that much stress entering the dam's body.

In general, the most materials (solids) entering into the water reservoir can be divided in two different categories. The first category includes the materials with higher densities than water so they settle at the bottom of the reservoir. The second category includes objects such as tree trunks and pieces of ice which are floated on the water surface and make impact on the dam's body. The PT design for reducing the effect of the second category on the dam's cover is usually a riprap. So the PT is floated on the reservoir and near the dam's cover. (Figure 2).

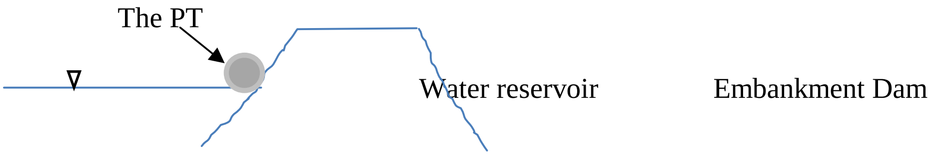

Figure 2: The PT condition

RESULTS AND DISCUSSION

The water present in the bottle could control floatation and stability of the bottle which was a simulation of a PT. Thus, it was a modification of a PT. When the bottle was empty it did not have enough stability to stay at a position on the water surface. On the other hand, with too much water it was too heavy and consequently could not move as easy as when the bottle was empty (Figure 3). The solution was to optimize the amount of water in the bottle. Bearing in mind that water as a liquid could move in the bottle. Therefore, the impact force of the water inside the bottle moved in the reverse direction of the force vector and it gained more stability (Figure 4).

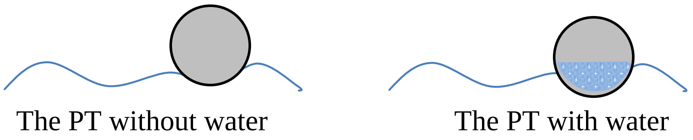

Figure 3: With water the PT has more stability

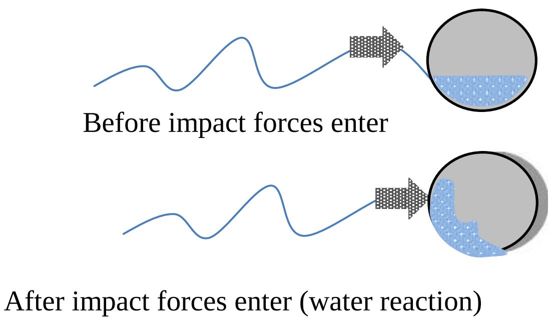

Figure 4: Stability and the water reaction

Figure 4 shows how water leads to the stability of the PT. The impact force vector moved the PT in its initial direction. (The PT moves but the water inside the PT has a reverse movement). Thus, water moves in the reverse direction and the mass center changes. This behavior prevents excessive movement of the PT. However, there is a limitation for the amount of water inside the PT.

THE PT DIAMETER

The PT diameter depends on H_s and x. H_s is significant wave height and x is the average level of the PT being sunk in water by its mass and also the mass of water which is inside it (Figure 5).

$$\text{Diameter} = H_s + x \qquad (1)$$

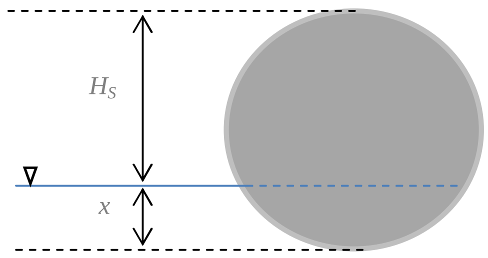

Figure 5 : The PT high

The results showed that the following experimental relationship existed between Hs and x.

$0.125\ H_s \leq X \leq 0.375\ H_s$ (2)

So the diameter (D) is:

$1.125\ H_s \leq D \leq 1.375\ H_s$ (3)

The type of material used for the PT wall and also its thickness are important factors which influence the PT's perimeter above the water. If the volume of water inside the PT is increased, the density increases. Since the density of the water is much more than the PT's density, the PT's density can be ignored. The most important factor for the PT volume is diameter which itself depends on H_s. The diameter (D) is assumed to be

$D = 1.25\ H_s$ (4)

And

$x = 0.25\ H_s$ (5)

with unit length so:

$$A = \frac{(1.25H_S)^2 ®}{4} \quad (6)$$

and

$V = A * 1_m$ (7)

It was attempted to calculate the PT's height out of water level (Figure 6). The variable r is $0.5\ D$.

$$r = 0.5\ D \Rightarrow \tag{8}$$
$$r = 0.5\ (1.25\ H_s) = 0.625\ H_s \tag{9}$$

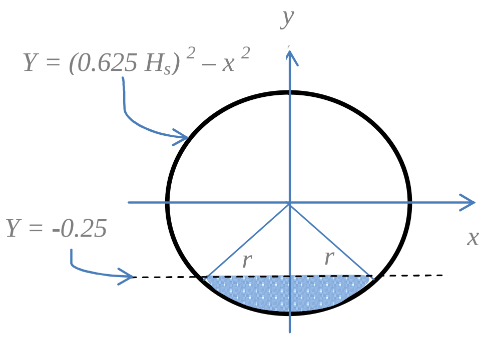

Figure 6 : The PT cross section

The equation of circle (the PT) is:

$$x^2 + y^2 = (0.625\ H_s)^2 \tag{10}$$

The optimum water volume is the portion of PT which sinks in water but height of the PT on the water level should not be less than H_s. According to the optimum water volume and H_s the PT's diameter should be minimum. With trigonometry, the amount of water inside the PT can be estimated (Figure 7).

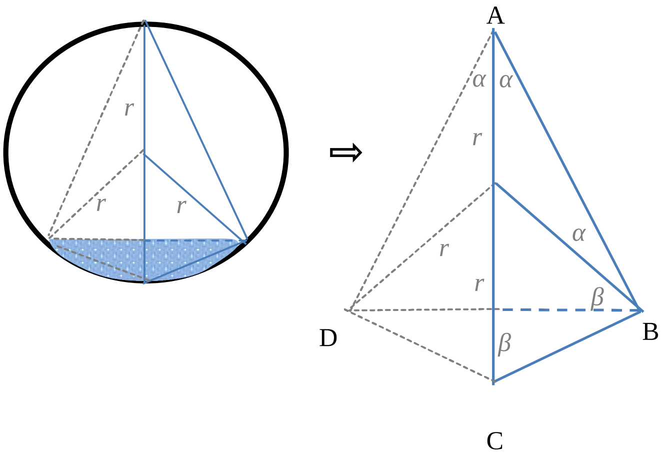

Figure 7: The PT cross section

The sum of angles is equal to 180^o so:

$$(\alpha+\beta) + \alpha + \beta = 180 \;\Rightarrow\; \alpha + \beta = 90 \quad (11)$$

It can be assumed that:

$$\Rightarrow \quad \alpha=30^o \;,\; \beta = 60^o \quad (12)$$

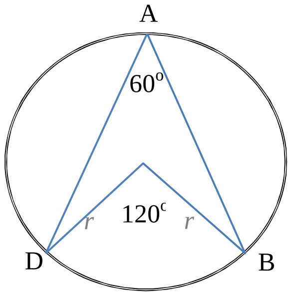

Figure 8: Distance between B and D on perimeter is under water

In fact, the PT perimeter (cross section) for determining H_s is shown in Figure 8. 1.3 H_s m^2 show the area that is under water per unit length and 2.63 H_s m^2 shows the area above the water level per unit length so marked on the PT to operate better.

If α is assumed to be more than 30° the diameter increases because it has to keep the height above water level as H_s and if it is assumed to be less than 30° the water reaction is weak.

When the water inside the PT moved to one side, the PT lost its balance (Figure 9). According to the dam length as same as the PT's length, it is recommended to divide the PT to some parts. Between each part, ring tubes are used, the ring tube is a ring around the PT, like automobile tires, situated around from one end to another end of the PTs. A ring tube should be full of air to protect its balance (Figure 10).

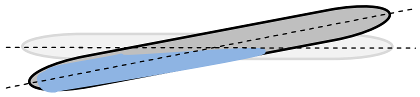

Figure 9 : The PT loses balance

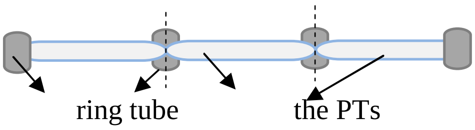

Figure 10: Ring tube situation

To prevent the PT's buckling, it is recommended to choose the best distance. The distance depends on the ring tubes and the PTs thickness and the kind of material making the tubes. If the buckling was more than usual, spare ring tube should be used. In addition, the ring tube helps better movement especially on the riprap.

THE PT FOR EMBANKMENT DAM

The embankment dams are inclined and their slopes depend on the kind of riprap cover. Approximately, the highest slope of the embankment dam is 1:3.5; the ring tubes around the PT help it in movement. There are beams such as first parts of instruments these are fixed on riprap vertically. In the second parts of the instrument, there are spool and anchor that can move on the beam. The third part is a rope that is fixed by the ring tube and its other side is fixed by the anchor. The anchor has a definite mass that causes its sinking due to gravity. The anchor moves (with its mass) on the beam easily thus the ropes are being under slight tensile force (Figure 11).

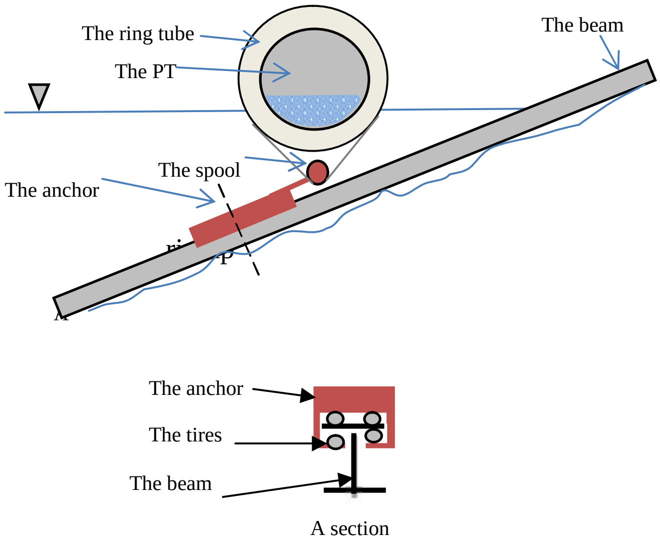

Figure 11: The anchor for embankment dam

There are wheels inside the anchor to move the anchor better under the flange of the beam. When the PT moves toward the reservoir at one end of the anchor, it stops while moving toward the reservoir.
When the water rises up, the PT raises with the anchor and when the water level falls the PT also falls and the anchor is sunk. The anchors restrict the movement of the PT. For each ring tube there is a fixed beam.

THE PT FOR CONCRETE DAM

The instrument and the operation are similar to the embankment dam. The anchor's definite mass for concrete are not heavy like anchor of embankment dam because it moves vertically. These beams can operate on concrete dams. They are available for arch dams as well.

CONCLUSION

The PT can reduce the force of water waves, water wave hydrodynamics and ice or tree trunks hitting the dam's body, and especially when the weather is cold or windy, on account of its flexibility and mobility. Consequently, the cover (riprap) life increases.

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