THE STUDY OF THE BEHAVIOUR OF THE GALBENI CHANNEL

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The paper deals with the problem of the washing of the Galbeni channel which provides water to the Galbeni hydropower plant. The main purpose is to find the way to eliminate the big deposit of sediments from the channel. The authors use suitable similitude criteria and indicate the preferable mode to clean the channel.

Keywords: sediments, channel, similitude.

1. Introduction

The improvement of the functioning of the hydropower plant of Galbeni corresponds to a sustainable development using a clean source of energy. The accumulation of the sediments inside the channel which provide water to the plant can even block and stop the turbines. As a consequence, it must be establish a suitable way of alimentation with water, so that less sediment is deposited. The biggest part of the quantity of the solid material must be transferred downstream, together with the water, through the turbines.

2. The theoretical aspects

2.1 Hydraulic aspects

Because the slope of the bottom of the channel is $I = 0$, the shear stress at the bottom is $\tau = \gamma RI \cong \gamma hI = 0$ and doesn't produce the wished effect.

It results that the particles of sediment cannot be moved using the tangential component of the gravitational force and they must be scoured using the suction effect.

It is recommended to obtain a bigger speed of the water. The flow regime must be turbulent.

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The sediment particles can be moved with the tangential component of the gravitational force only on the small bended part of the sediment dune, near the dam.

Because the turbines are functioning in a well known range of flows, the transversal section must be small to obtain high scour speeds. So, the depth of the water in the channel must be small.

2.2. Similitude aspects

Because in the channels where a free surface flow is produced the gravitational force is predominant, one must have the same value of the Froude number on the prototype installation at the natural scale with the Froude number on the model installation at a small scale in the laboratory.

With other words:

$$\mathrm{Fr} = \mathrm{Fr}'$$

One obtains:

$$\frac{V^2}{gh} = \frac{V^2}{g'h'} \tag{1}$$

Because the gravitational acceleration remains constant and considering that the speed on the model installation is measured in the laboratory, one can determine the average speed of flow V from the transversal section at the natural scale and then the volumetric flow in the channel which is later turbinated.

It results:

$$V = V' \sqrt{\frac{h}{h'}} \tag{2}$$

As it is well known, a complete dynamic similitude cannot be obtained, the Froude criteria of similitude is sufficient in the situation in which the Reynolds numbers on the prototype and model installations are in the same range, or one can say that is the same flow regime [1].

It is obviously that in the case of the Galbeni channel, the regime of flow must be turbulent to scour the sediments.

3. The experiment

As the flow and the speed of water in the model channel are growing, it is observed a slow movement of the sand.

One reads the indication of the manometer in form of tube U, Δh = 10 mm at a depth of the water in the channel h' = 30 mm. The speed is to small.

The flow in the channel is growing and appears the turbulent flow and at Δh = 15 mm and h' = 47 mm becomes the scour.

At Δh = 19 mm and h' = 70 mm becomes the massive scour of the sand.

One simulates the growing of the flow into the turbines, so that the speed and flow are growing and the depth is decreasing at Δh = 24 mm and h' = 55 mm. A big movement of the sand is produced.

In the same manner, at Δh = 38 mm and h' = 44 mm the regime is advanced turbulent and a continuous movement of the sand takes place.

At the end of the measurements, one can remark the values Δh = 40 mm and h' = 50 mm.

At the end the channel was completely washed, as it can be seen in the figure 1.

Figure 1. Experimental installation

Because of the small depth of the model channel, the value of the speed V' can be considered as a medium value of the speed in the transversal section.

4. The calculus of the speed and flow

One calculates the five sets of experimental results [2], [3].

In every case one obtains the average speed with the indication of the manometer fixed at the Pitot-Prandtl tube.

The dynamic pressure in the channel is equal with the pressure of the water column:

$$\rho \frac{V'^2}{2} = \rho g \Delta h \quad (3)$$

Simplifying results:

$$V' = \sqrt{2g\Delta h} \quad (4)$$

Case 1. Δh = 15 mm and h' = 47 mm

$$V' = \sqrt{2 \cdot 9.81 \cdot 0.015} = 0.54 \text{ m/s} \quad (5)$$

If the depth of the water is h = 1 m, then the bottom speed differs a little from the average speed and the scour of the sediments is better produced.

The speed of the water in the Galbeni channel should be, according with the theory of similitude:

$$V = V' \sqrt{\frac{h}{h'}} = 0.54 \sqrt{\frac{1}{0.047}} = 2.5 \text{ m/s} \quad (6)$$

The aria of the transversal section through the channel between 137,5 m (the superior level of the sediments) and 138,5 m is the following:

$$A = \frac{40+35}{2} 1 = 37.5 \text{ m}^2 \quad (7)$$

The volumetric water flow is then:

$$Q = AV = 37.5 \cdot 2.5 = 93.75 \text{ m}^3\text{/s} \quad (8)$$

At this flow, according with the precedent observations becomes the movement of the fine particles. It is useful to work two turbines, each with a flow of 50 m^3/s, so a total flow of 100 m^3/s.

Case 2. Δh = 19 mm and h' = 70 mm

$$V' = \sqrt{2 \cdot 9.81 \cdot 0.019} = 0.61 \text{ m/s} \quad (9)$$

$$V = 0{,}61 \sqrt{\frac{1}{0{,}07}} = 3.78 \text{ m/s} \quad (10)$$

$$Q = 37.5 \cdot 3.78 = 141.75 \text{ m}^3\text{/s} \quad (11)$$

So at the depth of the water in the Galbeni channel of 1 m and the turbinated flow of 150m^3/s (one with 100 m^3/s the other with 50 m^3/s), should become the scour of all sediment particles.

Case 3. Δh = 24 mm and h′= 55 mm.

$$V' = \sqrt{2 \cdot 9.81 \cdot 0.024} = 0.68 \text{ m/s} \quad (12)$$

$$V = 0.68\sqrt{\frac{1}{0{,}055}} = 2.9 \text{ m/s} \quad (13)$$

$$Q = 37.5 \cdot 2.9 = 108.75 \text{ m}^3\text{/s} \quad (14)$$

The movement of the sand continues at this flow.

One proposes the same turbinated flow as in the previous case, 150 m^3/s.

Case 4. $\underline{\Delta h}$ = 38 mm and h' = 44 mm

$$V' = \sqrt{2 \cdot 9.81 \cdot 0.038} = 0.86 \text{ m/s} \quad (15)$$

$$V = 0.86\sqrt{\frac{1}{0.044}} = 4.1 \text{ m/s} \quad (16)$$

$$Q = 37.5 \cdot 4.1 = 153.75 \text{ m}^3\text{/s} \quad (17)$$

Two turbines can work, each with 100 m^3/s, situation which corresponds to a strong turbulent regime.

Case 5. Δh = 40 mm and h′ = 50 mm

$$V' = \sqrt{2 \cdot 9.81 \cdot 0.04} = 0.89 \text{ m/s} \quad (18)$$

If the depth of the water in the Galbeni channel is h = 2 m then the free surface of the water is at 139.5 m.

$$V = 0.89\sqrt{\frac{2}{0.05}} = 5.63 \text{ m/s} \quad (19)$$

The aria becomes:

$$A = 37.5 + \frac{45+40}{2} 1 = 37.5 + 42.5 = 80 \text{ m}^2 \quad (20)$$

$$Q = AV = 80 \cdot 5.63 = 450.4 \text{ m}^3\text{/s} \quad (21)$$

Two groups should work with the maximum flow and the sediments are moved also at this depth of the water.

5. Conclusions

Taking into account the five studied cases, one can conclude that the efficient scour of the sediments in this channel can be done at flows with small depths and big speeds.

After a while, after the channel is washed, the depth of the water in the channel will increase inevitable, because the depth of the dune of the sediments will decrease. So the flow must increase to succeed to scour other sediments.

It is preferable to work both turbines, not to let first the particles to deposit.

It should be maintained a turbulent flow until the complete wash of the sediments.

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