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CHANGE IN LENGTH OF HYDRAULIC JUMP WITH CHANGES OF CHANNEL BOTTOM ROUGHNESS

by

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Translated from the Russian by
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ABSTRACT

CHANGE IN LENGTH OF HYDRAULIC JUMP WITH CHANNEL BOTTOM ROUGHNESS--A Translation from the Russian. A series of model tests in a two-dimensional glass walled flume 20 cm wide were conducted. Six discharges and 9 roughness were used on a horizontal bottom. Bottom roughness was changed by attaching different size sand grains to a steel plate. The dimensionless ratio, length of jump for a given roughness $/\ell/$ divided by length of jump for a glass floor $/\ell_0/$ was plotted against the relative roughness $/d/h_1/$. An approximate equation was fitted to the points. The plot indicates that for a relative roughness of 0.025 the length of jump is decreased by approximately 25 percent. The author concludes that investigations on models with a roughness exceeding the actual roughness can lead to underestimating the predicted length of jump by 10-30 percent, and that additional tests and mathematical derivations are necessary. 13 Ref. 1 fig.

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CHANGE IN LENGTH OF HYDRAULIC JUMP WITH CHANGES OF CHANNEL BOTTOM ROUGHNESS

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In the hydraulics laboratory of the institute of water problems and hydraulic engineering (IVPiG), Academy of Sciences of Uzbeck SSR, near the end of 1961 and beginning of 1962, a series of tests were conducted to determine the effects of roughness on the length of a hydraulic jump. The tests were conducted for a two dimensional condition, in a glass walled flume approximately 20 cm wide. Six discharges and nine categories of roughness were used on the horizontal bottom of an overflow spillway. The model was approximately 0.5 meter high, and the spillway was made from a sheet of aluminum. It was found that when a plate of glass was substituted for the horizontal steel floor there was a relatively small change on the length of jump (2-3 percent), but when the roughness of the bottom was increased by means of a patch on the steel floor with sand grains attached of 0.37, 0.75, 1.5, 2.5, 3.5, 9.5, and 20 mm (*diameter) there was a very pronounced change on the length of the jump. In the tests the lengths of jumps were compared by considering the average measured length of the jump from its beginning to the location where the flow divided between return flow and downstream flow; in other words the length of the jump used in the tests was equal to the length of the swirl (highly turbulent section). For increased roughness the length of the jump was considerably reduced in comparison with the length of the jump which occurred for the glass bottom; for a value of relative roughness of $\Delta / h_2 = 0.4$ the length of the jump was reduced by approximately 1/2 (figure).

The approximate relation

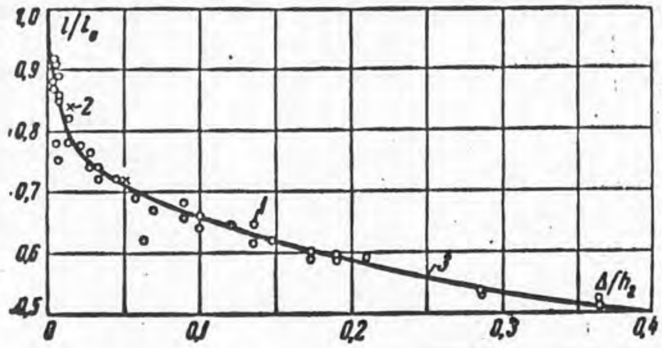
$$\frac{\ell}{\ell_0} = 1 - k\left(\frac{\Delta}{h_2}\right)^{0.28}$$

was found to fit the experimental test points. In this equation:

- ℓ_0 = length of jump for glass bottom
- ℓ = length of jump for variation of Δ / h_2 from 0.0001 to 0.4
- $k \approx 0.65$ - a coefficient which is a function of the critical depth and is given as:

$$k = \frac{13 + 722\, h_{kp}^{1.5}}{h_2^{0.72}}$$

*Translation note: (it is assumed h_{kp} is the critical depth).



RELATION OF LENGTH OF HYDRAULIC JUMP TO BOTTOM ROUGHNESS

1. Tests Yu. M. Kuz'minova in the institute of water problems and hydraulic engineering (IVPiG) Academy of Sciences of Uzbeck SSR (flow from overflow spillway p = 46 cm in a flume 20 cm wide); 2. Tests of K. A. Suleymenova in institute of power engineering, Academy of Sciences, Kazakh SSR (discharge from under sluice gate in a flume 40 cm wide); 3. Curve constructed from experimental points according to equation (1).

The following was concluded from calculations using k = 0.65:

1. It is possible to reduce the length of a jump if its roughness is increased. For example, by creating a relative roughness of Δ/h_2 = 0.1, it is possible to reduce the length of jump by approximately 35 percent in comparison with the length of jump for a smooth floor. By further increasing the ratio Δ/h_2 on the floor (or mounting) the jump becomes even shorter.

2. Investigations on models with a roughness exceeding the actual roughness can lead to underestimating the predicted length of jump and the necessary length of slab by 10-30 percent (assuming a correct forecast of the influences of, φ, (Ref. 1) the aeration of flow, and of the depth of local erosion (Ref. 2)).

3. Additional tests are necessary, and also a theoretical derivation should be undertaken, where the force due to friction is considered in the derivation of a formula to determine the length of a hydraulic jump. It is also necessary to have a more detailed study on the influence of roughness on the aeration and pulsations (surge) in the zone of the jump.

For a series of installations in mountainous and foothill areas concrete aprons are often lined with boulders embedded in the concrete. They protect the concrete from erosion by sediments, especially if they are placed with a certain slope according to the flow (mounted overlapping like shingles). Our tests permit more efficient design of lengths of slabs. Increased roughness of these linings reduced the turbulence of flow, improves the uniformity of flow and reduces the depth of local erosion of the river channel (Refs. 2-8).

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