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Model Research of Ice Jams

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Abstract: This research of ice involvement under ice cover is a part of study process of ice jams formation on rivers. Model research can determine conditions of drifting under ice cover glaciers of various planned sizes and thicknesses upon various hydraulic parameters of flow. This work gives the results of model research of effect of deepening obstacle over ice involvement under obstacle under Froude $F_{гкр}$, under which critical speed is increased.

Key words: Ice aggregates · Diving jams · Hummockingjams · Formation of jamming · Froude number

INTRODUCTON

In spite of complexity and variety of jams on the rivers two basic type of jam processes can be classified:

- Formation of jam aggregations through increased number of glaciers under edge –diving jams;
- Formation of jam aggregates upon destruction of ice cover in the hummocking process and ice nip through leak-in, thrust and ice bulk "hummocking jams".

In the first case process of formation of ice aggregates is determined by energy of flow, required and sufficient for diving of glaciers and their migration under ice cover to the area with declined current speeds where aggregate is formed. Volume of glaciers forming a jam does not exceed flow depth. Formation of jamming through ice involved under edge is observed mainly at the approach to edge of separate glaciers at the section of adjusted rivers in the dam transient region, lower reaches of hydro power plants, as well as in cases of accelerated movement of ice masses entering from upper river sections upon fracture of jamming or opening of inflowing streams. Moreover, this type of jam is observed at the river section with sufficient destruction of ice cover under effect of solar radiation (the Don, the Dnepr, the Danube, the Amur, the Syr-Darya). Formation of jams upon hummocking in the process of general destruction of ice cover under effect of static and dynamic compression of icefields is most spread on the rivers in the northern regions.

Model study of involved slob ice and ice under edge of ice cover is a key part of studying jam processes on the rivers and stage of experimental development, methods of hydraulic regulation of slob ice and ice transportation. Model study can determine conditions of drift under ice cover of glaciers of various sizes and thickness upon various hydraulic parameters of flow [1].

Research: As resemblance criteria in flow modeling non-dimensional numbers of Froude and Reynolds are usually used, but as simultaneous satisfaction of these criteria is impossible Froude number Fr is used in modeling of ice transit, that reflects ratio of gravity and inertia. Difficulty in modeling of ice transit is choice of material to substitute ice. Works of different authors tend to select material substituting ice with specific gravity as similar to specific gravity of ice $\gamma = 0{,}9g\ /\ sm^3$. Most frequently used material substituting ice is paraffin. Water repellency of paraffin plates at some extent affects their interaction with obstacle and in case of low-scale models can undergo significant distortions in modeling occurrence of ice involved under obstacle. Such disadvantage takes place if another wide-spread ice substituting material – wood of various types is used. Currentlyvarieties of polystyrols andpolyethylenes have become more and more spread ice-substituting materials.

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Canadian scientists studied involvement of ice under edge connected critical speed with depth characterizing critical moment by Froude number $F_{r\kappa p} = \frac{\upsilon_{cp}}{\sqrt{gh}}$.

$F_{r\kappa p}$ = 0,08 and $F_{r\kappa p}$ = 0,15.

where: g – acceleration of gravity, υ_{cp} – Average flow velocity, h – depth of flow.

Trying to connect these values Michel B. introduced porosity coefficient for ice aggregates forming an obstacle and offered the following formula for calculating $F_{r\kappa p}$:

$$F_{r\kappa p} = 0.154\sqrt{1-\varepsilon} \tag{1}$$

where ε – porosity of ice mass to edge. Under this formula value of $F_{r\kappa p}$, obtained by authors [4] can be compared under ε, equal correspondingly 0,73 and 0,05. [2-3].

Authors carried out modeling of ice involvement under obstacle depending on expected sizes and thicknesses of glaciers. The obtained range of values $F_{r\kappa p}$ (0,06-0,22) [4].

Authors carried out modeling of ice involvement under obstacle in auto modeling under Reynolds R_e [1]. The results of research demonstrated that upon dimensional length of glaciers and depth of flow meaning of current speed that determines ice involvement under obstacle depends of glacier length:

$$\upsilon_{cp} > \sqrt{0.035gl}$$

or

$$F_{r\kappa p} = \frac{\upsilon_{cp\kappa p}}{\sqrt{gh_{cp}}} \approx 0{,}19 \tag{2}$$

The work studied [2] effect of obstacle deepening to glacier dive-in. results of research are given for deepening h/δ, equal to 0,37, 0,44, 0,62, 0,67.For the said values of h/δ, ice involvement under edge takes place and does not affect speed of dive-in upon Froude number $F_{r\kappa p}$.

where: h – height of deepening obstacle.

Authors [5], viewing moment of ice impact on the obstacle obtained the following equation of dynamic glacier balance:

$$\frac{1}{2}g\rho_{\pi}l^2 + K_H^{'}\rho l\delta\frac{\upsilon^2}{2} - \frac{1}{2}g\rho l^2\delta - K_H\delta\rho\frac{\upsilon^2}{2} = 0$$

Solution of it to υ gives formula for critical speed in the form of:

$$\upsilon^2 = \sqrt{g\frac{\delta\left(1-\frac{\rho_{\pi}}{\rho}\right)}{K_H^{'}\frac{\delta}{l} - K_H\frac{\delta^2}{l^2}}}, \tag{3}$$

where K_H– glacier shape coefficient, $K`_H$– proportion coefficient, $K`_H = K_H$, K, ρ and ρ_{π} – density of water and ice, l – length ofthe ice, δ – thickness ofthe ice.

This equation demonstrates that critical speed depends on thickness and length of glacier [6-7].

Aim of this work is experimental determination of effects of obstacle deepening over involvement of glaciers under obstacle under Froude $F_{r\kappa p}$, under which increase of critical speed takes place.

Experimental part of work has been executed in the tray of 8.0 m length, 0.3 m width and 0.6 m height (Fig. 1). Flowspeedrangesforthemodel: 0,1-0,35 m/sec. Measurement of speeds was carried out through Pitot's tube. Paraffin plates were used as glaciers in experiment (specific gravity of paraffin 0,9 g/sm^3). Ice cover was imitated through immerged and touching tray walls polistyrol plate 0f 0.3 m width and 1.0 m length. Plates with length l from 3 to12sm and thickness δ from 0,4 to 4 sm were used in experiment.

In calculations water depth was appointed depending on planned plate size (l = 3 – 12sm). It is obvious that surface as well as medium speed sof the same value canoccur in flows of different depth. Therefore, the same experiments but in different ranges of depth measurement can obtain definite values of $F_{r\kappa p}$, unapproved among each other.

Thus, for example, at a definite height of deepening obstacle h, thickness of plates δ varied and occurred in current speed tray when increase of critical speed of ice involvement under obstacle took place (for deepening h/δ). The following series of experiments specified another height for obstacle deepening, thickness of plates varies and current critical speeds were organized when increase of critical speed of ice involvement under obstacle took place (for deepening h/δ).

During delivery of plates to obstacle their even distribution along the whole width of tray took place. At a definite speed of currents depending on the height of obstacle deepening plate was involved under obstacle. Further movement at lower surface of obstacle along the tray was carried out through multiple rotations. Plate movement in the form of sliding on the obstacle lower surface was carried out.

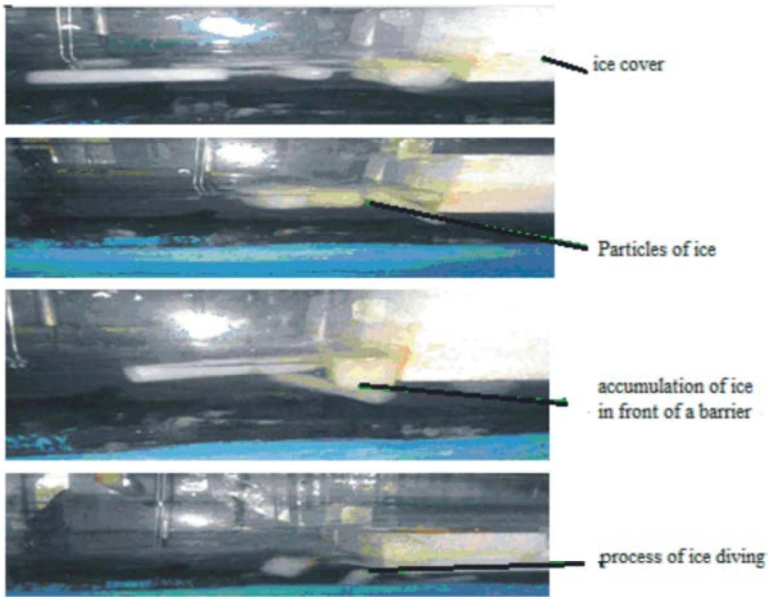

Fig. 1: Involvement of plates under obstacle edge

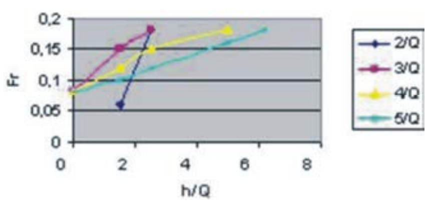

Fig. 2: Effect of obstacle deepening height over critical speed of ice involvement under obstacle depending of $Fr_{ёð}$, were h -penetrationheightof the ice cover(hedge), from 2 to 5 sm, Q – thickness of ice cover from 0,4 to 4 sm (Figure 2).

CONCLUSION

The research studied effect of deepening height over speed of ice involvement under ice cover edge. Figure 2 gives the results of research. When ratio of obstacle deepening to plate thickness is $h/\delta = 6,2$, critical speed of plates involvement under obstacle under Froude number $F_{rкр}$ stops its effect and glacier is not involved under obstacle edge, at a water speed $\vartheta = 0.12 m/s$.

Form the said we can conclude that for deepening h/δ = 6,2 higher critical speed under Froude number is required.

Estimate of model ratio h/δ specifies Froude number value used as characteristic of plates stability to obstacle.

REFERENCES

1. Ashton, G.D., 1985. J. Energy Resour. Tech., 107: 177-182.
2. Beltaos, S., 1983. J. Hydraul. Engng. ASCE, 109(10): 1338-1359.
3. Beltaos, S., 1997. Cold Regins. Technol., 25(3): 183-196.
4. Beltaos, S., 1995. River ice jams [M]. Water Resources Publications, LLC.
5. Sui, J., B. Karney, Z. Sun and D. Wang, 2002. Journal of Hydraulic Engineering, ASCE, 128(8): 781-787.
6. Shen, H.T. and D.S. WANG, 1995. Journal of Hydraulic Engineering, ASCE, 121(2): 184-195.
7. Wang, D., H.T. Shen and R.D. Crissman, 1995. Journal of Cold Regions Engineering, ASCE, 9(3): 119- 134.