AVALANCHE CAUSED CATASTROPHES ON THE MOUNTAINOUS RIVERS

A.I.Soldatov
Central Asian Research Hydrometeorological Institute (SANIGMI)
Tashkent, Republic of Uzbekistan

ABSTRACT

Alongside with the danger of snow avalanching for the objects and population, the subsequent phenomena caused by the avalanching are not less serious. One of such reasons can be the choked lakes and outflash floods on the mountainous rivers. The investigation of this matter has revealed the following. :

1. The spreading of this phenomena is typical for all mountainous regions of the world with the water courses and snow avalanches available.
2. Its danger is in the unexpected occurrence and catastrophic nature of the flood.
3. With the great number of the avalanche slides blocking in the mountainous river beds the occurrence of the outflash floods is not observed in all cases.

Using the real data collected in the Western Tien Shan mountains the numerical models were elaborated which allowed to calculate the volumes of the checked lakes, the time of their outbreak, the maximum levels of the outflashing floods and the length of their spreading. The elements of the river bed morphometry, of the avalanche centers, the water and snow conditions are used in the calculations. The comparison between the real and calculated data proves the satisfactory convergence and makes it possible to begin the forecasting of such dangerous phenomena on the basis of the standard hydrometeorological data.

DESCRIPTION OF THE PHENOMENA

Modern avalanche study has made a great progress in solution of a great number of problems connected with formation, movement, forecasting of snow avalanche and avalanche safety. However, the phenomenon accompanying avalanche breaking up still remain less investigated. Air wave blows, snowdust clouds movement, luminescence and electromagnetic waves emanation, formation of temporary avalanche blocked lakes and floods on the mountainous rivers - this is far not exhaustive list of phenomenon, which may cause a catastrophe in some cases.

Some results of investigation of outbreak floods - the consequent of a snow avalanche on the mountainous rivers - are given in the present report. Moving at a high speed for the extent of tens kilometers, water-snow flow, which height exceeds the extreme range of spring melting and rain freshets, possesses a great power and may cause a destruction of buildings and communication lines in the flood-lands. It also may lead to the destruction of ecological balance in the area as it wipes out the vegetation and washes away the soil.

Numerous literature evidences and the results of on land and air-visual investigations of descended avalanches point on formation of blocked lakes in the river beds in the mountains of Tien-Shan, Pamir, Altai, Caucasus, Alps.

A thick snow of avalanche sediments builds a dam in the mountainous river bed, keeping the flow from drain for the time from several hours to 4-5 dais.

Simultaneously with the filling of the avalanche lake, the process of freshet water filtration through the body of a snow dam begins.

Gradually weakening the mechanical resistance of the snow, the freshet water washes through a tonnel in the zone of contact between the bottom of the river bed and the lake smoothly disappears.

This smooth drainage of the lake becomes possible due to the sinking of the snow roof of the tonnel, broken into huge blocks. In this way practically the same size of a tonnel, regulating the flow can be kept. The flow itself has a character of an insignificant flood, which in this case for the distance of 1-2 km remains within normal range.

Among the other examples, the avalanche, descended in 1970, 5.30 p.m., March, 26 on the Transtienshan road, connecting the city of Bishkek (former Frunse) and the town of Osh, blocked the river Chichkan. According to the data of avalanche service the volume of avalanche was 1.5 mln m3, the length of the avalanche sediments - 850 m, width - 130 m and maximum height - more than 40 m.

The lake formed had been increasing in size for 10 hours and its volume had grown to 30000 m3 and after that time the fall of the water level had begun. Through the tonnel formed in the body of the snow block up the lake was emptied until at 6 p.m. 27 th of March; it hadn't caused a significant flood.

In certain cases the collecting of the huge masses of water occurs faster than its filtration along the river bed. Then the decantation of waters over the surface, momentary destruction of the block up and the forming of the outbreak flood take place.

This way the avalanche descended on the 27 th of January 1969 in the middle of the flow of the river Bartang (Pamir> blocked up the river for 4 hours. As a result a pool 1.5 km long, 10 m deep was formed. Water, overfilled the pool, washed off the snow block up and snow-water wave passed along the river, reaching the height of 6 m. At the distance of 32 km the level of the flood waters was 2.5-3.0 m.

On the river Jazgulem snow dam had been keeping the flow from 24 of January till 29 of January 2 p.m. 1969. The volume of water in the blocked lake to the moment of its outbreak had reached 4 mln m3. On the hydrometric post, situated in 15 km below the outbreak the water wave 5 m high had broken the measuring laths.

CALCULATED OF THE EXTREMAL PARAMETERS

For more detailed investigations of the mechanism of such outbreak floods formation, the basin of the river Oygaing in Western Tien-Shan had been chosen. In the estuary of the river since 1933 the observation of the water level and water flow were having been made.

In 1966 the regular observations upon the snow avalanches had been started by "Oygaing-estuary" snow avalanche station. Controlled area was the territory of the valley from its estuary. Its extent was 52 km. Here the works on observation of the avalanches and formation of block up lakes using airvisual and onland means were having been done since 1986. In all here are 40 avalanche centers marked. In these centers avalanches form and block up the river bed with the recurrence of 0,5-2,0 times a year. Collecting of water in blocked lake occurs when the common river flow exceeds the filtration flow. With the increase of the water level, the area (cross-section) of the filtration flow grows and as a result of it, the index of the filtration flow increases. When the indexes of common and filtration flows become equal the moment of maximum possible water level Hmax can be fixed. It depends on morphometric characteristics of the river bed: its width b, shores slope - i_s , the slope of the river bed - i_b . We must take into consideration the index of common flow Q_b and the speed of water filtration through the body of the snow dam.

In majority of cases the area of the crass-section can be approximated to the trapeze with the basic side equal with the width of a river bed and upper side equal to the width of the overflow. Concluding from the condition of zero balance of the lake, the maximum possible level can be defined by the equation

$$H^2_{\max} + bi_b H_{\max} - \frac{Q_b i_b}{V_f} \qquad (1)$$

and maximum possible volume

$$W_{\max} = \frac{H^2_{\max}\left(\frac{2H_{\max}}{i_b} + 3B\right)}{6 i_b} \qquad (2)$$

where B - is the width of the overflow in the zone of head water.

In cases, when the maximum possible level is equal to the real height of the avalanche block up ha or exceeds it, the decantation of the water over the surface of a snow dam and its momentary destruction occurs. Then the volume of the outbreak flood will be equal to the maximum volume of the lake and it can be defined as

$$W_p = \frac{h_l^2\left(\frac{2h_l}{i_b} + 3B\right)}{6 i_p} \qquad (3)$$

The analysis of the winter drain of Oygaing river during the period of 60 years, has shown that the level of outbreak flood reduces to considerable extend while its movement down the river bed. In 75% of cases of abrupt fall of water level in the snow dam basin, the water level index was always gradually restored until the initial phase without forming the outbreak flood wave. In 20% of the cases floods with small increase of the water level were registered. Only in 5% of cases subsequent of the avalanche dam outbreak was a serious flood and extreme water level.

The investigation of the parts of the flood-lands after passing one of the floods in march 1987 has demonstrated that only insignificant part of the snow cover was involved in the stream. The main mass, impregnated with water, was partly pushed to the banks and had hummock barrier shape, partly rested motionless.

The comparison of physical and mechanical qualities of the snow in the zone of the flood and in the zones close to it, leads to a conclusion that the mass of kept water amounts to 14-30% from the initial mass of the snow cover.

Additional experiments with the examples of snow taken from the shaft out of the zone of the flood give the following results

The density of the snow, g/cm3	The speed of the final water (vertical impregnation), sm/s	The time of the water (return impregna tion), hours	Maximum water ability, %
0,25-0,30	0,75	10-12	30-28
0,31-0,34	0,75	7-10	28-22
0,35-0,40	0,90	2-7	22-19
0,41-0,43	0,97	1-2	19-14

So, in several minutes 1 m3 of the snow cover of the flood-land can absorb from 60 to 90 liters of the flow water and can contain for the period of 10 hours 100-250 litters of water. As far as the flood wave moves on, the area of its contact with the snow cover enlarges.. The stabilization of the water level within the common index and the exhaustion of the speed of impregnation and the time of the water return.

Considering that the whole volume of the flood is absorbed by the snow cover of the flood-lag for the approximate calculation of the extent of the flood spread we can use the next formula

$$X_{\max} = \frac{100 h_l^2 \left(\frac{2 h_l}{i_b} + 3B \right)}{6 i_p \rho \alpha b_p h_{sn}} \tag{4}$$

or

$$X_{\max} = \frac{100 Q_b T}{\rho \alpha b_p h_{sn}} \tag{5}$$

where T - the time of the catch of the flow by the avalanche, r - the average density of the snow cover in the flood-land, α - the water keeping ability of the snow cover in % from the primary weight of the snow, bn - average width of the river bed, hons - average height of the snow cover.

For the calculation of the maximum level and the speed of the outbreak wave in given alignment the scheme of calculation offered by B.L.Istoric and V.M.Lyachter for, unstationary flood [1] was applied.

Accepted approximations: the dam is broken immediately to the whole width, natural river-bed in the tail - water - is prismatic, water movement - unsettled - are available.

The solution of the problem is numeric integration of the equation of Saint-Venant for unsettled movement of a liquid in the open river bed. Integration was taken in relative quantities and for the transition from abstract quantities the following formulas had been used

$$V_x = \sqrt{\frac{g H_{\max}}{\Psi}} \tag{6}$$

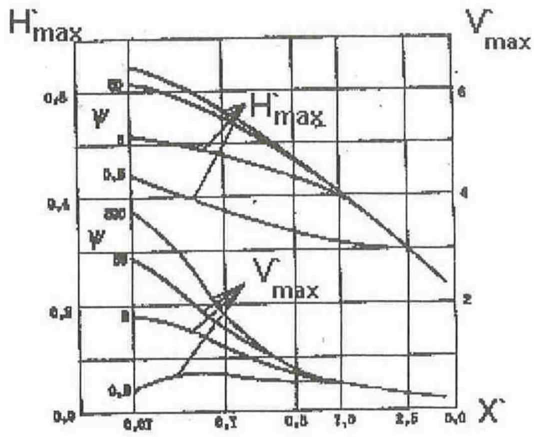
$$H_x = H_{us} H'_{\max} \tag{7}$$

Where vx and Hx are maximum indexes of level and speed of the spread of the outbreak flood in given alignment; $\Psi = \lambda\beta / 2 i_o$ - parameter, characterizing the river bed, $\lambda = 2 g n^2 R^{-1/3}$ - is a factor of hydraulic friction, β =2- is a coefficient of the river bed shape, n=0,03-0,04- factor of the roughness for stony river beds, $R = H_{us} / \beta$ - a hydraulic radius.

Authors of this method of integration of the Saint-Venant's equation composed a nomogramm for the definition of parameters v'max and H'max, where for the longitudinal coordinate the had been chosen

$$X' = L_p \; i_0 / H_{\max} \tag{8}$$

where i_0 - the average slope of the bed, L_p - distance from the dam to the necessary alignment.Graphic explication of the result of the integration helps its practical application.



The indexes of average abstract maximum speed V'_{max} and depth H'_{max} in the chosen (point).

During the comparison of the data calculated using this method, with the real observations on the rivers of Oygaing, Maydantal, Sandalash in the Western Tien-Shan the difference was discovered. While 100% covering of the flood-lands the exhaustion of the flood occurs more intensively. In addition to the spreading of the snow, considered by the equations (6) and (7), the exhaustion of the flood volume is observed, which is caused by the snow absorbtion.

The experiments on definition of the speed of the vertical impregnation and the time of water return discover their dependence from the structure and density of the snow.

Thus in the range of the primary densities of the snow of 0.25-0.43 g/sm3 the speed of vertical impregnation was accordingly 2.7-0.8 sm/s, the time of effective water return was fluctuating from 12 to 1 hours.

For more objective evolution of extreme characteristics of the outbreak flood in given alignment the factor of the degree of absorbtion should be input. The test of calculation scheme with

$$X` = L_p \ i_0 / H_{max} \ (1 - \alpha) \qquad (9)$$

had given satisfactory results, which deviation are not exceed the 20% grade of the real results. α-water keeping ability of the snow cover, its units are defined from the correlation

$$\alpha = \frac{S_n h_{sn} \rho_{sn}}{Q_b T_n} \qquad (10)$$

where S_n - the area of a river bed part, h_s - the height of the snow block, r_s - density of the snow, Q_b - common river flow, T_n - the time of the drain keeping.

RESUME

As a rule in all mountainous regions from the moment of formation of the stable snow cover and until the beginning of spring snow melting ,the feeding of the rivers is being realized by the subsoil waters.

The water flows and levels do not change much this time. The survey of the results of many years observations on hydrometric post.

Oygaing-estuary has confirmed the presupposition about the special fluctuations of the level caused by the avalanche fall. If after the avalanche fall the blocked up lake is being emptied smoothly, the hydrographer will register the drastic fall of the water level, sometimes the full drying of the water level to the initial index. In the case of outbreak the hydrographer will mark the drastic growth of the water level that reaches the extreme grades. Such facts as water turbidity, appearance of snow lumps, ice segments of plants and debris are witnessing about the avalanche fall. The frequency of appearance of all these symptoms is well correlated with the quantity of avalanches in the area of controlled basin, which has helped to recognize the years of the most avalanche activity.

After further improvement of the calculation schemes and using the present data about the weather conditions, avalanche formation and the regime of the water flow the efficient forecasting of the outbreak floods and their characteristics becomes possible.

Reference

Constantinov N.M., Petrov N.A., Visotzkiy L.I. Hydraulic, hydrology, hydrometry. M., High school, 1987, p. 65-72.