CRITICAL HYDROLOGIC CONDITIONS FOR OVERFLOW BURST OF MORAINE LAKE

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ABSTRACT: Floodwater and debris flow caused by glacial lake burst is an important land process and a serious mountain disaster in glacial area of Xizang (Tibet) Autonomous Region, and the overflow burst is mainly caused by glacial landslide falling into moraine lake. On the premise that moraine lake is full, instantaneous burst in part of the lake bank happens, as flow velocity at burst mouth caused by overflow head is higher than threshold flow velocity of glacial till. Under some supposes, d0 and d0 of the glacial till in the bank were used as the threshold sizes of coarse and fine grains respectively. Thus, the formula of calculating threshold flow velocity of uniform sand was simplified, and threshold flow velocity of glacial till was calculated with the formula. Then, with synthesis formula calculating flow velocity of instantaneous part burst, flow velocity at overflow burst mouth was calculated, and calculation formula of critical height (H0) of overflow head was derived. Overflow head was caused by volume and surge of glacial landslide falling into moraine lake, calculation formulas of ascendant height (H1) of lake water surface and surge height (H2) on burst mouth caused by glacial landslide falling into moraine lake were derived. To sum up, critical hydrologic conditions of moraine lake burst with overflow form are: the burst is inevitable as H1 ≫ H0; the burst is possible as H1 < H0 and (H1+H2) > H0; the burst is impossible as (H1+H2) < H0. In the factors influencing the burst critical conditions, it is advantageous for the burst that scale of the lake is 105 m² range; terminal glacial till is more fine and is even more uniform; the width of overflow mouth is even smaller than the length of the bank; the landslide has large scale and steep slip surface; and glacial end is close to the lake. With burst of Guangxiecuo Lake in Midui Valley of the Polongzangbu River in Xizang as an example, the burst critical conditions were tested.

KEY WORDS: moraine lake; terminal moraine bank; overflow burst; critical height of overflow head; glacial landslide; Guangxiecuo Lake

1 OVERFLOW BURST OF MORAINE LAKE

Floodwater and debris flow caused by glacial lake burst is an important land process and a serious mountain disaster in glacial area. Glacial lakes with burst can divided into the glacier-obstructed lake (ice dam lake) and the terminal moraine lake (Xu and Feng, 1988). Typical burst of ice dam lake happens in the modern glacier area of the upper reaches of the Keleqing River in Uygur Autonomous Region of Xinjiang (Wang, 1990). But most of burst glacial lakes are moraine lakes, which centralize in Xizang Plateau and Himalayas area. In Xizang Region, there are thousands of glacial lakes in high mountains, of which 1/4 are danger moraine lakes where bursts possibly happen. Now, 12 moraine lakes with burst are already investigated, which all happened since 1935. In direct causes of the bursts, most are glacial landslide or ice avalanche (be generally called glacial landslide in the following) falling into moraine lake. Floodwater caused by moraine lake burst and debris flow developed by the flood caused enormous disasters. The relevant main data are listed in Table 1 (Lu et al., 1999).

Bursts of the moraine lakes can be divided into two types. One is overflow burst which is caused by washing and down cutting of overflow head, as velocity of the overflow is higher than threshold flow velocity of glacial till and as descent speed of the lake water level is smaller than speed of down cutting. The overflow head is made by ascendant height of lake water level...
and surge height at burst mouth caused by glacial landslide falling into the lake. Other burst type is piping wreckage caused by melt of buried ice under terminal moraine. In 12 bursts of glacial lakes in Table 1, 9 bursts were the overflow bursts caused by glacial landslide, and other 3 bursts were made together by overflow and piping. Overflow burst is the research object of the paper.

Since the 1990s, the debris flow disaster caused by burst of moraine lake were investigated in China (YANG, 1983; LU and LI, 1986; XU, 1987; LU et al., 1987; DENG, 1988; DING and LIU, 1992). Furthermore, dangerous degree of moraine lake was judged with scales and shapes of glacier, glacial lake and terminal moraine bank, and burst flood were calculated (XU and FENG, 1989; LUO and MAO, 1995; CHEN et al., 1996). After debris flow of moraine lake burst in Midui Valley of Bomi County in Xizang happened in 1988, the disaster situation, genesis and floodwater of the burst were investigated and studied (LI and YOU, 1992; CHEN, 1993; ZHU et al., 1999; LI, 2001). Outside China, there are a few bursts of moraine lakes on high mountains, only burst forecast (KEPEMKOV and KUPENSKAYA, 1985) with accumulated temperature was reported, but many researches were done on bursts of ice dam lake (PERCHANOK, 1980; YONG, 1985) at high latitude region. Besides, for bursts of landslide dams (ASANSA et al., 1991; FENG et al., 1994; WANG, 1995; LU et al., 2000; YAN et al., 2001) and earth dams (HUNT, 1984; XIE, 1993; WU et al., 1994; WU and GUO, 2000) of reservoirs in China and abroad, hydraulics principle of which is similar to burst of moraine lake, the key researches are the analysis of burst origin and establishment and improvement on calculating models of burst flood and its development to lower river, and experiment (KUANG, 1993) and calculation (Takahashi and Yagi, 1983) of overflow burst process are very few. Above studies on bursts of moraine lake, landslide dam and reservoir earth dam did not relate to critical overflow conditions. Study on the critical hydrologic conditions of overflow burst has obvious meaning for forecast of burst dam and controlling of burst disaster in the paper.

2 MODEL OF CRITICAL OVERFLOW HEAD OF MORAINE LAKE BURST

With evaporation and seepage flow through terminal moraine bank, moraine lake keeps water budget to