Wave breakthrough factor in dam destruction

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Abstract. Currently, more and more attention is paid to water bodies. All hydraulic engineering construction projects created by humans pose a particular danger to human life and health. Without proper care, the structure wears out and deteriorates. It can lead to the destruction of the latter and finally to the emergency. The article discusses the operational status of the partitioning structure - the dam on the Kazenny pond, Dergachevsky district, Saratov region. The calculation of probable harm in an accident at the hydraulic structures of the reservoir are presented and problems of presentation of the research results at the international level from the point of view of adequate translation in English, where specific terms are widely used, is described.

1 Introduction

Hydraulic structures are considered to hazardous facilities and if promptly measures on elimination of problems identified as a result of visual and instrumental observations are not taken, they can cause significant damage to both the population and agriculture, production facilities which are situated in the flooded area. A dam breakthrough entails a breakthrough wave, which sweeps away everything in its path at great speed. Therefore, it is necessary to predict how dangerous a water body is in case of a breakthrough of a blocking structure - a dam. The initial stage of a hydrodynamic accident is a breach. It can be viewed as a parabolic gap. Water rushes through the hole into the ebb side of a dam, which causes even greater destruction of the ridge and the body of the dam [1-3].

A breakthrough wave is destructive and even with a small reservoir capacity can cause serious social and economic consequences. In this case, the damaging effect of the breakthrough wave during a hydrodynamic accident will be associated with the spread of the downstream territory, the high speed of water, which causes the threat of emergency.

2 Purpose of research

The purpose of this work is to study the breakthrough wave as a result of the destruction of the dividing structure on the Kazenny pond near the village of Novoroslyaevka, Dergachevsky district, Saratov region.

3 Research methodology

Pond "Kazenny" is located 2 km south of the village of Novoroslyaevka, Dergachevsky district,
Saratov region. The pond was created for fire prevention, economic and recreational purposes. It is filled up by groundwater and precipitations. Currently, the reservoir is not used according to its functional purposes. Pond "Kazenny" at Dergachevsky district of Saratov region is shown in Figure 1.

![Figure 1. Pond "Kazenny"](image)

The elevations of the dam crest range from 71.3 to 72 m. The design elevation of the crest is 72 m. The soil from which the dam body is dumped consists of dense clayey - clay, heavy loam. The length of the dam along the ridge is 604 m.

The main destruction in the downstream during a dam breakthrough will occur under the hydrodynamic action of the front of the approaching breakthrough wave. Thus, the calculation is reduced to determining the parameters of the dynamic interaction of the breakthrough wave with the structures, as well as the parameters of its propagation along the downstream territory.

The main parameters of the damaging effect of the breakthrough wave are the speed, height and depth of the breakthrough, water temperature, and the lifetime of the breakthrough wave.

In its physical essence, a breakthrough wave is an unsteady movement of a water flow, in which the depth, width, slope of the surface and the speed of the current change over time.

![Figure 2. Schematic longitudinal section of a breakout wave](image)

1. Side of the destroyed waterworks
2. Valid breakout waveform
3. Wave crest
4. Wave front
5. Wave tail
6. Calculated breakout waveform
7. Zone of water level decline
8. Zone of water level decline

The breakthrough of the partitioning structure leads to the flooding of the area. The flood zone is formed as follows. Following the front of the breakthrough wave, its height increases intensively, reaching after some time a maximum exceeding the edges of the river banks, as a result of which floodplain flooding begins. After the cessation of the rise of levels along the entire width of the flow, a more or less long period of motion will begin, close to the steady-state one. The last phase of the inundation zone formation is the decline in levels. After the breakthrough wave has passed, a waterlogged floodplain and a strongly deformed river bed remain.

Since the breakthrough wave is the main damaging factor in the destruction of a hydraulic structure, then to determine the indicators of the situation in the catastrophic flooding zone, it is necessary to determine its parameters: wave height, flow depth, movement speed and travel time of various characteristic points of the wave (front, crest, tail) to calculated sections located on the river below the hydroelectric complex, as well as the duration of the wave passage through the indicated sections and the time of its decay.

To predict the breakthrough wave and the characteristics of terrain flooding during the destruction of the structures of the hydroelectric complex, the program "Wave", version 2.0 is used [4,5,6,15]. The program allows you to assess the consequences of a hydrodynamic accident. The parameters of the terrain flooding are determined - the maximum flooding depth, flooding width and current velocity; the time of arrival of the front, crest and tail of the breakthrough wave, the maximum water discharge in the section, the wave height (the excess of the water level above the level of the domestic flow) and the maximum flooding mark [7,8,9,10].

The full name of the GTS is a hydraulic structure - a dam on the Kazenny pond near the village of Novoroslyaevka, Dergachevsky district, Saratov region. For calculations, an estimated high-water year with a percentage security (R 5%) is taken.

![Figure 3. Dam site](image)

1. Dam crest width
2. The water level in the headwater at the time of destruction
3. The width of the flooding zone in the downstream
4. The difference in water levels at the time of destruction
5. The height of the breach threshold
6. Water depth in the downstream
Table 1. Initial data for the waterworks

| Parameter | Name                                      | Unit of measure | Value |
|-----------|-------------------------------------------|-----------------|-------|
| N         | Number of permanent crossings along the river | -               | 2+2   |
| Wₙ        | reservoir capability at the highest level of horizon | mln.m³       | 1,36  |
| Hₙ        | The depth of the reservoir at the dam at the highest level of horizon | m               | 6     |
| Sₙ        | Reservoir surface area at the highest level of horizon | mln.m²      | 0,68  |
| Bₙ        | Width of the reservoir at the dam the highest level of horizon | m            | 604   |
| H₆₀       | River depth in the downstream of the hydroelectric complex | m            | 0,1   |
| B₆₀       | Width of the river in the downstream of the hydroelectric complex | m            | 2     |
| V₆₀       | The depth of the reservoir at the dam at the time of destruction | m/s         | 0,1   |
| Hₚ        | The depth of the reservoir at the dam at the time of destruction | m            | 6     |
| Eₚ        | Degree of destruction                      |                 | 0,1   |
| P         | Height of the threshold                    | m               | 0     |
| Zₙ        | Water reservoir level mark                 | m               | 72    |

The choice of calculated permanent sections is carried out on the map of the region based on the highest probability of flooding of objects.

The calculated transformed discharge of the breakthrough wave along the advance is determined depending on the volume of the reservoir, the slope and section of the valley, the breakthrough discharge and the distance from the dam objects [7-11,13-17].

The hydrological and morphological characteristics of permanent river sections are determined from the data of the geological and geographical description of the area and the topographic map of the region.
To calculate the hydrological characteristics of a flood wave in any (variable) section located between two constants, the compiled graph of the flood wave movement using the linear interpolation method is used [11,14,15].

### 4 Results and discussion

Based on the results of calculating the breakout wave, the following results were obtained, shown in the table:

#### Table 2. Report on work in the program "Volna" version 2.0

| Issue report       |   |   |
|--------------------|---|---|
| Date: 27.03.2019, time: 11:19:43. |   |   |
| name:              |   |   |

| Dam shot characteristics | 0-shot |
|--------------------------|--------|
| 1. Reservoir capability at the W_b | m3 | 1.36 |
| No   | Characteristic                                                                 | Value | Unit | Value  |
|------|-------------------------------------------------------------------------------|-------|------|--------|
| 1.   | Highest level of horizon                                                       |   6   | m    |        |
| 2.   | River depth in the downstream of the hydroelectric complex                    | Hb    | m    | 0.68   |
| 3.   | Reservoir surface area at the highest level of horizon                        | Ss    | mln.m² | 0.68   |
| 4.   | Reservoir width at the highest level of horizon                               | R     | m    | 604    |
| 5.   | River depth in the downstream of the hydroelectric complex                    | Hd    | m    | 0.1    |
| 6.   | Width of the river in the downstream of the hydroelectric complex             | Bd    | m    | 2      |
| 7.   | The depth of the reservoir at the dam at the time of destruction              | Vo    | s/c  | 0,1    |
| 8.   | The depth of the reservoir at the dam at the time of destruction              | Hp    | m    | 6      |
| 9.   | Degree of destruction                                                         | Ep    | m    | 0,1    |
| 10.  | Height of the threshold                                                       | p     | m    | 0      |
| 11.  | Reservoir water edge mark                                                     | Zr    | m    | 72     |
| 12.  | Number of permanent sections along the length of the river                   | N     |      | 4      |

| Characteristics of dam shot \( \times \) No of dam shot | 1 ст. | 2 ст. | 3 ст. | 4 ст. |
|---------------------------------------------------------|-------|-------|-------|-------|
| The distance of i-s t from dam shot \( Lci \) \( km \)  | 0,69  | 0,92  | 2,88  | 4,15  |

| Natural flow:                                           |       |       |       |       |
|---------------------------------------------------------|-------|-------|-------|-------|
| Water edge mark \( Z6i \) \( m \)                      | 64,9  | 64,5  | 58,7  | 58,2  |
| Depth                                                  | 0,1   | 0,1   | 3     | 3     |
| Width                                                   | 50    | 5     | 55,2  | 54    |
| Current flow \( V6i \) \( m/s \)                        | 0,1   | 0,1   | 0,1   | 0,1   |

| Left bank                                               |       |       |       |       |
|---------------------------------------------------------|-------|-------|-------|-------|
| Shoreline height \( Hm \) \( m \)                       | 0     | 0     | 0     | 0     |
| River floodplain width \( Br \) \( m \)                 | 0     | 0     | 0     | 0     |
| Mark of the 1st contour of the terrain \( z1 \) \( m \) | 65    | 65    | 62,5  | 62,5  |
| Distance from the river axis to the 1st gm \( B1 \) \( m \) | 140,3 | 6,67  | 41    | 80,6  |
| Mark of the 2nd contour of the terrain \( z2 \) \( m \)  | 67,5  | 67,5  | 65    | 65    |
| Distance from the axis of the river to the 2nd gm \( B2 \) | 667,3 | 10    | 837,6 | 1825,6|
| Mark 3rd contour of the terrain \( z3 \) \( m \)         | 70    | 70    | 67,5  | 67,5  |
| Distance from the axis of the river to the 3rd gm \( B3 \) | 1223,3| 13,4  | 1005  | 2125,6|

**RIGHT BANK**
Shoreline height Hm (m) 0 0 0 0
River floodplain width Bm (m) 0 0 0 0

Mark of the 1st contour of the terrain Z1 (m) 65 65 62.5 62.5
Distance from the river axis to the 1st contour B1 (m) 2610.3 6.67 63 330
Mark 2nd contour of the terrain Z2 (m) 67.5 67.5 65 65
Distance from the river axis to the 2nd contour B2 (m) 5110.3 100 1442 1005
Mark 3rd contour of the terrain Z3 (m) 70 70 67.5 67.5
Distance from the river axis to the 3rd contour B3 (m) 7693.8 134 1863 1107

Characteristics of dam shot

| № of dam shot | Lci (km) | Qi (m³/s) | Time (min) | Wave line lag  (min) | Wave top lag  (min) | Wave tail lag (min) | Flooding lag (min) | Maximum current speed (m/s) | Wave height Hw (m) | Maximum flooding rate (m) | Minimum flooding rate (m) | Maximum flooding width (m) |
|---------------|---------|-----------|------------|----------------------|---------------------|---------------------|---------------------|-----------------------------|---------------------|--------------------------|-------------------------|-----------------------------|
| 0             | 0       | 0.41      | 0          | 0                    | 0                   | 0                   | 0                   | 3.84                        | 3.6                 | 3.6                      | 69.6                    | 148.11                     |
| 1             | 0.69    | 0.23      | 5.3        | 25.16                | 25.16               | 25.16               | 25.16               | 1.08                        | 0.47                | 0.47                     | 197.61                  | 197.61                     |
| 2             | 0.92    | 0.19      | 9.54       | 28.53                | 28.53               | 28.53               | 28.53               | 4.53                        | 0.37                | 0.37                     | 11.11                   | 11.11                     |
| 3             | 2.88    | 0.09      | 17.96      | 569.48               | 569.48              | 569.48              | 569.48              | 4.76                        | 3.82                | 3.82                     | 62.22                   | 62.22                     |
| 4             | 4.15    | 0.07      | 23.6       | 781.15               | 781.15              | 781.15              | 781.15              | 4.76                        | 3.52                | 3.52                     | 60.3                    | 60.3                      |

5 Conclusion

According to the calculation results, the maximum flood e along the left bank is 197.61 m; along the right bank 2882.16 m. and the maximum wave height is 3.82 m. Thus, we conclude that the breakthrough wave will pass in natural topographic low with further infusion into the river bed of Altata river. The calculation is performed for the flooded zone with the development of the most severe accident scenario [1-2,12-15]. In this case, settlements, industrial enterprises, asphalt roads, bridges, forests, agricultural lands do not fall into the flooded zone.

The results of the following research can be applied to the dams of similar structures, that is why we find it important to present this work at the international level. But, unfortunately, a lot of specialists, related to technical sciences, inevitably face the difficulties while interpreting their researches in English because they fail to translate technical terms correctly. Therefore the question of studying English for specific purposes together with work-related disciplines also needs to be resolved [16].
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