Zoning Study on the Influence of Sluice Operation on Flood Drainage of Plain River Network

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Abstract: The drainage of river network in Yaobei plain is of great significance to the social and economic development of Yuyao and Ningbo. Linhai Pujiang gate and Taojia Road gate are two important gates for drainage of the river network in Yaobei plain. With the different time of opening the gate for dispatching, the water level reduction values of different towns, streets and communities in the river network are different. If the water level decline in the river network area is classified according to a certain way, the impact degree and impact range of sluice drainage on river network drainage can be studied, so as to classify and partition the impact of drainage according to the degree of impact, township streets can formulate different drainage countermeasures. Therefore, it is of great significance to study the impact of gate operation on river network drainage. In order to fully study the flood drainage function of the sea gate of Yaobei plain river network, based on the preliminary establishment and verification of the plane two-dimensional mathematical model of Yuyao plain river network, this paper calculates the changes of water level and velocity in different areas of towns and streets of Yuyao river network with time and region after the flood drainage operation of the gate for 7 hours under different conditions, according to the range of water level drop of 0.05 m and different numerical ranges, this paper classifies the influence areas of large gate dispatching on Yaobei river network drainage, and obtains seven partitions of the influence of large gate dispatching on Yaobei river network drainage. According to this partition, the regional river network drainage countermeasures are preliminarily analyzed, which provides a reference basis for the drainage decision-making of township streets.

1. Introduction

Yaojiang River System is the main flood channel running through the central urban area of Yuyao and some areas of counties (cities) such as Yuyao, Yinzhou, Jiangbei and Zhenhai. In recent years, key water conservancy projects, especially the "6+1" project of Yaojiang River control, have been advancing steadily. After the implementation of the "six major projects", Yuyao flood control and drainage system will form an overall layout of "East discharge, South storage, North discharge (West Branch), Central drainage and low enclosure". The main North discharge pump gates include Linhaipu gate and Taojia road gate, which are the control works of the first and second channels of Yuyao North discharge. Linhaipu sluice is located in Linhai Township, Yuyao City, 2060 m downstream of...
Hengshan Shiqiao sluice. It undertakes the drainage task with an area of 241 square kilometers together with Xiejia road sluice. The building grade of Taojia road gate is class III and class III. It is also an important project for flood control in Yaojiang plain. Water conservancy engineering measures have played a great role in flood control and drainage of river network in Yuyao plain.

Non engineering measures are also an extremely important link in flood control and drainage of Yuyao river network. For example, by using Linhai pu sluice and Taojia road sluice to drain the flood, the water level of the river network can be reduced. The scheduling of these pump gates in the river network needs to be based on the reduced water level in order to carry out more effective further scheduling. According to the flood control and drainage demand of Yuyao river network and the fluctuation law of water level (tide) in the outer river, the operation dispatching mode of pump gate entering pre discharge program control, the decreasing range of water level above the gate are comprehensively determined it is of great significance to study the water level reduction and water level reduction of Yuyao river network by studying the flood drainage of Linhai pu sluice and Taojia road sluice [1] - [2].

The distribution law of the influence degree and influence range of sluice drainage operation on the water level reduction value of the river network can be expressed more intuitively by zoning [3] - [5]. Due to the insufficient measured data of river network, the above zoning cannot be realized so far, but a large number of hydrodynamic factors such as water level and velocity can be obtained by using the calculation of river network mathematical model. Mathematical model is an important research tool and has been widely used. However, there are many one-dimensional mathematical models [6] - [7] and few two-dimensional mathematical models in the research of Yuyao river network, but the two-dimensional mathematical model has many advantages. It is of great significance to use the two-dimensional mathematical model to study the pump gate drainage of Yuyao river network [8] - [10].

2. Two dimensional hydrodynamic plane mathematical model of river network in Yuyao plain and its verification

2.1. Basic equation of two-dimensional model of water flow in river network

2.1.1. Basic equation

Flow continuity equation:

$$\frac{\partial z}{\partial t} + \frac{\partial (hu)}{\partial x} + \frac{\partial (hv)}{\partial y} = 0$$

X. Y-direction flow equation:

$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} - fu + g \frac{\partial z}{\partial x} + g \frac{u \sqrt{u^2 + v^2}}{c^2 h} = \lambda \Delta u$$

$$\frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + fu + g \frac{\partial z}{\partial y} + g \frac{u \sqrt{u^2 + v^2}}{c^2 h} = \lambda \Delta v$$

Where: x and y are spatial coordinates; z is the water level; t is the time; u, v is the velocity component in X direction and Y direction respectively; h is the water depth; f is Coriolis force, $f = 2W \sin \Phi$; W is the rotation velocity of the earth; $\Phi$ is the latitude of the earth; c is Xie Cai coefficient; g is gravitational acceleration.

2.1.2. Definite solution condition

Initial conditions: give the initial terrain, velocity, water depth, etc. of each calculation grid node

Boundary conditions: the flow process at the inlet of a given model; discharge process of given water level at outlet.
2.2.2D model validation
Due to the limitations of measured topographic data, flood data and pump gate operation data, the "20120617" flood is selected for model verification, and the model parameters are calibrated and calculated for verification calculation. Due to the limitations of model range selection, the boundary conditions for calculation are in accordance with "20120617". The measured boundary conditions of flood and the boundary conditions of hydrological calculation are properly and reasonably extended. When the river roughness is selected as 0.018-0.021, the maximum water level is calculated. The difference between the measured maximum values of 3.71m near the mountain, 3.39m above Xiheng River and 3.38m below Xiheng river is 0.03m, 0.03m and 0.02m respectively. The calculated value of the highest flood level is basically consistent with the measured value, indicating that the parameters calibrated by the model are basically reasonable.

3. Study on influence zoning of waterlogging drainage

3.1. Calculation conditions
In order to study the impact of the drainage of Linhaipu gate and Taojialu gate on the decrease of river network water level, it is assumed that the river network water level is 3.7m at the initial time of calculation, the drainage flow of the two drainage gates is 100m³/s, and the boundary conditions of other inlets and outlets of the river network are assumed not to flow into or out of the river network. The regional distribution of water level and velocity at different times and locations under the drainage of the gate is calculated, the influence intensity and process of waterlogging drainage are analyzed.

3.2. Calculation results and analysis

3.2.1. Calculation results and Analysis Study on zoning of waterlogging impact intensity
In order to analyze the influence intensity of large gate drainage on river network drainage, it is necessary to select the time when the large gate drainage affects the whole river network. The analysis of the calculated data shows that the conditions can be met when the large gate drainage is about 7h. Based on the spatial distribution of the water level value of the whole river network at this time, the influence intensity of flood drainage by the gate is divided. The water level of the whole river network decreases from the initial 3.7m after the flood discharge of the sluice gate. With the increase of time, the water level decreases the most in the area with the smallest flow resistance of the river network closest to the flood discharge gate, and the water level decreases the least in the area with the smallest flow resistance of the river network furthest from the flood discharge gate. The greater the water level drop, the smaller the drainage resistance, the easier the drainage, and the greatest impact intensity of the flood discharge of the sluice gate. Conversely, the smaller the water level drop, the greater the drainage resistance, the more difficult the drainage, and the impact intensity of large gate drainage is also the smallest. According to the drop value of water level from 3.25m to 3.60m and the drop range of river network water level of 0.05m, the impact intensity of flood drainage by the sluice is divided into seven areas. The water levels of the seven areas are defined as: area I water level from 3.25m to 3.300m, area II water level from 3.30m to 3.35m, area III water level from 3.35m to 3.40m, area IV water level from 3.40m to 3.45m, area V water level from 3.45m to 3.50m The water level in area VI is from 3.50m to 3.55m, and the water level in area VII is from 3.55m to 3.60m. It can be seen from the zoning map that although the water level difference of the seven zones is 0.05m, the shape and area of the seven zones are different. Different drainage countermeasures can be formulated according to different zones and township streets according to the conditions of drainage facilities and drainage projects in the region.
3.2.2. Analysis of waterlogging impact process

The decline process of water level with time includes the time and amplitude of water level decline. This time, 11 representative locations in Yuyao river network area are selected for analysis. The locations of representative points are shown in Fig. 1. The process of water level decline and flow rate increase are analyzed, as shown in Fig. 2 and Fig. 3. It can be seen from the water level hydrograph shown in Fig. 2 that the water level in Simen Town and Sibeiz Village, the two closest locations to the drainage gate, decreased the most. Taking the location of Simen Town government as an example, the water level decreased from 3.7m to 3.61m for 0.5h after the gate was opened for drainage, and decreased by 9cm. With the increase of the gate opening and drainage time, the water level continued to decline. After the gate opening and drainage time was nearly 6.8h, the water level decreased to 3.39m, and decreased by 31cm, the water level drops obviously and the drainage effect is significant. Therefore, the drainage decision near Simen Town can be combined with the law that the water level can continue to decline, so as to reduce the construction scale and quantity of the pump gate project.

Yuyao railway station, the farthest location from the flood gate, is analyzed as follows. The water level begins to be affected about 1h after the gate is opened. With the increase of time, the intensity of the impact is relatively weak. The flood gate opening and drainage time is close to 6.8h, and the water level drops to 3.60m, down 10cm. The flood drainage effect has a great impact, but the decline range of water level is significantly reduced, and the flood drainage effect is weak. Therefore, the drainage and disaster reduction near Yuyao railway station should be carried out through other ways.
It can be seen from the flow velocity hydrograph shown in Fig. 3 that near the Linshan Town government, which is close to the drainage gate, the flow begins to flow at 0.22h after the gate is opened, and increases to the maximum at 0.75h, with the maximum flow velocity of 0.112m/s, but the flow velocity only increases slowly during the drainage time thereafter. It can be seen from the water level (principal coordinate) and flow rate (secondary coordinate) hydrograph of a point in the river near the Linshan Town government shown in Fig. 4 that the drainage flow rate in this river increases slowly with time, but the water level keeps a range and continues to decline, indicating that the drainage flow is the largest at 0.75h. With the increase of drainage time, although the water level continues to decline by a range. However, the drainage flow rate increases slowly, indicating that the drainage flow also continues to decline. It can also be seen from Fig. 3 that the flow velocity near Huangjiabu government is the lowest, mainly due to the following reasons: on the one hand, because the Huangjiabu government is connected with Shangyu District, and the rivers connected between the two districts in the drainage section are controlled by sluice, the water flow in Shangyu cannot be discharged to Yuyao District, and the water flow is not connected. The boundary condition set during calculation is that the water flow in the outer region cannot flow into Yuyao river network. So the flow rate is very small. On the other hand, the boundary of the study area near Huangjiabu government is restricted by the boundary conditions, and the main flow is discharged from the middle channel of the river network into Hangzhou Bay. It can also be seen from Figure 3 that the flow velocity of the river near Sibei Village and Fengbei middle school has been continuously increasing, indicating that the nearby river is the main channel for waterlogging drainage within the calculation time.
4. Conclusion
Based on the establishment and preliminary verification of the plane two-dimensional mathematical model of the river network in Yuyao plain, the reasonable boundary conditions for the application of the sluice drainage are analyzed; the changes of water level and flow velocity in different areas of township streets of Yuyao river network with time and region after the operation of large gate drainage for 7 hours under different conditions are calculated. According to the amplitude of water level decline of 0.05m and different numerical intervals, the influence areas of large gate drainage on Yaobei river network drainage are classified, and seven zones of the influence of large gate operation on Yaobei river network drainage are obtained. According to this zoning, the drainage countermeasures of regional river network are preliminarily analyzed, which provides a reference basis for the drainage decision-making of township streets. The impact of waterlogging drainage is complex and there are many calculation data. Further analysis is needed for waterlogging drainage decision-making.

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