Study on the Determination Method of Water Surface Ratio for Transfer Flooding and Drainage in Dyke Type River Network Area

Yao Shuiping[1]

([1]Zhejiang Institute of Water Resources and Estuary, Hangzhou 310020, China)

Abstract: Based on the analysis of the characteristics of flood discharge and water-logging prevention in dyke type river network area, a method for determining the flood and water-logging water surface ratio in the area is proposed, namely, calculating the water surface ratio from the flood discharge and water-logging prevent functions carried by different waters. The flood and water-logging water surface ratio is an indicator of dynamic change. The example shows that this method is reasonable and feasible.

1. Introduction

The water surface ratio is the ratio of the area carrying water function to total surface area, expressed as a percentage. The regional flood and water-logging rate is a technical indicator from the perspective of water management based on the status quo and meeting the regional flood protection and flood removal function requirements. The regional flood and water-logging rate is a dynamic indicator. With the continuous development of the economy and society, the flood discharge criteria will be improved, and the rate of flooding will be adapted to it.

This paper puts forward the method for determining the water surface rate of flood removal in the dyke type river network area.

2. Characteristics of flood removal in the dyke type river network area

The topography of the river network is flat. The ground elevation of most areas is between the rivers (lakes) and flooding and drying level. The rivers are crisscrossed，gates often built in the junctions between the outer rivers and inner rivers (ports). The floodgates are closed to keep the flood out of the river during the flood season, and opening the floodgates during drought can draw water.

In this type of area, flood discharge and local drowning removal task generally were undertaken by outer rivers. The inland rivers (ports) normally undertake the task of removing the rafts. Therefore, the water surface rate required for flood and drainage can be calculated separately from the outer river and the inner river (ports). The sum of the two is the water rate required for flood removal.

3. Method for determining flood surface rate

In Dyke Type River Network Area, the flood discharge task usually undertaken by the outer rivers, the over-current capacity of the river course determined by the flood control standard, so the scale and size of river decided by the calculation of the river network water flow. The calculation of general steps is: Analysis the design flood process of each block according to the design standard river design rainstorm; According to the structure of river network, the river flood calculation is carried out to deduce the design flood of each river section. Climbing elevation and dike spacing could be calculated by surface line, etc.

The water flow state of the dyke-type river network is non-constant flow, and its flow rate and flow velocity change with time and along the path. It can be calculated by Saint Venant's One-dimensional unsteady flow mathematical model:

Basic information

1.Hydrological data   2.Watershed section data

3. Water network diagram   4. Other data

Design floodwater

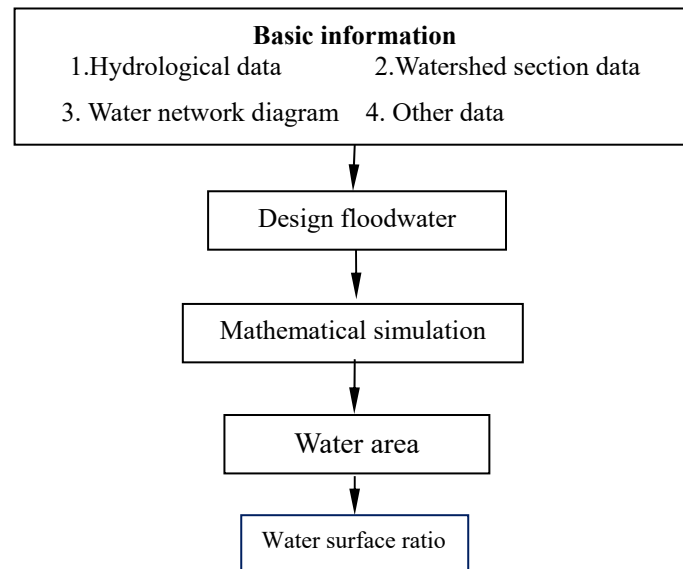Mathematical simulation

Water area

Water surface ratio

Figure 1. Block diagram of draining flood water

surface rate calculation

Continuous equation:

$$\frac{\partial Q}{\partial x} + B \frac{\partial Z}{\partial t} = q \qquad (1)$$

Momentum equation:

$$-\frac{\partial Z}{\partial x} = \frac{u^2}{C^2 R} + \frac{u}{g} \frac{\partial u}{\partial x} + \frac{1}{g} \frac{\partial u}{\partial t} \qquad (2)$$

Where: Q is the cross-sectional flow; Z is the cross-sectional water level; q is the side inflow; u is the average flow velocity of the section; R is the hydraulic radius; g is the gravitational acceleration; B is the water surface width; x is the process coordinate; t is the time coordinate; C is the Xiecai coefficient.

Using this equation, the water level and flow rate of each designated section of the river can be solved under certain boundary conditions.

The mathematical model is carried out under the condition of known river channel size, generally for a variety of river network layouts, assuming the calculation of the river section size, determining the layout and scale under the optimal conditions, and then calculating the flood surface in this case. Its calculation block diagram is shown in Figure 1.

4. Method for determining the basic water surface rate

4.1. Designing the exhaust flow

The Inner Harbor generally undertakes water-logging task, and the drainage area is the area surrounded by each diked area. In the event of heavy rain, the amount of water produced in all dyke areas, except for the stagnation of the field and the sluice pump should operate the stagnation of the river network. The remaining waterlogging should be discharged within the time required by the drainage standard. The calculation formula of the drainage flow is as follows:

$$Q(t) = q_1(t)A_1 + q_2(t)A_2 + q_3(t)A_3 + q_4(t)A_4 - W(t)/(8.64T) \quad （3）$$

In the formula:

$$q_1(t) = \frac{\sum_{t=1}^{n}[P(t) - h_1 - e(t) - f(t)]}{86.4T} ; \quad q_2(t) = \frac{\sum_{t=1}^{n}[P(t) - e(t) - f(t)]}{86.4T}$$

$$q_3(t) = \frac{P(t) - e(t) - f(t)}{86.4T} ; \quad q_4(t) = \frac{P(t) - e(t) - f(t)}{86.4T}$$

$Q(t)$ is the calculation of the drainage flow of a certain period of time t, m³/s; A_1、 $q_1(t)$ present the paddy field area within the zone, km² and t period of time paddy field drainage modulus, m³/s.km2; A_2、 $q_2(t)$ present dry land area within the zone, km2 and t period of time dry land drainage modulus, m³/s.km²; A_3、 $q_3(t)$ present the non-agricultural area area in the sub-area, km² and t period of time non-agricultural area drainage modulus, m³/s.km²; A_4、 $q_4(t)$ For the water area within the zone, km² and t-time water drainage modulus, m³/s.km²; $W(t)$ is the water retention during the t period of time 10,000 m³, $\sum_{t=1}^{n} W(t) \leq WMAX$; $WMAX$ In order to calculate the maximum amount of water retention within the zone, 10,000 m³; $P(t)$ is the designed rainstorm for t period, mm; h means the depth of water in the field of paddy field, mm; T is the length of time for the t period, d; n on behalf of the total number of analyzed time periods

4.2. Calculation method for removing water surface rate
The basic method for calculating the water surface rate required by the radon can be divided into three steps:first, calculation of the drainage capacity of different underlying surface conditions in the crucible; second , judgment of out-row capacity and internal stagnation capacity in each divisional area;third, the water surface rate can be calculated by analysis of out-row capacity and internal stagnation capacity. The block diagram of its calculation is shown in Figure 2.
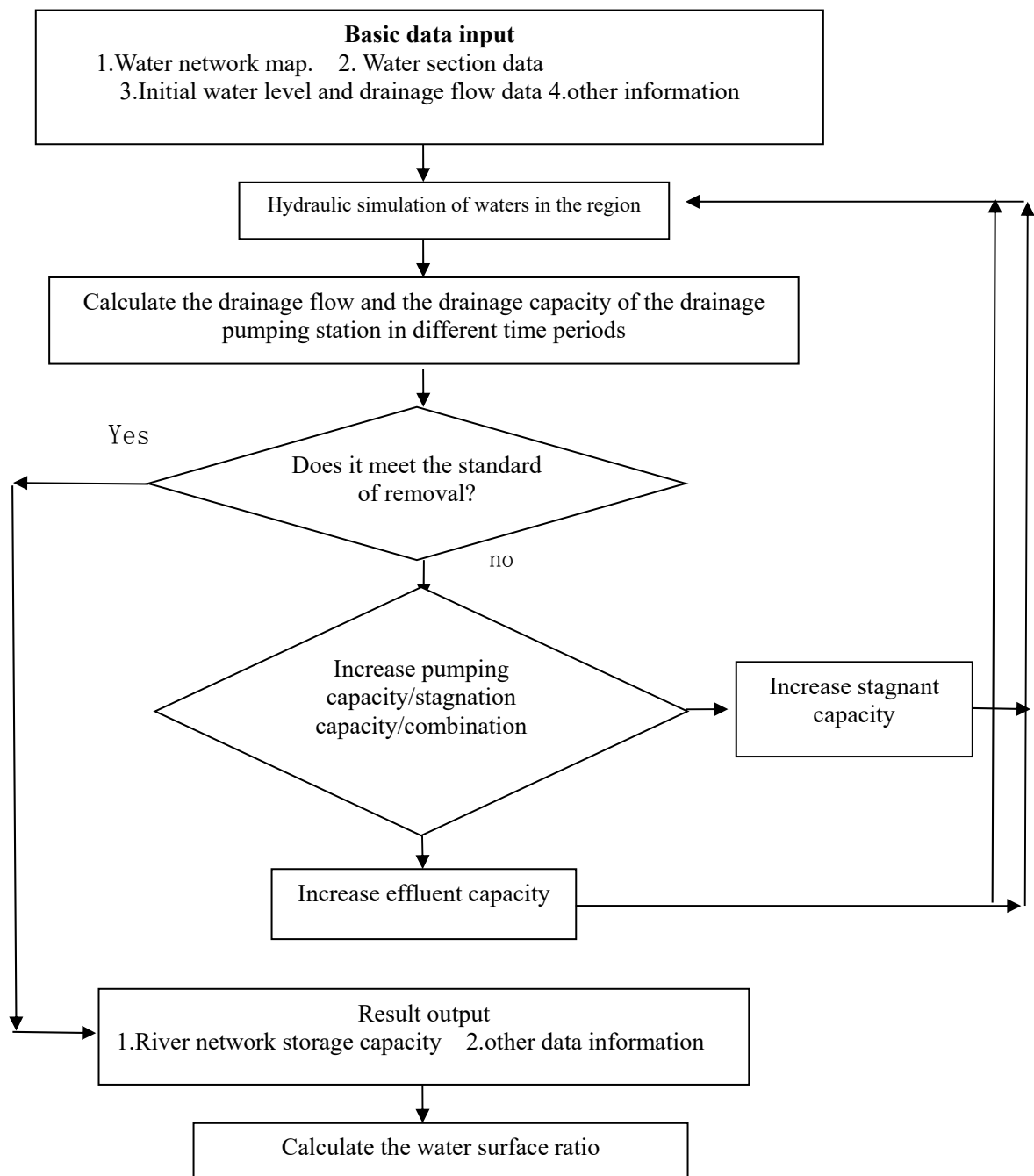
Figure2．Block diagram of the water surface rate calculation

4.3. Economic model of program comparison

It can be seen from Fig. 2 that when the current drainage flow and the discharge capacity cannot meet the requirements of the removal, the removal capability should be increased. In addition to the sputum route, there are three options: increasing the capacity of the efflux (water pump) ;increasing the water storage capacity or a combination of both. The comparison of the schemes is mainly from the economic point of view, that is, the total investment and operating costs are minimum when the system is removed. Since

the investment is a one-time investment, the operating expenses occur every year. To facilitate the comparison of the plans, the annual value method for comparison is used. Its mathematical formula is:

$$\min NF = \min[IB \times (A/P, i, n) + IS \times (A/P, i, n') + UB + US] \qquad (4)$$

In the formula: NF is the equivalent annual value of increasing project investment and system operating costs if the water-logging engineering measures meet the standard requirements; IB is the engineering construction investment to increase the installed capacity of the pump and increase the over-flow capacity of the drainage channel; IS is the project to increase the water storage capacity Construction investment; UB and US are respectively the annual operation management costs of the installed pump and water area; n, n′ is the number of years of operation of the system, n is taken as 20 years, and n′ is taken as 100 years; (A/P, i, n) is the capital recovery factor, $(A/P, i, n) = \dfrac{i(1+i)n}{(1+i)n\text{-}1}$;i is the social discount rate, according to national regulations to take 12%.

5. Flooding and water removal rate
The linear superposition of the flood surface rate and the raid water surface rate is the flooding rate.

6. Calculation example
Tongxiang City belongs to the river network area of Hangjiahu Plain. The territory is flat and there is no hill. After the 1990s, the construction of the reclamation area was basically completed. It is a typical flood plain river network area. This article analyzes one of the examples.

6.1. Basic situation
A certain area of Tongxiang City, its area is 130.9km^2, The criteria for the removal of water-logging is a 24h rainstorm in the non-agricultural field area once in 20 years and a 24h rainstorm in the farmland area once in 10 years The basic situation is shown in Table 1.

<p align="center">Table1． Basic situation of a dyke area in Tongxiang City</p>

Content	Value	Content	Value
Total area (km^2)	130.9	Water area (km^2)	7.9
Water volume (10,000 m^3)	2170	10% maximum daily design rainstorm (mm)	123
5% maximum 24h design rainstorm (mm)	190	2% design flood level (m)	3.04
Pump draining capacity (m^3/s)	128	Paddy field water retention depth (mm)	30

6.2. Calculation results of water removal rate
Based on the basic data of this area and the calculation procedure of the flood excavation rate, the efflux capacity of the reclamation area with the most economical plan under the standard of flood discharge is 157 m^3/s, and the outer river increases the water area. The area is 0.35km^2, and the inner harbor has an increased water area of 0.06km^2. According to its definition，the flood discharge water surface rate of this area can be calculated:

$R_{\text{flood discharge}}$＝（$A_{\text{status quo}}$＋$\Delta A_{\text{flood discharge}}$）/$A_{\text{sum}}$＝（9.3+0.35）/130.9＝0.98%

$R_{\text{waterlogging}}$＝（$A_{\text{status quo}}$＋$\Delta A_{\text{waterlogging}}$）/$A_{\text{sum}}$＝（7.88+0.06）/130.9＝6.07%

$R_{\text{flood discharge and waterlogging}}$＝$R_{\text{flood discharge}}$＋$R_{\text{waterlogging}}$＝7.05%

7. Conclusion

This paper provides a way to calculate the water surface rate of flood discharge in the dyke type river network area. This method is based on the characteristics of flood discharge and flood removal in this kind of area. The research in this paper shows that from the perspective of water management, it is feasible and achievable to study the water surface rate of flooding and water-logging. The water surface rate of flood removal determines the lower limit of the water area that meets the standard of flood discharge, and provides an operational basis for water management.

The flood rate cannot be calculated independently for only one area, multiple factors need to be considered ,such as transit water, and the analysis should be based on the entire area or basin.

The determination of water-logging rate scheme is determined by the comparison of economic model, which is greatly influenced by local economic factors. Therefore, the selection of water-logging removal scheme should be based on the local actual situation

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