

# Hydrodynamic Influence Dabanhu River Bridge Holes Widening Based on Two-Dimensional Finite Element Numerical Model

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**Abstract:** In order to analyze the influence of bridge holes widening on hydrodynamic such as water level, a two-dimensional mathematical model was used to calculate the hydrodynamic factors, river network flow velocity vector distribution is given, water level and difference of bridge widening before and after is calculated and charted, water surface gradient in seven different river sections near the upper reaches of bridges is counted and revealed. The results of hydrodynamic calculation indicate that The Maximum and the minimum deducing numerical value of the water level after bridge widening is 0.028m, and 0.018m respective. the seven sections water surface gradient becomes smaller until it becomes negative, the influence of bridge widening on the upstream is basically over, the range of influence is about 450m from the bridge to the upstream. reach

## 1 Introduction

The river network flow of Shaoxing city and Keqiao district is slow and weak hydrodynamic. This is an important factor restricting the water environment of the river network, and this have a direct impact on flood control and drainage area water environment and water safety and sustainable development between local water environment and economic society. Criss cross the plain river networks is the important carrier of river water, and have the functions of flood drainage, water regulation, water supply, irrigation, shipping, transportation, landscape leisure and ecological environment. The early construction of the railway bridge holes is small, this result in water flow resistance, less flow velocity, higher water level, and this further affects the flood control, drainage and water environment of the river network.

By widening the bridge holes width and with streamlined design of revetment works, these this can reduce flow resistance, increase flow velocity, cut down the water level, increase the river network water flow

$$\frac{\partial U}{\partial t} + U \frac{\partial U}{\partial x} + V \frac{\partial U}{\partial y} + g \frac{\partial Z}{\partial x} + \frac{gn^2 U \sqrt{U^2 + V^2}}{H^{4/3}} - fV - \varepsilon \left( \frac{\partial^2 U}{\partial x^2} + \frac{\partial^2 U}{\partial y^2} \right) = 0$$
$$\frac{\partial V}{\partial t} + U \frac{\partial V}{\partial x} + V \frac{\partial V}{\partial y} + g \frac{\partial Z}{\partial y} + \frac{gn^2 V \sqrt{U^2 + V^2}}{H^{4/3}} + fU - \varepsilon \left( \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} \right) = 0$$

In which, U and V is flow velocity; H is water depth; Z is elevation of water surface level ;C is Checy's

coefficient and 
$$C = \frac{1}{n} R^{1/6}$$

hydrodynamic. This is an important measure to enhance river networks

In the past, there were many researches on the backwater of bridge and culvert, but the influence scope and intensity of backwater were not much studied from the point of decreasing the gradient of the branch reach. In this paper, based on the two-dimensional mathematical model, the river flow velocity, water level and other dynamic factors are numerical calculated and Analyzed.

## 2 Two Dimensional Finite Element Numerical Model

### 2.1 The Governing Equations and Deterministic Conditions

The equations of continuity:

$$\frac{\partial Z}{\partial t} + \frac{\partial(HU)}{\partial x} + \frac{\partial(HV)}{\partial y} = 0$$

The equations of motion:

### 2.2 Boundary Conditions

The outlet and open boundary condition: water level process is given.

At the entrance, flow discharge is given, such as

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$Q(x, y, t) = Q_0(x, y, t)$ ,  $Q_0(x, y, t)$  is the discharge process.

For the closed and rigid boundary the velocity is zero,

ie:  $u_n|_{\Gamma_2} = v_n|_{\Gamma_2} = 0$  in which,  $\Gamma_2$  expresses closed boundary; n is normal unit vector.

### 2.3 Initial Conditions

The initial water level and the initial velocity are given by measured tidal level or given value zero, initial conditions does not affect the precision of computed result.

### 2.4 The Establish of Finite Element Model

The finite element method is employed to solve the equations. this model, Triangle grids are selected to disperse calculation zones.

### 2.5 Verification of the Model

Verification of the model is shown in Reference.

## 3 Calculation Results and Analysis

### 3.1 Calculation Condition

#### 3.1.1 River Network Survey

Many rivers arranged in a crisscross pattern of Keqiao District river network, Dabanhu river is an important channel connecting south and north plain river networks, the railway bridge go across on the Dabanhu river, because of the small bridge holes, water flow is obstructed. In order to speeding up the flow of the north and south river networks. widening the bridge is necessary. This is shown in Figure 1.

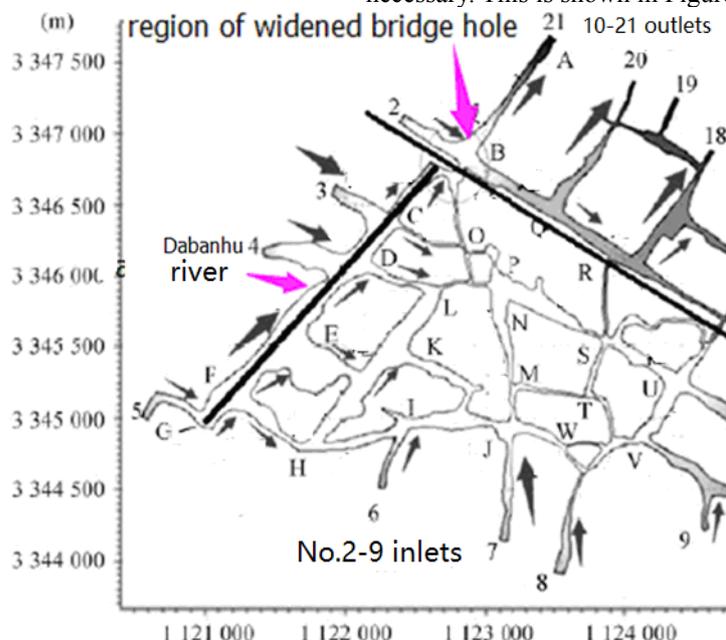


Figure 1 River Network and Boundary Conditions

#### 3.1.2 Boundary Conditions of Model Calculation

Figure 1 is the relevant part of the whole bridge and river network model, The river network inlet is from No.2 to No. 9, the water level is controlled at 3.95 m, and the river outlet No. 18 - 21. The water level is controlled at 3.90 m, and different water level control conditions are set up respectively

#### 3.1.3 Selection of Model Parameters

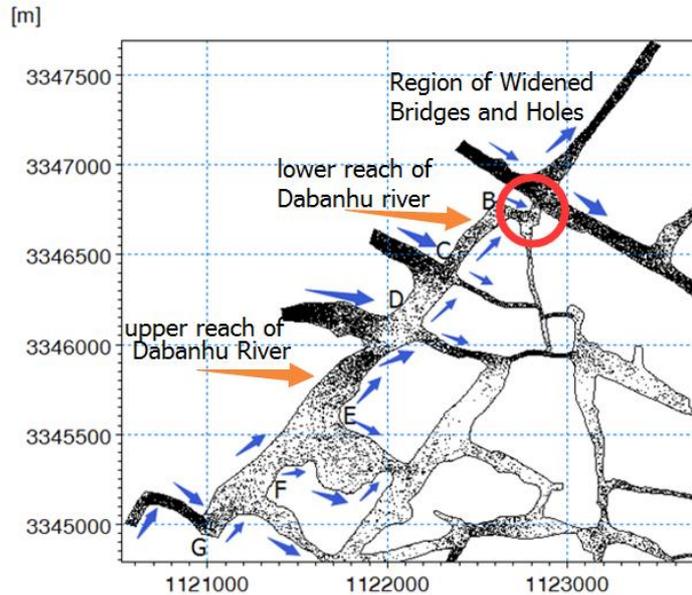
In the river networks past planning, one-dimensional unsteady flow mathematical model is established and validated, selection of model parameters is mainly on the basis of the previous planning design results, The parameters selection of the two-dimensional hydrodynamic mathematical model is reasonable.

In order to analyze the influence of bridge holes widening on hydrodynamic such as water level, The most influential reaches of the upper reaches of the bridge are selected, marking the different letters B-C-D-E-F-G at the intersection of river network. The black line segment of Figure 1, location G and B is two. From the starting point G to the position B of the bridge, the length of the river channel is 2448.56m. On the river reach of the starting point G to the bridge point B, 250 points are chosen in equidistant manner as the object of water level analysis, location (see Figure 1).

#### 3.2.1 River Network Flow Velocity Vector Distribution

Figure 2 is river network flow velocity vector distribution nearby the bridge and along the Dabanhu river,

### 3.2 Calculation Results and Analysis

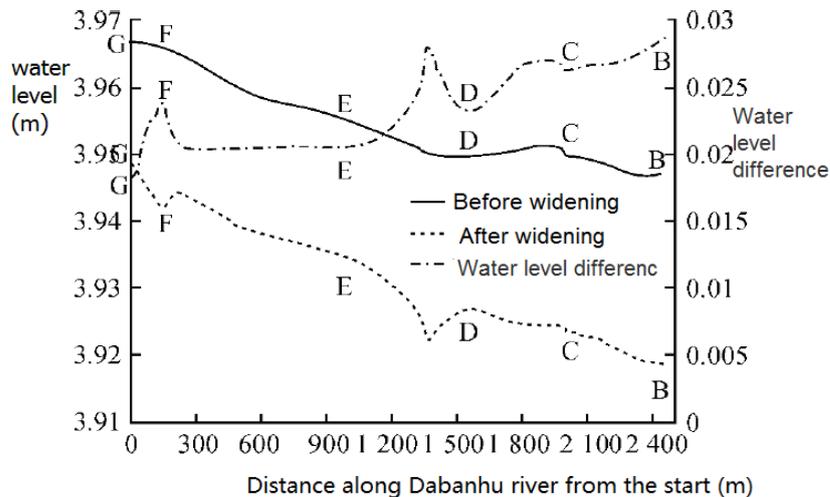


**Figure 2** River Network Flow Velocity Vector Distribution

### 3.2.2 Effect of Water Level Analysis of Bridge and Culvert Widening

The water level of river network is directly related to river flood control and railway bridge safety. In this

paper, the change of water level before and after widening of bridge is analyzed and the inflow and outflow conditions of water flow are at the same the condition (see Figure 3 and Figure 4).



**Figure 3** Water Level and Difference of Bridge Widening Before and After (Upper Reaches of the Widened Bridge Along the Dabanhu River)

There are selected and analyzed 250 points in the distance of 2 448.565m from start point G to end point B, so as to enough point to reveal to water level and water surface gradient (in Figure 5) The graphs show that the water level is different before and after the widening of bridges, although the inlet and outlet boundaries of the water flow are the same. the water level is obviously higher before widening than the after.

In Figure 3 and Figure 4, the number in the abscissa axis represents the distance, that indicates the distance from the starting point G, There are two vertical coordinates, The main coordinate is the water level before and after the widening of the bridge, sub coordinate is the difference of water level before and after widening of bridge. The Figure 3 is about upper

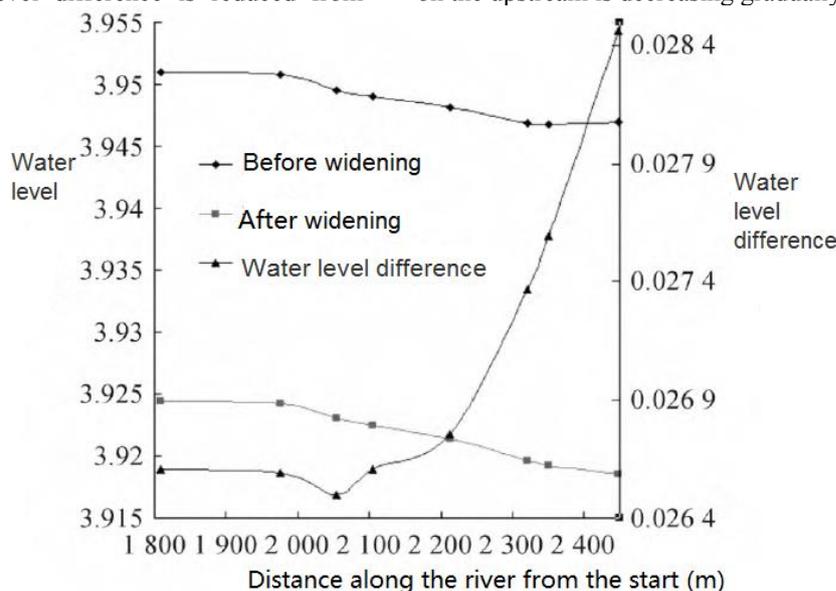
reaches of the bridge along the Dabanhu River, Letter B-G is the location of water level analysis, Figure 4 is that nearby the widened bridge

As can be seen from the graph, as a whole, From the location B of the bridge to the upstream and the position G, the general trend of water level change is increasing, whether before the bridge widened or after; but the water level decreases at all time after bridge widening. The Maximum and the minimum deducing numerical value of the water level after bridge widening is 0.028m, and 0.018m respective.

In order to analyze the intensity and range of local backwater before and after widening of bridges, comparison chart of the water level and water level difference in the long enough upstream of the bridge are

given in Figure 4. As can be seen, from the bridge to upstream, the water level difference is reduced from

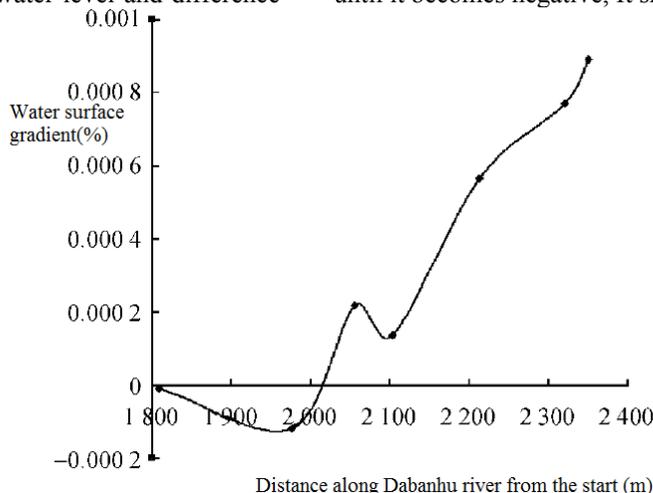
0.0285 m to 0.0265m, the influence of bridge backwater on the upstream is decreasing gradually.



**Figure 4** Water Level and Difference of Bridge Widening Before and After (Nearby the Widened Bridge)

Figure 5 is chart of water surface gradient in seven different river sections near the upper reaches of bridges. This gradient is calculated by water level and difference

and distance of the points each other in 8 points. The chart shows the seven sections gradient becomes smaller until it becomes negative, It shows that the



**Figure 5** Water Surface Gradient

Surface water gradually Change from steep to slow, until the upper reached water level is lower than the lower. It shows that the influence of bridge widening on the upstream is basically over, the range of influence is about 450m from the the bridge to the upstream reach.

calculation indicate that The Maximum and the minimum deducing numerical value of the water level after bridge widening is 0.028m, and 0.018m respective. the seven sections water surface gradient becomes smaller until it becomes negative, the influence of bridge widening on the upstream is basically over, the range of influence is about 450m from the the bridge to the upstream reach.

## 4 Conclusions

A two-dimensional hydrodynamic numerical model of river network and lake is used to calculate and analyze the influence of bridge holes widening on hydrodynamic such as water level and water surface gradient

flow velocity vector distribution is given, water level and difference of bridge widening before and after is calculated and charted, water surface gradient in seven different river sections near the upper reaches of bridges is counted and revealed. The results of hydrodynamic

## Acknowledgements

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