Parameter Calibration of Sediment Transport Capacity Formula of the Third Entrance of Xinqiman Reservoir in Tarim River Based on CCHE2D Model

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In this study, sediment transport at the third entrance of the Xinqiman Reservoir in the Tarim River was simulated using the CCHE2D model. The flow conditions, the suspended sediment concentration of each grain size, and the boundary grain size of the wash load in the reach were determined. Regressions between the suspended sediment concentration, $S$, flow condition, $U^3/\rho H$, and flow-sediment factor, $U^3/\rho \omega R$, were developed, which strongly adhered to the power law and Zhang Ruijin’s formula for the sediment transport capacity. The parameters in Zhang Ruijin’s formula for the target reach were determined. Under the defined flow and sediment conditions, sediment particles $\geq 0.091$ mm and particles $\leq 0.061$ can be regarded as the bed material and wash loads, respectively. Using multivariate linear regression, the sediment transport capacity coefficient ($k_0$) and exponent ($m$) were determined to be 0.0197 and 0.928, respectively. These results can serve as an important theoretical reference for the calculation of sediment transport at the third entrance of the Xinqiman Reservoir in the Tarim River.

1. Introduction

Sediment transport capacity is the amount of sediment that can be discharged through the reach under certain flow and sediment conditions [1]. Currently, Zhang Ruijin’s formula for sediment transport capacity [2] is widely used in China for rivers with low sediment discharge ($<10$ kg/m$^3$).

$$S^* = K \left( \frac{U^3}{\rho \omega R} \right)^m = k_0 \left( \frac{U^3}{\rho \omega} \right)^m,$$

where $S^*$ is the sediment transport capacity (kg/m$^3$); $U$ is the average flow velocity in the cross section (m/s); $R$ is the hydraulic radius (m), which can be substituted by the average water depth $H$ (m) for wide and shallow natural rivers; $\omega$ is the sediment settling velocity (m/s); $g$ is the gravitational acceleration (m/s$^2$); and $k_0$ and $m$ are the sediment transport coefficient and sediment transport exponent, respectively, which adhere to $k_0 = K/g^m$.

In (1), the key to accurately calculating the sediment transport capacity is to determine the values of coefficient $k_0$ and exponent $m$. Such parameters have been calibrated by many researchers using measurement data from the middle and lower reaches of the Yangtze and Yellow rivers. One example is the study by a sediment transport research group at the Wuhan Institute of Hydraulic and Electrical Engineering. By analyzing the measurement data, the parameters suitable for the upper and lower reaches of the Yangtze River were identified as follows: $K = 0.061$, $m = 1.54$, and $K = 0.036$, $m = 1.54$, whereas the parameters suitable for the Yellow River were identified as $K = 0.22$ and $m = 0.76$ [3, 4]. Chunhang et al. [5] utilized the hydrological and sediment data from the Tarim River.

The Alar station, which is located at the entrance section of the primary stream of the Tarim River, enabled the calibration of the sediment transport capacity parameters of the Alar reach, and the obtained results were $k_0 = 0.02$ and $m = 0.92$ [5, 6].

The third entrance of the Xinqiman Reservoir is located in the lower section of the upper reaches of the Tarim River, which is a typical wandering reach with a relatively straight river body intertwined with wide and shallow sandbars [7].
To improve the adaptability of Zhang Ruijin’s formula for sediment transport capacity, the parameters of the formula were adjusted according to the actual flow and sediment conditions in the reach. Based on this analysis, the current study uses the CCHE2D model to perform a numerical simulation of sediment transport at the third entrance of the Xinqiman Reservoir of the Tarim River and determines the parameters in the Zhang Ruijin’s sediment transport capacity (1). The research aims to provide an important theoretical reference for the calculation of sediment transport at the third entrance of the Xinqiman Reservoir of the Tarim River.

2. Fundamental Equations of the CCHE2D Model

The CCHE2D model was developed by the National Center for Computational Hydroscience and Engineering (NCCHE), USA. The model can simulate the dynamic interaction processes of flow and sediment transport in rivers, lakes, estuaries, and coastal waters. The equations used in this study for the numerical simulations are discussed in subsequent sections.

2.1. Governing Equations. CCHE2D is based on finite element methods and adopts the following two-dimensional equations to solve shallow-water problems:

2.1.1. Continuity Equation

\[
\frac{\partial h}{\partial t} + \frac{\partial (hU)}{\partial x} + \frac{\partial (hV)}{\partial y} = 0,
\]

where \(x\) and \(y\) are the Cartesian coordinates in the horizontal plane, \(h\) is the water depth (m), and \(U\) and \(V\) are the depth-averaged flow velocity components in the \(x\)- and \(y\)-directions, respectively (m/s).

2.1.2. Momentum Equations

\[
\begin{align*}
\frac{\partial (hU)}{\partial t} + \frac{\partial (hUU)}{\partial x} + \frac{\partial (hVU)}{\partial y} &= -gh\frac{\partial z}{\partial x} + \rho \frac{\partial (hT_{xx})}{\partial x} + \frac{1}{\rho} \frac{\partial (hT_{sy})}{\partial y} \\
&\quad + \frac{\partial D_{xx}}{\partial x} + \frac{\partial D_{sy}}{\partial y} + \frac{1}{\rho} \left( \tau_{sx} - \tau_{bx} \right) + f_c hV, \\
\frac{\partial (hV)}{\partial t} + \frac{\partial (hUV)}{\partial x} + \frac{\partial (hVV)}{\partial y} &= -gh\frac{\partial z}{\partial y} + \frac{\partial (hT_{yx})}{\partial x} + \frac{1}{\rho} \frac{\partial (hT_{yy})}{\partial y} \\
&\quad + \frac{\partial D_{yx}}{\partial x} + \frac{\partial D_{yy}}{\partial y} + \frac{1}{\rho} \left( \tau_{sy} - \tau_{by} \right) + f_c hU,
\end{align*}
\]

where \(z\) is the water surface elevation (m); \(g\) is the gravitational acceleration (m/s²); \(T_{xx}, T_{sy}, T_{yx},\) and \(T_{yy}\) are the depth-averaged turbulence Reynolds stresses (N/m²); \(D_{xx}, D_{sy}, D_{yx},\) and \(D_{yy}\) are the discrete terms to compensate for the nonuniformity of velocity and the influence of secondary flow; \(\rho\) is the density of water (kg/m³); \(\tau_{sx}\) and \(\tau_{sy}\) are the shear stresses on the bed surface (N/m²); \(\tau_{bx}\) and \(\tau_{by}\) are the shear stresses on the flow surface (N/m²); and \(f_c\) is the Coriolis coefficient.

2.2. Two-Dimensional \(k-\varepsilon\) Model. In this model, the equations for the turbulent kinetic energy \(k\) (\(k = 0.5\rho\overline{u^2}\)) and the rate of dissipation of turbulent kinetic energy \(\varepsilon\) \((\varepsilon = \mu_t \overline{\partial u^2/\partial x} \overline{\partial u^2/\partial x})\) are presented correspondingly. The average equations of the vertical lines of \(k\) and \(\varepsilon\) are

\[
\begin{align*}
\frac{\partial k}{\partial t} + u \frac{\partial k}{\partial x} + v \frac{\partial k}{\partial y} &= \frac{\partial}{\partial x} \left( \nu \frac{\partial k}{\partial x} \right) + \frac{\partial}{\partial y} \left( \nu \frac{\partial k}{\partial y} \right) - \\
&\quad \frac{\partial}{\partial x} \left( \frac{\nu}{\sigma_x} \frac{\partial k}{\partial x} \right) - \frac{\partial}{\partial y} \left( \frac{\nu}{\sigma_y} \frac{\partial k}{\partial y} \right) + f_c, \\
\frac{\partial \varepsilon}{\partial t} + u \frac{\partial \varepsilon}{\partial x} + v \frac{\partial \varepsilon}{\partial y} &= \frac{\partial}{\partial x} \left( \nu \frac{\partial \varepsilon}{\partial x} \right) + \frac{\partial}{\partial y} \left( \nu \frac{\partial \varepsilon}{\partial y} \right) - \frac{\partial}{\partial x} \left( \frac{\nu}{\sigma_x} \frac{\partial \varepsilon}{\partial x} \right) - \frac{\partial}{\partial y} \left( \frac{\nu}{\sigma_y} \frac{\partial \varepsilon}{\partial y} \right) + f_c, \\
\end{align*}
\]

where \(P\) is the pressure (Pa); \(c_f\) is the friction coefficient; and the empirical constants are \(c_{1k} = 1.45, c_{2k} = 1.90, \sigma_x = 1.0,\) and \(\sigma_y = 1.3.\)

2.3. Sediment Transport Equation. The sediment model adopted by the CCHE2D numerical simulation software primarily comprised suspended load. The transport equation for the suspended load is as follows:

\[
\begin{align*}
\frac{\partial (hC_k)}{\partial t} + \frac{\partial (hU C_k)}{\partial x} + \frac{\partial (hV C_k)}{\partial y} &= \frac{\partial}{\partial x} \left( \varepsilon h \frac{\partial C_k}{\partial x} \right) + \frac{\partial}{\partial y} \left( \varepsilon h \frac{\partial C_k}{\partial y} \right) + \frac{\partial S_c}{\partial x} \\
&\quad + \frac{\partial S_c}{\partial y} + \omega_{sk} (C_{sk} - C_k),
\end{align*}
\]

where \(C_k\) is the depth-averaged concentration of the suspended load (kg/m³); \(C_{sk}\) is the capacity or depth-averaged concentration of the suspended load in the equilibrium state of sediment transport (kg/m³); \(\varepsilon\) is the turbulent diffusion coefficient of the sediment, which is determined by \(\varepsilon = \nu \overline{\partial u \partial u} / \sigma_x,\) in which \(\sigma_x\) is the turbulent Schmidt number, ranging between 0.5 and 1.0; \(\omega_{sk}\) is the settling velocity of the sediment (m/s); \(\alpha\) is the nonequilibrium adaptation coefficient; and \(k = 1, 2, \ldots, N.\)

3. Experiments Using Numerical Simulation

3.1. The Flume Model. Experiments with the flume model were performed at the Key Laboratory of Water Conservation Engineering Safety and Water Disaster Prevention of
3.2. Numerical Simulation. First, the topographic data file of the flume model in Figure 1 was imported into CCHE-MESH. Subsequently, a boundary was defined to perform elevation interpolation. Finally, the model was meshed with quadrilateral grids; the maximum number of longitudinal grid lines, \( I_{\text{max}} \), was set to 180, the maximum number of horizontal grid lines, \( J_{\text{max}} \), was set to 600, and the RL (with smooth function-1) orthogonal meshes were used to improve the distribution of regional mesh quality and density, as well as to optimize the overall mesh quality. The layout of the numerical model and the meshes is shown in Figure 2.

3.3. Configuration of Initial Conditions

3.3.1. Flow Conditions. According to the statistics of floods discharged at the Xinqiman Hydrological Station in the primary stream of the Tarim River between the years 1956–2012, the floods are categorized into the following groups by their occurrences: once in 100 years, once in 50 years, once in 20 years, once in 10 years, and once in 5 years, with flow discharges of 1890 m\(^3\)/s, 1770 m\(^3\)/s, 1600 m\(^3\)/s, 1450 m\(^3\)/s, and 1280 m\(^3\)/s [9], respectively. After the flow scale conversion, the flow discharges for the simulation of these cases were 0.06048 m\(^3\)/s, 0.05664 m\(^3\)/s, 0.0512 m\(^3\)/s, 0.0464 m\(^3\)/s, and 0.04096 m\(^3\)/s, respectively.

3.3.2. Sediment Discharge Conditions. According to the statistics of Xinqiman Hydrological Station of the Tarim River, the annual average sediment discharge ranges between 2.32 and 5 kg/m\(^3\), the maximum average sediment discharge in the cross section ranges between 8.84 and 12.7 kg/m\(^3\) [9]. Therefore, the sediment discharge conditions for the simulation were chosen as integer values from 2 to 10 kg/m\(^3\).

3.3.3. Roughness Conditions. The comprehensive roughness coefficient is an important parameter in the mathematical modelling of fluid flow [10]. A comprehensive dimensionless number reflects the influence on flow resistance. The rougher the boundary surface, the greater the roughness; the smoother the boundary surface, the smaller the roughness. The authors of this study calibrated the comprehensive roughness coefficient of the third entrance of the Xinqiman Reservoir of the Tarim River by using the CCHE2D model. The consistency between the simulated and measured flow surface profiles was compared, considering the standard deviation, correlation coefficient, and root mean square error. Consequently, the comprehensive roughness coefficient of the flume model that yielded the minimum error was 0.018. According to the model-scale conversion, the comprehensive roughness coefficient of the original reach was 0.01 [11]. Therefore, 0.018 was selected as the comprehensive roughness coefficient for the numerical simulations in this study.

<table>
<thead>
<tr>
<th>Type of scale</th>
<th>Value of scale</th>
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</thead>
<tbody>
<tr>
<td>Horizontal scale</td>
<td>( \lambda_v = 25 )</td>
</tr>
<tr>
<td>Vertical scale</td>
<td>( \lambda_H = \lambda_H^{1/2} = 5 )</td>
</tr>
<tr>
<td>Velocity scale</td>
<td>( \lambda_V = \lambda_V^{1/2} = 5 )</td>
</tr>
<tr>
<td>Roughness scale</td>
<td>( \lambda_s = \lambda_s^{1/2} = 5 )</td>
</tr>
<tr>
<td>Time scale of flow movement</td>
<td>( \lambda_t = \lambda_t^{1/2} = 5 )</td>
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<tr>
<td>Flow scale</td>
<td>( \lambda_J = \lambda_J^{1/2} = 5 )</td>
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<tr>
<td>Sediment settling velocity scale</td>
<td>( \lambda_Q = \lambda_J^{1/2} = 5 )</td>
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<tr>
<td>Sediment starting velocity scale</td>
<td>( \lambda_Q = \lambda_J^{1/2} = 5 )</td>
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<tr>
<td>Sediment transport capacity scale</td>
<td>( \lambda_Q = \lambda_J^{1/2} = 5 )</td>
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<tr>
<td>Sediment concentration scale</td>
<td>( \lambda_Q = \lambda_J^{1/2} = 5 )</td>
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<tr>
<td>Sediment grain diameter scale</td>
<td>( \lambda_Q = \lambda_J^{1/2} = 5 )</td>
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</table>

Table 1: Scales of the flume model.
3.3.4. Suspended Load Gradation. The gradation of the suspended load is one of the key factors affecting sediment movement, which has a direct impact on sediment transport capacity. Chaoqing et al. [9] collected four groups of suspended loads graded from measurements of the Alar station in the flood season of 2001 and considered the average as the representative gradation of the average suspended load of the original inlet section in the flood season (Table 2) [9].

Based on the scheme presented in Table 2, the gradation of the suspended load required for this study was developed. Considering the test conditions and other factors, the median grain size of the modeled sediment was 0.06 mm, and the median grain size of the original sediment was 0.047 mm [9]. The final suspended load gradations used in the numerical simulation in this study are listed in Table 3. The grain size distribution curves of both the modeled sediment and original sediment are presented in Figure 3.

From Figure 3, it can be seen that the gradation curve of the modeled sediment is similar to that of the original sediment. Therefore, the gradation of the modeled sediment can be representatively used in this study.

3.3.5. Settling Velocity of Modelling Sediment in Static Water. The settling velocity of particles is given by Stokes equation as follows:

$$
\omega = \frac{1}{18} \frac{\gamma_s - \gamma}{\gamma} \frac{gd^2}{V},
$$

(6)

where \(\omega\) is the settling velocity (m/s), \(\gamma_s\) is the weight density of the sediment (N/m\(^3\)), \(\gamma\) is the weight density of water (N/m\(^3\)), and \(V\) is the kinematic viscosity coefficient (m\(^2\)/s).

From (8), the theoretical settling velocity was calculated to be 0.00252 m/s. The measurement of the settling velocity in static water performed by Zhou (2015) concluded that the modeled sediment \(d_{50}\) of 0.06 mm exhibited a settling velocity of 0.0025 m/s [8], which is considerably close to the calculated value. Therefore, the calculated settling velocity of 0.00252 m/s can be representatively used in this study.
3.3.6. Gradation of Bed Sediment. Based on the gradation of the surface bed sediment collected by Chaoqing et al. [9] on the left bank of Xinqiman and the primary stream of the Tarim River, the gradation of the bed sediment in the numerical simulation is shown in Table 4.

3.4. Verification of the Independency on Meshing. At the simulated flow discharge of 0.0512 m³/s, steady flow simulations were performed with four different configurations of mesh numbers: 15000, 45000, 81000, and 108000. The dependencies of both the water depth and average flow velocity at the outlet on the number of meshes were verified, and the results are shown in Figure 4.

As illustrated in Figure 4, with the increase in mesh number, both the water depth and average flow velocity at the outlet tended to plateau. Considering the computational capability with respect to ensuring accuracy, grid 4 was used in the simulations of this study.

3.5. Verification of the Model. Chunhong et al. [5] determined the relationship between the average water depth \( H \) and flow discharge \( Q \) as \( H = 0.3192Q^{0.2336} \), through a large number of measurements obtained at the Xinqiman section of the Tarim River. To verify the accuracy and reliability of the model designed to simulate the third entrance of the Xinqiman Reservoir of the Tarim River, steady flow simulations were performed under the five different discharges discussed in Section 3.3.1. Through this, the simulation results of the water depth at the outlet section were extracted. The results from the numerical simulation were then compared with those calculated using the relationship between the water depth \( H \) and flow discharge \( Q \), derived by Chunhong et al. [5]. The details of these comparisons are presented in Table 5.

Table 5 shows that the deviation between the numerical simulation and calculation was between 0.05295 and 0.06168 m. As defined in the Technical Regulations for Flow and Sediment Simulation of Inland Waterways and Ports [12], the allowable deviation of the modelling water level in plain regions is ±0.5 m. The deviation of this simulation is a little larger than the standard one, which can basically meet the requirements of this study. In summary, the computation method, boundary conditions, and initial conditions selected for the model are equitable, and the CCHE2D model can appropriately simulate the scenario of this study.

4. Distinction of Bed-Material Load and Wash Load

4.1. Classification of Bed-Material Load and Wash Load. In the classical theory of river dynamics, the coarse particles which are constantly exchanged with the sediment on the riverbed are often called “bed-material load,” whereas the fine particles which basically remain suspended and do not exchange with the sediment on the riverbed, are called “wash load”. Einstein was one of the earliest scholars to propose the concepts of wash load and bed-material load. Through a flume test with approximately constant flow, the sediment discharged from the upstream was modified, and the sediment transport downstream was studied. The transport of the sediment with a grain size >0.1 mm was identified to be constant, whereas that of sediment <0.06 mm varied with the sediment discharge. Thus, Ning [13] introduced the concepts of wash load and bed-material load [13]. According to the method summarized by Huai et al. [14] for the distinction between the two loads,
0.06 mm or 0.0625 mm is usually considered as the boundary grain size of the wash load. For sediment particles larger than the boundary grain size, the transport volume becomes irrelevant to the upstream sediment discharge and is always maintained approximately at a certain average value; therefore, it is categorized as a bed-material load. In contrast, for sediment particles smaller than the boundary grain size, its transport volume changes according to the sediment discharge, which makes it the wash load [14].

Therefore, in this study, under the condition of different sediment discharges, sediment transport was simulated utilizing the CCHE2D model, and the suspended sediment concentration of each grain size at the outlet section was extracted from the simulation results. For increasing sediment discharge from upstream, the sediment that was always maintained approximately at a certain average concentration was classified as bed-material load. The sediment whose concentration increased with the volume of sediment discharged from the upstream was classified as wash load [15].

4.2. Results and Analysis. The suspended sediment concentration for each grain size at the outlet section under different sediment discharges is shown in Figure 5.

As shown in Figure 5, for sediment particles of grain size 0.193 mm, the suspended sediment concentration at the outlet section always remained 0.0118 kg/m$^3$, approximately, despite the increase in sediment discharge. Similar results were observed for sediments of 0.160, 0.131, and 0.110 mm, with constant suspended sediment concentrations of 0.0512, 0.1304, and 0.2851 kg/m$^3$, respectively. As these suspended sediment concentrations were independent of the sediment discharged, the sediments of these grain sizes could be grouped into bed-material load.

For the sediment of grain size 0.091 mm, the suspended sediment concentration at the outlet section changed simultaneously with the sediment discharge, whereas the latter was smaller than 5 kg/m$^3$. When the sediment discharge was above the threshold of 5 kg/m$^3$, the suspended sediment concentration at the outlet section was stable at approximately 1.049 kg/m$^3$. Provided that the average maximum sediment discharge in the Xinjiang region of the Tarim River was from 8.84 to 12.7 kg/m$^3$, the sediment of grain size 0.091 mm used in this study could be categorized as bed-material load.

For sediment of grain sizes 0.006, 0.020, 0.035, 0.042, and 0.061 mm, the suspended sediment concentrations at the outlet section increased with increasing sediment discharge. Therefore, under the conditions of this study, these sediment dimensions were grouped into wash load.

To summarize, under the flow and sediment conditions of this study, sediment of grain size $\geq 0.091$ mm was classified as bed-material load, whereas sediment of grain size $\leq 0.061$ mm was classified as wash load. This classification of bed-material load and wash load agrees with the analyses by Einstein and Qian Ning.

5. Parameter Calibration in Zhang Rujin’s Formula of Sediment Transport

5.1. Methods. In this study, under different flow and sediment conditions, the CCHE2D model was used to simulate the sediment transport at the third entrance of the Xinjiang Reservoir of the Tarim River. In the simulation results, the flow conditions such as bed sediment concentration, $S$, cross-sectional average water depth, and average flow velocity were extracted, and the flow-sediment factor, $U^3/R_w$, was calculated, in which the hydraulic radius, $R$, could be replaced by the average water depth, $H$, in natural rivers that are wide and shallow. Relevant data of the original reach were obtained through model-scale conversion. Thus, the
parameters in Zhang’s sediment transport formula were calibrated for this reach.

5.2. Results and Analysis. A multivariate linear regression method was adopted to fit the numerical model and original reach. Figure 6 displays the regression between the suspended sediment concentration, \( S \), and the flow condition, \( U^3/gH \).

Consequently, the regression equation relating \( S \) and \( U^3/gH \) for the numerical model was determined to be \( y = 3536.26x^{1.574} \), \( R^2 = 0.961 \); for the original reach, the relationship was determined to be \( y = 410.02x^{1.55} \), \( R^2 = 0.950 \). It can be concluded that the suspended sediment concentration and flow condition adhered significantly through the power law, which complies with (1).

The multivariate linear regression method was also used to fit the relationship between \( S \) and the flow-sediment factor, \( U^3/R_{\omega} \), to determine the coefficient \( k_0 \) and exponent \( m \) in (1) for the third entrance of the Xinqiman Reservoir of the Tarim River. The relationship between \( S \) and \( U^3/R_{\omega} \) for the numerical model and the original reach are shown in Figure 7.

Consequently, the regression equation defining the relationship between \( S \) and \( U^3/R_{\omega} \) for the numerical model was determined to be \( y = 0.012x^{1.4} \), \( R^2 = 0.961 \); for the original reach, the relationship was determined to be \( y = 0.0197x^{0.928} \), \( R^2 = 0.854 \). Therefore, the sediment transport capacity coefficient, \( k_0 \), in (1) for the original reach was 0.0197 and the exponent, \( m \), was 0.928. Consequently, the sediment transport capacity formula for the third entrance of the
Xinqiman Reservoir of the Tarim River could be drawn as follows:

\[ S^* = 0.0197 \left( \frac{U^3}{gH\omega} \right)^{0.928} = 0.164 \left( \frac{U^3}{g\omega H} \right)^{0.928}, \]  

(7)

where \( S^* \) is the sediment transport capacity (kg/m³), \( U \) is the average flow velocity in the cross section (m/s), \( H \) is the average water depth (m), and \( \omega \) is the sediment settling velocity (m/s).

5.3. Theoretical Verification. In general, the sediment transport capacity coefficient, \( k_0 \), ranges between 0.01 and 0.05. The range of \( k_0 \) for the mainstream of the Tarim River is 0.015–0.023 [9]. Thus, the \( k_0 \) values obtained in this study considerably agree with the theoretical ranges.

The semiempirical estimation of \( k_0 \) proposed by Changqing et al. [9] is as follows:

\[ k_0 = \frac{\rho_s \rho_0 B_r}{(\rho_s - \rho_0)C}, \]  

(8)

where \( \rho_s \) is the sediment density (kg/m³), \( \rho_0 \) is the water density (kg/m³), \( B_r \) is the kinematic parameter of suspended sediment, which is set to 0.01, based on Bagnold’s research on laboratory-measured data, and \( C \) is the Chézy coefficient. The calculated \( k_0 \) from equation (8) was 0.012, which is similar to the result obtained in this study. Therefore, it is reasonable to conclude that \( k_0 = 0.0197 \) can be representatively used to study the sediment transport capacity in the target reach.

6. Conclusions

In this study, the CCHE2D model was used to simulate the sediment transport at the third entrance of Xinqiman Reservoir in the Tarim River, and the parameters in Zhang Ruijin’s formula of sediment transport capacity were determined under different flow and sediment conditions.

The primary conclusions of this study are as follows:

(1) Under the flow and sediment conditions of this study, sediment of grain size ≥0.091 mm can be considered as bed-material load, whereas sediment of grain size ≤0.061 mm can be considered as wash load.

(2) There is a good power-law relationship between the suspended sediment concentration, \( S \), and the flow condition, \( U^3/gH \), at the third entrance of the Xinqiman Reservoir of the Tarim River, which is consistent with the law of Zhang Ruijin’s formula for sediment transport capacity.

(3) Using multivariate linear regression, the relationship between suspended sediment concentration, \( S \), and flow-sediment factor, \( U^3/H\omega \), at the third entrance of the Xinqiman Reservoir of the Tarim River was fitted, and the parameters in Zhang Ruijin’s formula for sediment transport capacity were determined as \( k_0 = 0.0197 \) and \( m = 0.928 \).

Data Availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Disclosure

The sponsors had no role in the design, execution, interpretation, or writing of the study.

Conflicts of Interest

The authors declare no conflicts of interest.

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