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3D Numerical Modelling of Water Circulation in River Harbours Using the Zero- and Two-Equation Turbulence Models

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Abstract

In this paper details of the numerical model results of the layer integrated model for the square river harbour, using the zero- and two-equation turbulence models are discussed. For the zero- and two-equation turbulence models, the modified mixing length and depth integrated k- ε models were deployed to calculate the horizontal eddy viscosity coefficients, respectively. Likewise, the parabolic distribution and layer integrated k- ε models were used to determine the vertical eddy viscosity. The model was applied for prediction of flow within the river and harbour and the various numerical model and experimental results were then compared graphically with each other. General study of the numerical model results showed that the zero-equation model has predicted small values for the velocity components within the harbour, whereas the two-equation model has predicted reasonable values for the flow components and these values were relatively in good agreement with the experimental results. Also, the numerical model results of the vertical profile of horizontal velocity components have shown the capability of the k- ε turbulence model in predicting the experimental data.

Key words: Numerical models, Three-dimensional flow, Finite difference, River harbour, Turbulence models.



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$$\begin{split} \frac{\partial \tilde{k}H}{\partial t} &+ \frac{\partial \tilde{k}UH}{\partial x} + \frac{\partial \tilde{k}' H}{\partial y} = \\ \frac{\partial}{\partial x} \left(\frac{\nabla_{a}H}{\sigma_{k}}, \frac{\partial \tilde{k}}{\partial x} \right) + \frac{\partial}{\partial y} \left(\frac{\nabla_{a}H}{\sigma_{k}}, \frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \overline{\nabla}_{a} H \left[2 \left(\frac{\partial U}{\partial x} \right)^{2} + 2 \left(\frac{\partial V}{\partial y} \right)^{2} + \left(\frac{\partial U}{\partial y} + \frac{\partial V}{\partial x} \right)^{2} \right] \\ &+ v_{a} \left(1 \right) \\ \frac{\partial \tilde{k}EH}{\partial t} + \frac{\partial \tilde{k}UH}{\partial x} + \frac{\partial \tilde{k}}{\partial y} \right) \\ &+ v_{a} \left(1 \right) \\ \frac{\partial \tilde{k}EH}{\partial t} + \frac{\partial \tilde{k}UH}{\partial x} + \frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\nabla_{a}H}{\sigma_{k}}, \frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\nabla_{a}H}{\sigma_{k}}, \frac{\partial \tilde{k}}{\partial y} \right) \\ + \frac{\partial \tilde{k}}{\partial x} \left(\frac{\nabla_{a}H}{\sigma_{k}}, \frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\nabla_{a}H}{\sigma_{k}}, \frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\nabla_{a}H}{\sigma_{k}}, \frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\nabla_{a}H}{\sigma_{k}}, \frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\nabla_{a}H}{\sigma_{k}}, \frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\nabla_{a}H}{\sigma_{k}}, \frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial U}{\partial y} \right)^{2} + \left(\frac{\partial U}{\partial y} + \frac{\partial V}{\partial y} \right)^{2} \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial x} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial x} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\ &+ \frac{\partial \tilde{k}}{\partial y} \left(\frac{\partial \tilde{k}}{\partial y} \right) \\$$

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