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論文審査の要旨

博士の専攻分野の名称	博　士　（　工学　）	氏名	FIKRY PURWA LUGINA
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論　文　題　目

Numerical Simulation Methods for Flow Resistance and Sediment Transport Dynamics in Curved and Meandering Rivers

（湾曲・蛇行河川における流下抵抗と土砂輸送力学の数値解析法）

論文審査担当者

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〔論文審査の要旨〕

Flooding can be caused by more than just heavy rainfall; it can happen when the volume rate of flood water surpasses the river's capacity. Flow resistance plays a crucial role in governing the behavior of water in streams and rivers, significantly impacting flow hydraulics. It directly influences the ability of a channel to carry water by affecting the velocity of the flow and, consequently, the depth of the water.

The objectives of this study are (1) to investigate flow resistance and sediment transport dynamics in meandering rivers to get a comprehensive understanding of decreased river capacity mechanisms and (2) to develop a numerical model with both efficient calculation time and high accuracy. The work was divided into three parts: developing numerical models, investigating flow resistance, and investigating sediment dynamics.

In the first part, a high momentum transfer near the wall was found by incorporating shallow water assumption for flow dynamics investigation in curved open channels. This study developed a numerical discretization method of an upwind scheme for dispersion terms to overcome unphysical phenomena with the shallow water assumption. The proposed method was then applied to a quasi-three-dimensional numerical, so-called bottom velocity calculation (BVC), method to investigate its applicability in reproducing flow structures. The effectivity of the proposed method was then compared to a conventional two-dimensional model and a fully three-dimensional model for sharply and mildly curved channels dataset. The proposed method effectively mitigated the occurrence of excessively high velocities near the wall. It demonstrated the capability to accurately replicate both the experimental water levels and velocity profiles within the channel bend using the experimental dataset. The conventional two-dimensional model cannot predict well the water surface profile in the curved channel because of the inability to consider the increase in flow resistance due to secondary flow.

For the second part, this study investigated the flow resistance resulting from shear forces in meandering channels, by integrating laboratory experiments with numerical models featuring uniform width and rectangular cross-sections. The study has two primary objectives. Firstly, to examine the impact of channel shape, aspect ratios, and bed roughness on flow resistance through laboratory experiments. In this study, a combination of factors was explored to gain a more comprehensive understanding of flow resistance. Secondly, the study aims to validate the effectiveness of the BVC method in simulating the impact of different factors on flow resistance and to investigate flow resistance in channels with different sinuosity. The results show that the meandering channel exhibits higher friction factors compared to the straight channel, indicating a greater resistance in meandering channels. The larger the relative roughness height, the more dominant role bed roughness plays in determining flow resistance compared to distortion resistance. The numerical investigation demonstrated that as sinuosity increased, flow resistance also increased until reaching a sinuosity value of 1.75. However, beyond this point, flow resistance decreases with increasing sinuosity. This phenomenon can be attributed to the strengthening of secondary flow, whereby a smaller curvature ratio value resulted in a more pronounced secondary flow.

And the final part, sediment transport dynamics in curved and meandering channels with sediment supply conditions were discussed. The consideration of complex channel shapes and conditions is critical, e.g., sediment-flood disasters in Japan as a result of heavy precipitation in 2018. Therefore, this research aims to investigate the applicability of quasi-3D models to predict bed deformation in meandering channels with excessive sediment supply. The models of the BVC method were validated with three different cases, strongly curved channel, mild slope meandering channel, and steep slope meandering channel. The result showed that three-dimensional flow structures have a significant role in distributing sediment in curved and meandering channels. The numerical investigation confirmed that the BVC models' results are in good agreement with the experiment dataset in terms of predicting the location of scouring and deposition, however, they failed to represent the magnitude of scouring and deposition.

With the above evidence, the applicant is judged as sufficiently qualified to be awarded the degree of Doctor of Philosophy in Engineering .

備考：審査の要旨は，1,500 字以内とする。