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1. Introduction

The floodplain encroachment in a river is generally created due to construction of hydraulic structures such as embayment, spur-dykes etc. along the river for flood protection, navigation, bank protection, protection of bridges etc. The obstructed flow field in the downstream of a single spur-dyke or the flow field enclosed by two consecutive groynes are low velocity region compared to mainstream. This type of zone is generally termed as dead-zone. Flow velocity inside such kind of arrangement is lower than main channel. In addition to engineering applications, such structures increase the biodiversity of aquatic species by creating habitat and providing shelter for them. The main stream of a river, where the velocity is high, is not suitable for weak and small fishes. That's why the dead zone is a suitable shelter for them. In Bangladesh, the typical river encroachment means the earth filling of a portion of river course along the bank and pushing of river bank towards the center of river. Downstream of the fill, it creates a sudden enlarged portion along the river side. Such sudden enlarged zone due to width enchroachment are mainly observed in small rivers running through the cities or towns. Such filling may be continuous along the stream or discontinuous. In this study, the flow field in two types of dead zone have been studied: one is rectangular side cavity and another one is the dead zone created at the downstream of channel with width enchroachment (i.e. Sudden enlarged zone).

2. Numerical Model and Simulation Details

A FORTRAN code based on Navier-Stokes equation is used for simulating the flow field of this study. The basic equations are continuity equation and momentum equation. In simulation process, the partial differential equations are transformed to algebraic or numerical equations which are done by discretization. In the present code finite volume method is used for the discretization. The numerical simulations for 3-D unsteady flows are performed for three cases: two cases (C1 and C2) for open channel with rectangular side cavity and one case (E1) for sudden enlarged zone. The details of flow parameters are shown in Table 1.

Table 1: Hydraulic parameters for the simulations of open channel flows with (i) a rectangular side cavity, Case C1 and C2 (ii) a sudden enlarged zone, Case E1

Case no.	B (cm)	L (cm)	W (cm)	L/W ratio	Q_0 (cm^3/s)	ho (cm)	Fr no.	Bottom slope	Δt (sec)
C1	10	22.5	15	1.5	747.0	2.02	0.83	1/500	0.0001
C2	10	45	15	3	747.0	2.02	0.83	1/500	0.0001
E1	10	135	15	9	255	1.00	0.81	1/1000	0.0001

3. Flow Characteristics in a Side Cavity and in a Sudden Enlarged Zone

It is found that the flow in the side cavity is characterized by three types of flow phenomena: the circulation inside the dead zone, periodic coherent vortices at the interface of main stream and dead zone, and the water surface oscillation inside the dead zone. In this study all these characteristics are successfully reproduced by numerical simulation. Figure 1 shows the time averaged profile of stream-wise velocity (u) along the transverse cross-section at centerline of dead zone. The comparison of simulated result with experiment shows good agreement. The temporal variations of water surface shows a depressed water depth at the center of coherent vortices. This hollow of the free surface moves downward with time along the interface, which are observed in the movement of large vortices in vector plots. In the calculated result, a periodic change in depth difference between upstream and downstream end of dead zone indicates the existence of oscillation in the cavity. The period of oscillation is found same as that of instability vortex. Although the depth of the flow is small, strong secondary currents are found to be generated at inside the dead zone as well as near the interface area. An exchange of flow between main stream and dead zone is observed. Due to the formation of circulation in the dead zone, the velocity is very small compared to main stream, and the velocity at the center of circulation is zero. For length to width ratio of the cavity as 1.5 (l/w=1.5), the center of the circulation is found to be situated at the middle of the cavity in both the directions.

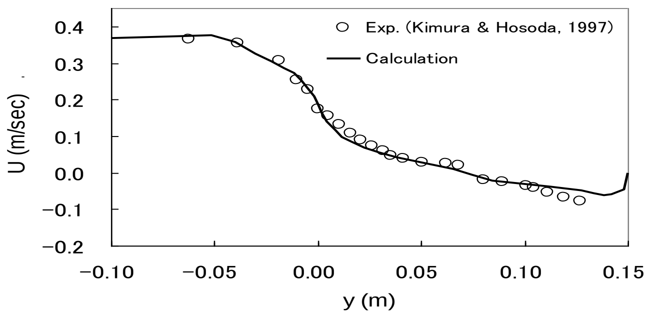

Figure 1: Comparison of time averaged velocity profile at the transverse section along the middle of side cavity.

With increasing the length of the cavity, the circulation pattern and their numbers are changed along with velocity magnitudes. In case C1, only one circulation was observed, but in case with higher length to width ratio of the cavity (Case C2, L/W=3), there are about two main circulations in the cavity, the first one is smaller than the second one due to the suppression by the prominent corner vortex. In this case the exchange of flow between main stream and dead zone is prominet compared to previous case.

For the open channel with sudden enlargement, although the upstream arrangement of flow domain is same as the cavity flow, the flow in the enlarged zone has the freedom to flow towards downstream in longitudinal direction. Due to this free downstream, the simulated flow field in the sudden enlarged zone is significantly different than that of open channel flows with side cavity. The simulated flow field of open channel flow with sudden enlarged zone for case E1 is shown in Fig. 2. Only one main circulation is observed in the dead zone of the enlarged portion of the channel. The main flow is observed to be deflected towards the enlargement (left side). At the end of the main circulations a small circulation formed at the opposite side of the enlargement (right side) due to the movement of flow towards left side. The water depth at the center of circulation is low compared to surroundings.

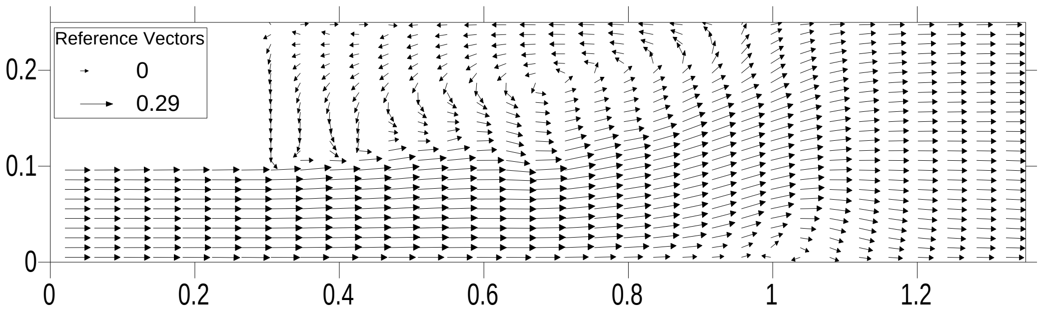

Figure 2: Instantaneous velocity vectors for case E1.

4. Conclusions

The flow fields in an open channel with two types of dead zone have been investigated by three-dimensional unsteady RANS computations: one is rectangular side cavity and another one is sudden enlarged zone. It can be concluded that the dead zone is a low velocity region, and due to this low velocity the sediments carried by the stream may deposit there easily to form shallow depth region. The effect of width enchroachment due to earth filling or construction of any obstruction extending inside the river also creates dead zone that finaly may filled up by sediments. Beside the academic research interests, the present study contributes to understand the developement, extent and behaviour of flows in a dead zone for proper managemnet of river system and other water courses.

References

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