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UNSTEADY FLOW BEHAVIOUR IN A COMPOUND CHANNEL

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INTRODUCTION

Unsteady flow characteristics were investigated experimentally recording detailed velocity measurements at three sections in a compound channel during repeated passages of a hydrograph. Extensive water depths measurements were recorded at eleven sections from upstream to downstream. 1-D numerical simulation was performed for a rectangular channel with lateral discharge at interface in order to analyze flow in a compound channel. Time variation of lateral discharge in the simulation indicates the rate of momentum transfer at interface. Furthermore, experimental results and calculated results both reveal that effect of longitudinal pressure gradient is significant in the flow mechanism.

EXPERIMENTAL PROCEDURE

The experiments were conducted in a 25m long, 1m wide tilting flume with one side flood plain of 60cm wide and 5.25cm high. The channel slope was set as 0.001. Detailed velocity measurements were recorded at three sections 5m apart being first section 8m from the flume entrance using 3mm diameter micropropellers. The water depths were measured using servo meters at the same points where the velocity measurements were taken in the transverse direction. Depth data were recorded at 11 sections being 1m distance apart.

RESULTS & DISCUSSIONS

1-D Numerical simulation was done for a rectangular channel with lateral discharge at interface. Set of equations used are as follows.

Continuity equation : $$\frac{\partial h}{\partial t} + \frac{\partial (Vh)}{\partial x} - \frac{q}{B} = 0$$

Momentum equation : $$\frac{\partial (Vh)}{\partial t} + \frac{\partial (V^2 h + g h^2/2)}{\partial x} - \frac{V_x q}{B} - gh(S_0 - S_f) = 0$$

Lateral flow is modeled as : $$q = \alpha h_f (V - V_f)$$

Interface velocity is approximated by : $$V_x = (V + V_f)/2$$

q	= Lateral flow per unit length
V_x	= Flow velocity at the interface
V	= Velocity in main channel
h	= Depth in main channel
V_f	= Velocity on flood plain
h_f	=Depth on flood plain
α	= Coefficient

The MacCormack scheme which is an explicit, two step predictor-corrector scheme with second order accurate both in space and time was used in one-dimensional simulation. Boundary conditions are velocity variations at upstream end and water depth variations at downstream end. As these equations are for the interior points specified interval approach was applied at the boundaries. Water depth variations and velocity variations at the second section are shown in Fig. 1 and 2 respectively. Numerical simulation for case 1 was done applying α=0 (no lateral flow). For case 2, α=0.03 was used at first phase of the rising stage (t <120s) and second phase of receding stage (t >220s) whereas close to the peak of the hydrograph α=0.003 was selected in order to obtain the close results with experimental data. It implies that momentum transfer is significant only in the first phase of the rising stage and second phase of the receding stage while it is low close to the peak of the flood.

Depth averaged primary velocities across the section 2 at given time instances are shown in Fig. 3. It indicates that velocity in the main channel reaches its peak earlier than peak of the hydrograph and then decreases slowly while velocity on the flood plain increases until hydrograph reaches its maximum. Cross-sectional averaged velocities are calculated taking into account of longitudinal water surface slope [d(D)/dx] in order to understand the above mentioned cross velocity phenomena. The calculated results are compared with the measured data in Table 1. It reveals that this cross velocity phenomenon (velocity -

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in the main channel decreases while it increases on the flood plain) occurs mainly by the effect of water surface slope on driving force.

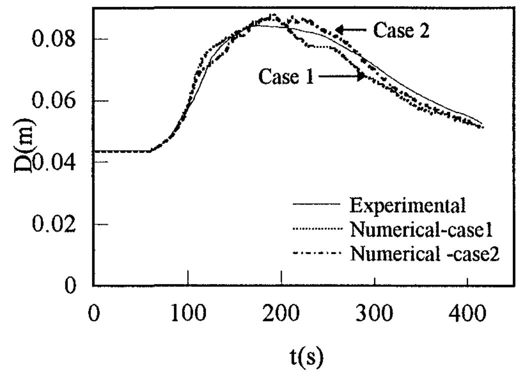

Fig. 1 Water depth variation at section 2

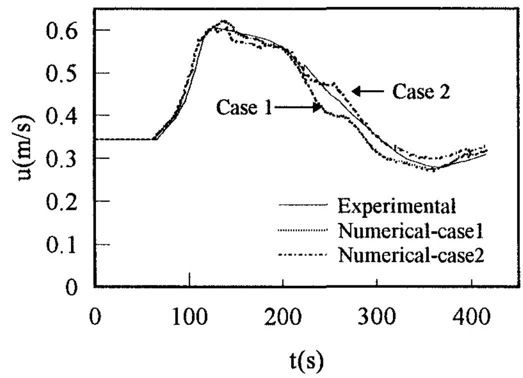

Fig. 2 Velocity variation at section 2

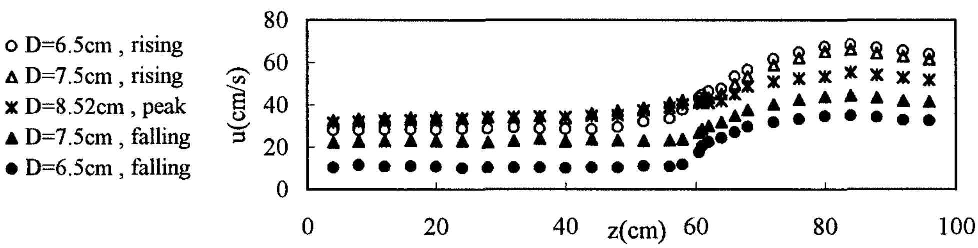

Fig.3 Depth averaged velocity variations across the section 2

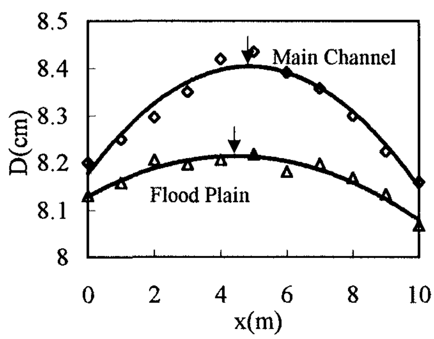

Fig. 4 Water surface profile at t=205s

Time (s)	Depth (cm)	u(cm/s)-calculated		u(cm/s)-measured	
		u_m	u_f	u_m	u_f
123	6.5	64.35	20.12	62.42	26.42
148	7.5	59.72	30.93	57.34	32.21
205	8.45	52.65	30.31	52.01	32.14
272	7.5	41.28	21.24	38.37	22.26
326	6.5	35.11	12.89	28.46	14.10

Table 1: Calculated & measured velocities

CONCLUSIONS

Lateral momentum transfer at interface is significant except close to the peak of the hydrograph. However different water surface slopes in main channel and flood plain play an important role in determining the longitudinal velocities.

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