OCCURRENCE OF COANDA EFFECT IN A NARROW OPEN-CHANNEL MODEL

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I. INTRODUCTION

The Coanda Effect has been discovered in1930 by the Romanian aerodynamicist Henri-Marie Coanda (1885-1972). He has observed that a steam of air (or a other fluid) emerging from a nozzle tends to follow a nearby curved surface, if the curvature of the surface or angle the surface makes with the stream is not too sharp.

Coanda Effect is the phenomena in which a jet flow attaches itself to a nearby surface and remains attached even when the surface curves away from the initial jet direction. It is the fact that the flow becomes asymmetric in spite of symmetric test sections and symmetric inlet and outlet conditions. An increase of velocity near one wall is accompanied with a decrease in pressure, and once a pressure difference is established across the duct, it will maintain the asymmetry of the flow. The choice of one side or the other is dependent on subtle details of the initialization and transient history of the flow.

From previously research conducted, Coanda Effect" was observed at the exit side downstream of the channel. This research aims to determine the following: 1) When does Coanda effect happen? 2) When does it deflect to the right or left bank wall? and; 3) When does symmetrical and asymmetrical flow patterns occurs?

II. METHOD AND MATERIALS

1. Research procedure

Laboratory experiments were performed in a one-sided glass rectangular flume 15 m long, 1.80 m wide and 0.40m deep. It has an adjustable slope of up to a maximum of 1/50 or 30 cm height difference between upstream and downstream sides of the flume. The downstream tailgate was fixed at a certain angle to maintain a steady flow at upstream side of the channel. A 15 kW - 4 pole three phase induction motor pump (HITACHI, Silent Power) is attached to it that supplies discharge of up to 123~124 L/s maximum. Water depth measurements were taken using a point gauge with a reading accuracy of ±1mm. Alternatively, velocities were measured using 3D-electronic magnetic current meter (KENEK, VM-1001RS). With an adjustable range of 0~200 cm/s and a time constant of 0.5~10 secs.

3. Laboratory Experiments

This research conducted two (2) cases. Case 1 was merely flow observation experiment. Case 2 on the other hand was conducted to thoroughly identify the asymmetry and symmetry of the flow. See **Fig. 1** and **Table 1** for river model and boundary conditions.

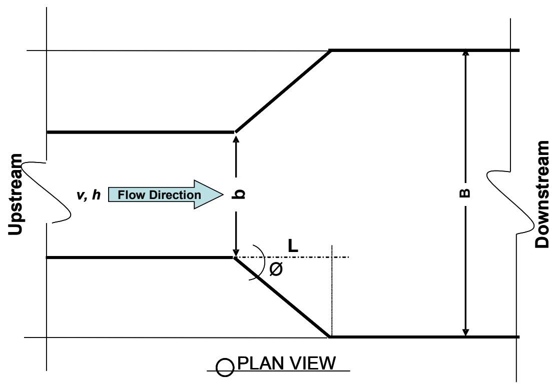

Fig. 1 Asymmetrical Model

Case	B [cm]	b [cm]	Q [L/s]	L [cm]	i	θ [º]
1	90	45	18	50	1/1000	24.23
2	90	44	3.3~16	19~130	1/5000	10~50

Table 1 Boundary Conditions

3.1 Asymmetrical Flow Observation

First, an experimental observation was conducted at the exit section of a narrow section. River and boundary conditions were : length equal to 15.0m; flume total width of 1.8m; model width of 0.9m; narrow path width of 0.45m; height of the model equal to 0.11m; and a river slope was set to 1/1000. Also, Manning's number used for the main river was equal to 0.025 s/m$^{1/3}$. Discharge applied at the upper stream boundary, Q was equal to 18L/s constant. Blue dye was used to identify the

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direction and pattern of the flow. First, it was sprayed at the middle section of the channel, and then sprayed randomly without spreading at a specific point.

3.2 Asymmetrical Flow Experiments

To further understand the occurrence of this phenomenon, asymmetry laboratory experiments were conducted. The exit section of the narrow model was then changed and adjusted to 10º-50º angles. Furthermore, bed slope was set to 1/5000 and upstream boundary conditions were set to a minimum of 3.3L/s to a maximum of 16L/s.

III. RESULTS

1. Asymmetrical Flow Observation

Fig. 3 results show that an asymmetrical flow pattern occurs as the flow exits the narrow path. It was observed that it is when an adverse pressure gradient occurs along the sidewall of the channel.

2. Asymmetrical Flow Experiments

This experiment aims to determine the asymmetry direction of the flow at the exit section of a narrow channel. **Fig. 4** shows the symmetry and asymmetry flow boundaries. Result shows that asymmetry flow to the right mostly occurs at tan θ equal to 3.0. Also, Froude number, Fr value greater than 1 from tan θ value 0.50 and from Fr 0.80 from N/W 3.0. On the contrary, asymmetry to the left mostly happens in between tan θ value equal to 1.0 to 2.0 and Fr value equal to 0.80-1.05. Furthermore, symmetry occurs at Fr greater than 0.95.

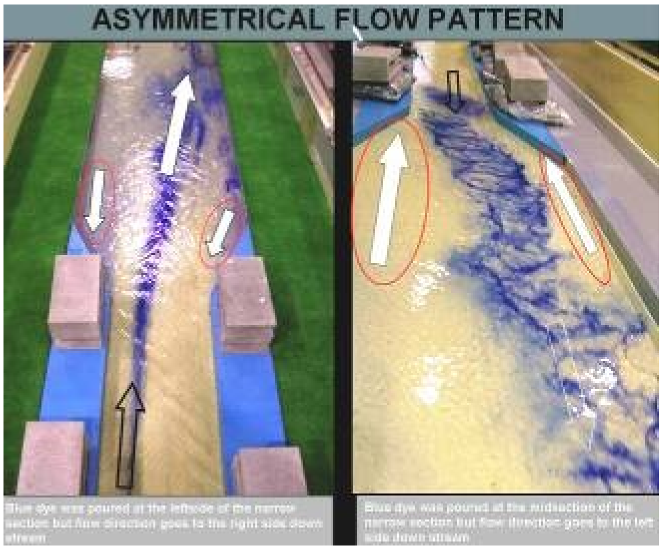


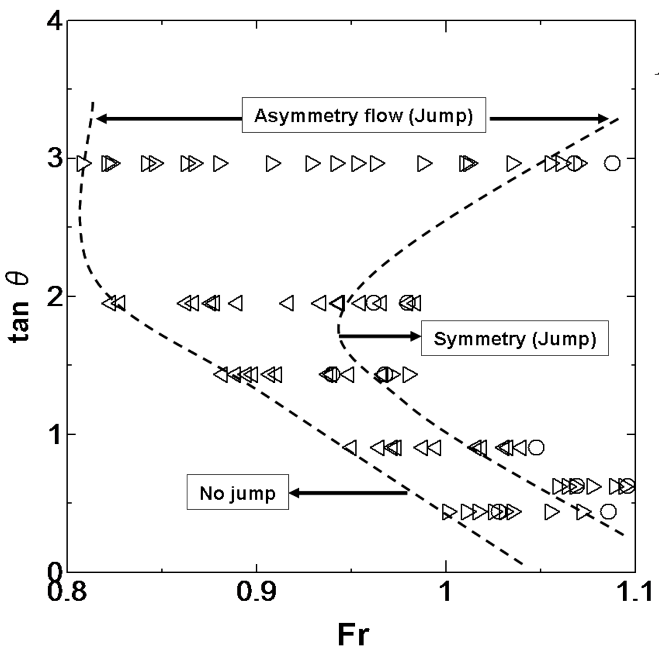
Fig. 3 Asymmetrical Flow Observation

IV. CONCLUSIONS

1. Regardless of the position of the initial pouring of blue dye, flow direction randomly goes to the right or left side of the downstream section of a narrow channel. The observation experiment proves Bernoulli's theorem: "that as the speed of a moving fluid increases, the pressure within that fluid decreases."
2. Symmetry occurs at Fr greater than 1.0. On the other hand, asymmetry of flow to the right or to the left direction is dependent on the angle inclination of the downstream section of the channel.

V. REFERENCE

1. Yamashita, K., Quimpo, M. Yamada, T. "Water Surface Profile Behavior in an Open-Channel Enlargement", unpublished.



$$Fr = \frac{V}{\sqrt{gh}}\ ;\ \tan\ \theta = (B-b)/2L$$

where:

V = Downstream surface velocity
h = Downstream water depth
B = Downstream width
b = Upstream width
L = Length of angle of inclination

LEGEND: (HYDRAULIC JUMP OCCURS)

○ :Symmetry
▷ :Asymmetry (right side)
◁ :Asymmetry (left side)

Fig. 4 Symmetry and Asymmetry Boundaries