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On the Resistance Coefficient by the Group of Column in the Open Channel

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ABSTRACT

The purpose of this study is examined the resistance coefficient of group of column. Therefore, the experiments were done. As the results, drag coefficient (C_D) changed the various values by the using velocity. Moreover, in case of group of column, each column increased the value of drag coefficient (C_D). It is thought that fish habitat evaluation and fell of trees can be calculating more accurately by using appropriate drag coefficient (C_D).

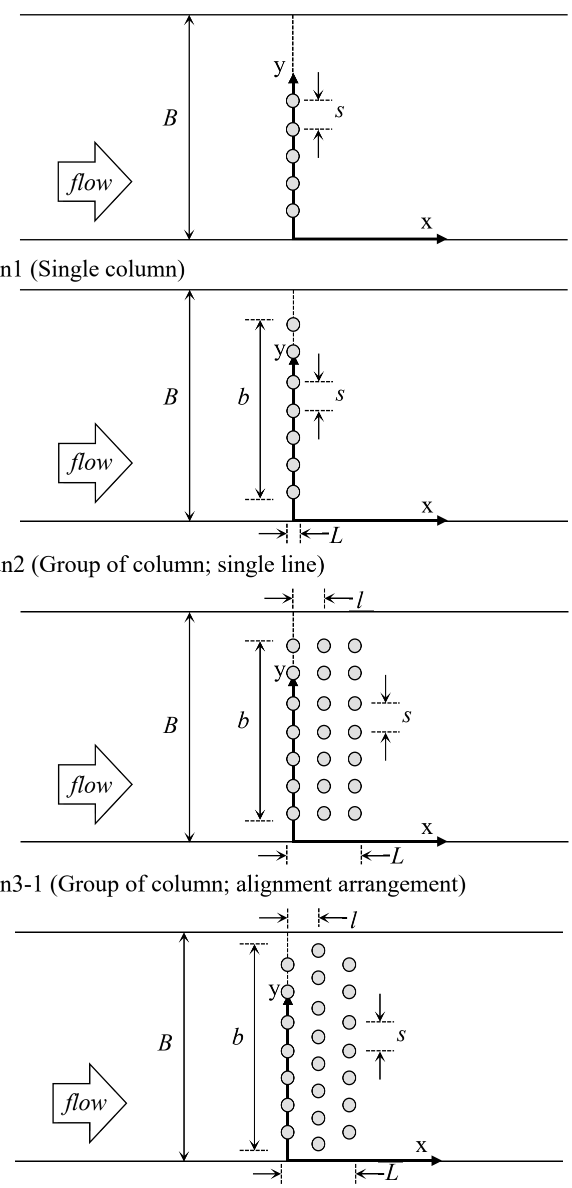
KEY WORDS: group of column drag coefficient, drag force, characteristics flow velocity, characteristics water depth, pile dikes, trees

INTRODUCTION

To examine fish habitat evaluation, management of trees and all that in the rivers, the forecasting calculation of river stream are implemented. On this occasion, drag coefficient (C_D) of pile dikes, trees, and all that are using approximately 1.0. In the anamnestic research, column is using in the similitude of tree, pile dike, and all that. Moreover, drag coefficient (C_D) of group of column equals drag coefficient (C_D) of single column that is approximately 1.0. On another front, value of its drag coefficient (C_D) is the result of a single column in the same flow velocity. However, the flor velocity distribution is formed in actual river stream. Therefore, drag coefficient (C_D) is guessed to be different depending on the positions, arrangements, density and all that of pile dikes, trees and all that. Additionally, there is a possibility that the value of drag coefficient (C_D) is different in a single column and the group of column. Moreover, drag force (F_{Dx}) is shown by using drag coefficient (C_D). When drag coefficient (C_D) is calculated, it is important to use appropriate the characteristics flow velocity (U) and the water depth (h). Eventually, this study aimed at using the suitable drag coefficient (C_D) for numerical analyses. At first, the part of this study is examined the drag coefficient (C_D) of group of column. Therefore, the experiments were done.

EXPERIMENTAL METHODS

The experiments were carried out by using a small open channel in the laboratory of Toyo University. Figure 1 shows the open channel used for the experiments. Width size of open channel; B is 0.8(m), total length of open channel is 10.8(m). Material of the column is stainless whose diameter is 0.01(m), and set up in the center of open channel. Table 1 shows the cases considered in the experiment.



a) Run1 (Single column)
b) Run2 (Group of column; single line)
c) Run3-1 (Group of column; alignment arrangement)
d) Run3-2 (Group of column; zigzag arrangement)
Fig. 1 Plain view of open channel for the experiments

Table 1. Cases considered in the experiments

Case	Quantity of flow Q(m^3/s)	Mean depth h_m(m)	Column diameter d(m)	Number of column T	Installation coordinate(m) / Line number / Arrangement	Interval in y direction s(m)	Interval in x direction l(m)	s/d l/d	Group of column		Densitiy λ
									Width b(m)	Length L(m)	
Run0		0.0705	-	none	-	-	-	-	-	-	-
Run1-1		0.0709			x=0, y=0.04						
Run1-2		0.0700			x=0, y=0.08						
Run1-3		0.0709			x=0, y=0.12						
Run1-4		0.0708			x=0, y=0.16						
Run1-5		0.0707		1	x=0, y=0.20	-	-		-	-	-
Run1-6		0.0707			x=0, y=0.24						
Run1-7	0.016	0.0707			x=0, y=0.28						
Run1-8		0.0707	0.01		x=0, y=0.32			4			
Run1-9		0.0706			x=0, y=0.36						
Run1-10		0.0705			x=0, y=0.40						
Run2		0.0731		19	single line	0.04	-		0.73	0.01	0.204
Run3-1		0.0729		57	alignment arrangement	0.04	0.04		0.73	0.09	0.068
Run3-2		0.0738		58	zigzag arrangement	0.04	0.04		0.77	0.09	0.066

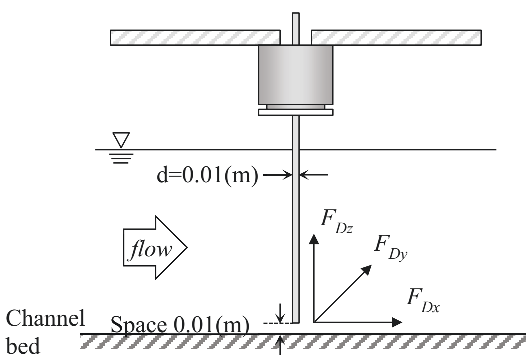


Fig. 2 Set up the multi-component load cell for measuring the drag force

Measurement of drag force

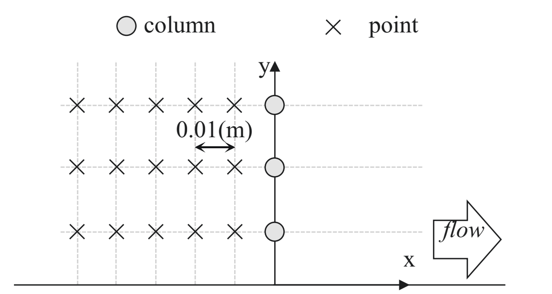
Figure 2 shows the set up the multi-component load cell. The multi component load cell was used to measure the drag force acting on each column. Drag force F_{Dx} is defined Eq. 1.

$$F_{Dx} = \frac{1}{2}\rho \cdot C_D \cdot A \cdot U^2 = \frac{1}{2}\rho \cdot C_D \cdot d \cdot h \cdot U^2 \tag{1}$$

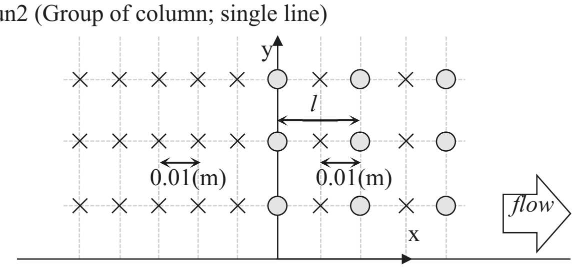
Here, ρ, water density (=1,000(kg/m^3)); C_D, drag coefficient; d, diameter of column; h, characteristics water depth; U, characteristics flow velocity.

Measurement of flow velocity and water depth

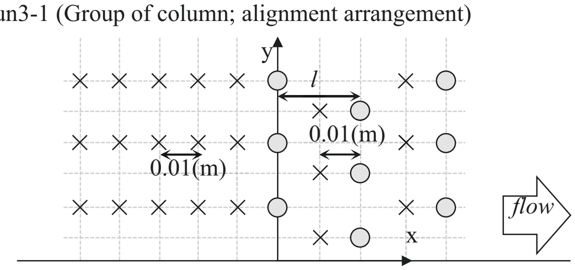
Figure 3 shows the measurement point of flow velocity and water depth. Flow velocity was measured by one-point method, two-point method and three-point method, because to decide the measurement point of the characteristics flow velocity (U).



a) Run2 (Group of column; single line)

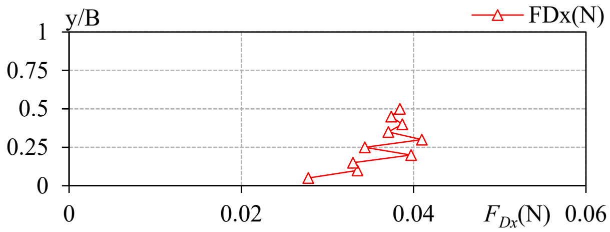


b) Run3-1 (Group of column; alignment arrangement)

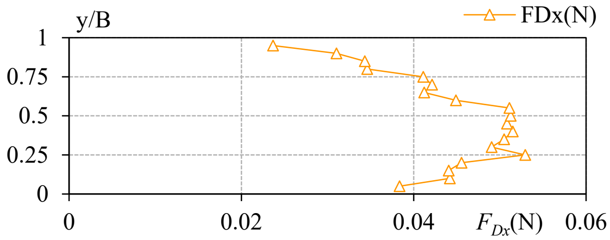


c) Run3-2 (Group of column; zigzag arrangement)

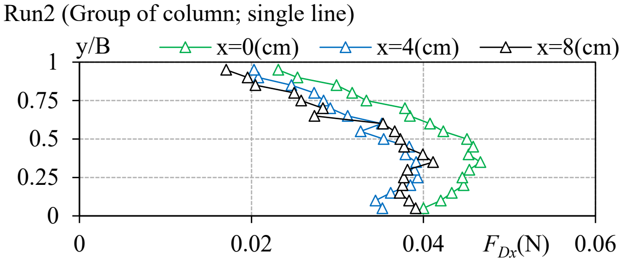
Fig. 3 Measurement point of flow velocity and water depth



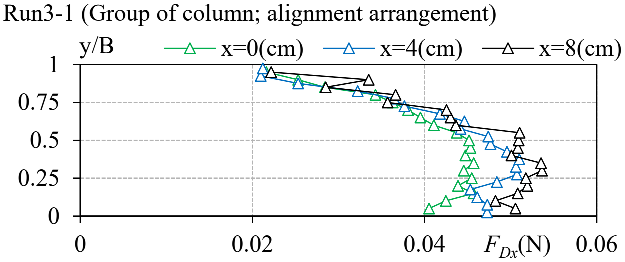
a) Run1 (Single column)



b) Run2 (Group of column; single line)



c) Run3-1 (Group of column; alignment arrangement)



d) Run3-2 (Group of column; zigzag arrangement)
Fig 4 Drag force distribution in transverse direction in each case

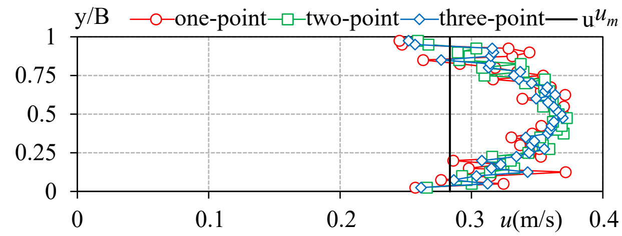
RESULTS OF EXPERIMENTS

Drag force

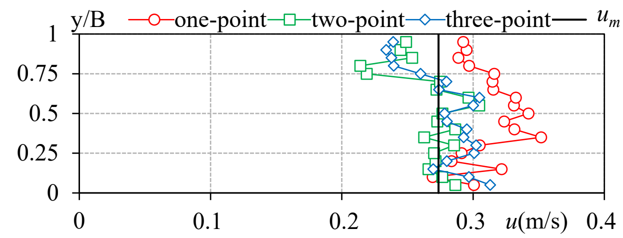
Figure 4 shows the drag force and flow velocity distribution in transverse direction in each case. Drag force was measured maximum value in the center of channel.

Flow velocity

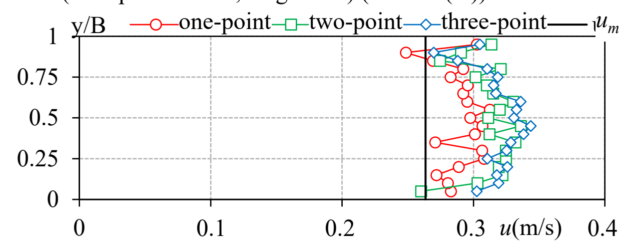
Figure 5 shows the flow velocity distribution in transverse direction in each case. Flow velocity was also measured maximum value in the center of channel. Moreover, the flow velocity value of one-point, two-point and three-point method was roughly corresponding. Figure 6 shows flow velocity in x direction in Run1. Flow velocity has decelerated just before the column. This flow velocity influences the drag force that acts on the column. Therefore, the characteristic flow velocity (U) was decided to the point of 0.01(m) upstream of the column in the one-point method. Characteristics water depth (h) was also similar point of flow velocity.



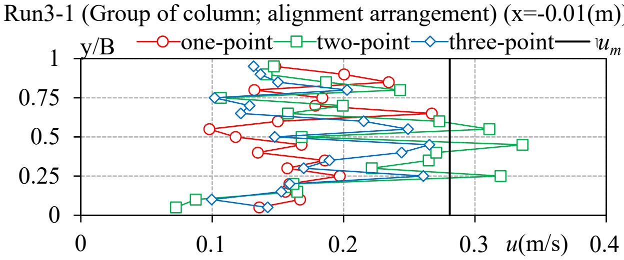
a) Run0 (none) (x=0(m))



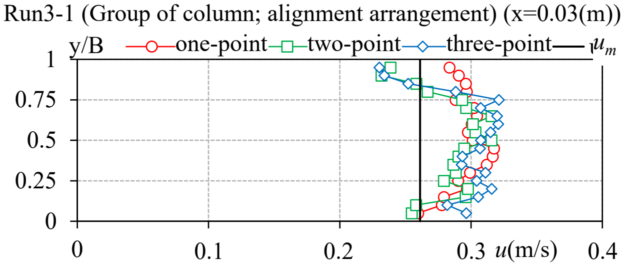
b) Run2 (Group of column; single line) (x=-0.01(m))



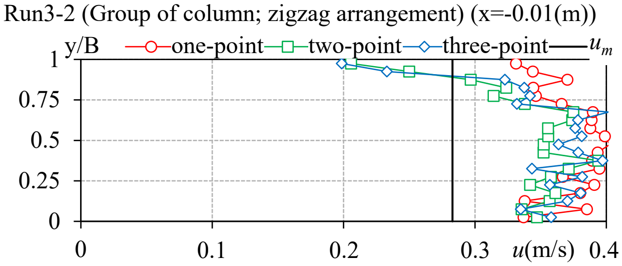
c) Run3-1 (Group of column; alignment arrangement) (x=-0.01(m))



d) Run3-1 (Group of column; alignment arrangement) (x=0.03(m))



e) Run3-2 (Group of column; zigzag arrangement) (x=-0.01(m))



e) Run3-2 (Group of column; zigzag arrangement) (x=0.03(m))
Fig. 5 Flow velocity distribution in transverse direction in each case

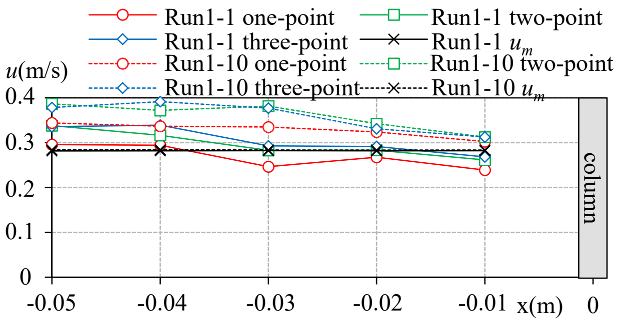


Fig 6 Flow velocity in x direction in Run1-1, Run1-10

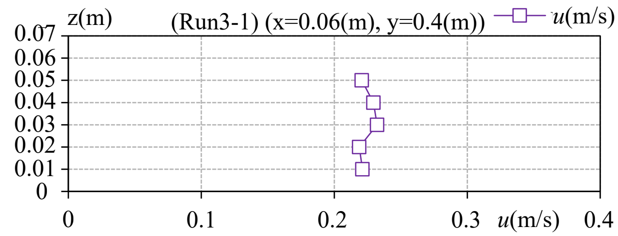


Fig 7 Flow velocity of water depth direction in group of column

Drag coefficient

Figure 8 shows the change of C_D at the measurement each point. C_D of single and upper of group of column was roughly 1.0 ~ 1.5. Additionally, C_D of Run3-2; zigzag arrangement was also 1.0 ~ 1.5. Therefore, C_D was roughly constant value of Run1, Run2 and Run3-2. However C_D whose Run3-1; alignment arrangement second and third column was not constant value. Figure 9 shows C_D–R_{ed} relationship of group of column. When R_{ed} decreases, C_D of group of column increases more than C_D of single column. Different value of CD shows resistance characteristics of group of column.

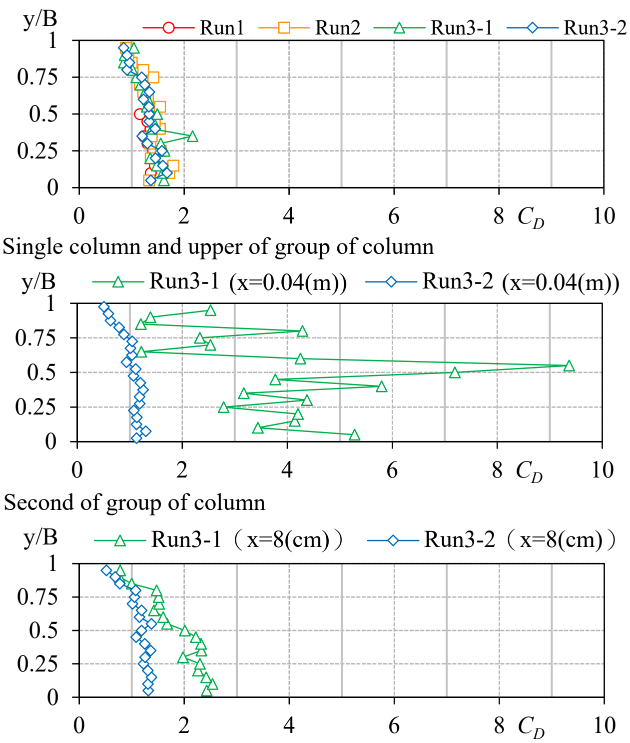


Fig 8 Change of C_D at the measurement each point

CONCLUSIONS

Especially, in group of column of alignment arrangement, each column increased the value of C_D. Therefore, CD might be underestimated possibly. These results and knowledge are useful information for fish habitat evaluation and fell of trees.

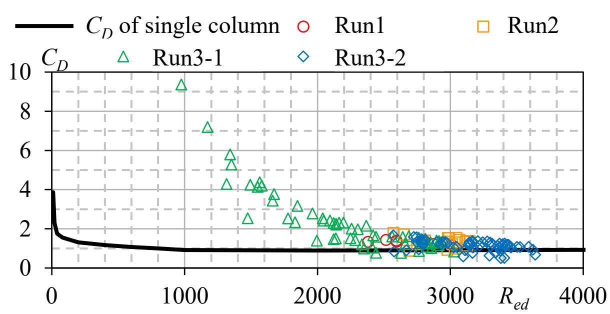


Fig 9 C_D-R_{ed} relationship of group of column

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