

Experimental Investigation of Height Preventing Structures for Vertical Wave Against Flow in Open Channel

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Abstract: When flow: flow through channel because of sop preventing shapes some Boundary layer will formed of initial stage of flow Because of separation stream lines vortex: phenomenon would be appeared and Because of overlapping of vortex flow to each other (and because of some prevention through flow) some: surface waves at: vertical direction (with 90 degree: to flow direction) will have been created experimentally Recent waves is known of cross sectional waves. These type pressure waves have been observed at under pressure flow. (Gas and liquid). At this Research at existence of Dams (prevention) at flow at laboratory flume with length equal to $0.6\text{m} \times 0.72\text{m} \times 0.62\text{m}$ have been created as Submerge situation formation of vertical waves against. Basic flow and changing the process of wave Domain depend on Decreasing of prevention Heights were been studied scientifically. Preventing at flow path, are wooden elliptical pier (with Diameter equal to 25) at Different arrangement (3 zigzag algorithms and 3 parallel algorithms). With different distance on Plexiglas surface has been setup at bottom of flume. At first experiment of submerged. Condition elevation of preventing structure have been evaluated (with flow Depth at canal and time of formation maximum Rang of wave Domain) and Type of unnumbered maximum Ranged. Preventing Height would been driver. At each Test with decline at flow Depth at flow (at fixed Condition of Submerged structure process of oscillating and formation at $n=1$, $n=2$ have been started from Minimum Rate and increased gradually and suddenly fall down. At gradual decrease situation about 1cm at each step and Increasing Submerged Ration, It has been observed that Maximum Range of Domain of waves has been decreased occasionally.

Key words: *Vertical wave against flow · Submerge flow Ratio · Domain of wave · Open channel · Preventing structures.*

INTRODUCTION

At open channel flow Condition many prevention structure have been existence at flow path such as Bridge, offshore structure or plant cover. Because of this type of block at flow path, flow velocity will go to zero value at Boundary, velocity Gradient make cause shear stress will been created normally Section of flow which have been influenced by shear stress were called Boundary layer. After development of Boundary layer, Because of pressure Gradient and shear on the boundary layer more slowly to be fixed and separator phenomenon will appear. At Down stream some divided stream line may cause that wake and vortex will been happened At Figure [1] schematic formation of flow around bridge pier will appear.

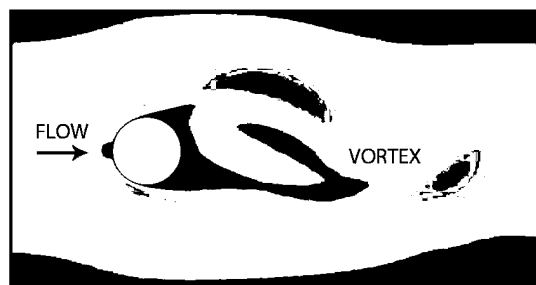


Fig. 1: Schematic form of flow around bridge

First study about vertex formation have been studied at Gas Condition: struohal, 1878 [1] figured at noise from wires at wind blowing have direct relationship with wire Diameter. another studies about Gas fluid had been done by Fitz-Hugh, 1973 [2], Zukauskas and Katinas, 1980 [3]

Belvins, 1985 [4], Weaver *et al.* 1986 [5] Ziada *et al.* 1989 [6] and Hamakawa *et al.* 2001 [7]. There are few reseaches on the vortex shedding and the related phenomena, when water is the medium. First study is about wave's production at open channel Crasse, 1939 [8]. Clay and Tison, 1968 [9] had studied about some wave distribution come from bridge pier. Falvey, 1980 [10] has investigated the wave that produced by the bridge's pier. Zima and Ackerman, 2002 [11] proposed a new formula in order simulating maximum length of waves as none dimensional (A/L) equation. Assi *et al.* 2006 [12] have studied about wave between two- cylindrical blocks at open channel. Ghomeshi *et al.* 2007 [13] have studied reason of some vertical wave production at flow channel and a new formula non dimensional equation and calculating struwahl number have been proposed.

About possibility of formation and Investigation of vertical wave at flow conditional. When flow passed and some blocks existence at flow path didn't study yet.

MATERIALS AND METHODS

At this study, a laboratory flume with dimension (6m×0.72m×0.6m) have been used bottom and side wall of flume is laboratory glass. In order to use wooden spherule pier at flow, bottom of flume were covered with Plexiglas plate with 183cm × 71.5cm and thickness about 10mm. Surface of Plax glass plate have been punch criss-cross and all holes have been located like series and distance between of them, is equal 3cm. block structure have been located at flow path which its diameter is about 25mm and Initial Height is 35cm. these structures have been tightened at 14 rows and distance of T, P. (T is distance of block serially and P is distance of them at vertical direction.) at two parallel and zigzag algorithm. During the experiments, flow was constant and was regulated at 10lit/s. flow after stilling reservoir come

through channel, Depth of flow will control with outlet gate. At each test, Height of gate would be changed step (with 5mm steps) and flow depth will change normally.

At this research ,firstly ,in order to find maximum domain of waves length at (type n=1,n=2) and depth of flow with 35cm block structures ,will located at non-submerged condition ,and flow rate is at none of 10. 6experiments with different algorithm were run. At these tests, with decreasing flow depth. (As mentioned before), domain of waves were recorded perfectly (at n=1, n=2 condition). In order to read wave domain, because of Maximum movement of row.(120mm) and distance between columns is 60mm, respectively at 2,4 sections, with using ruler will measured. At Table (1). A summery of all experiments at step (1) at formation of waves length (maximum) (at n=1, n=2) have been showed. Colum number (1) Discharge and Distance of T, P had been presented. At column (4) block arrangement were been demonstrated. column (5) and column (6) respectively is flume width and aggregation blocks (arrange of two continues rows). column (7) and (8) show gate depth and height of block structure. (With respect). At column (9) type of waves and maximum domain of wave and Coordinated depth wave shown at column (10) and (11) (with respect). None dimensional equation of wave domain has been presented at column (12). (Column 10 divided to column 9)

At step 2, for submerged of blocks, initial depth of structure was chosen. Shortly and moreover, height of blocks at the first test, for each experiment, have been considered at average depth of last experiment (before maximum depth of non-submerged were driven at n=1).

With variable of flow depths at different algorithm and limitation of blocks numbers (120). It's impossible to test at one time. Thus, at first fun, (at parallel algorithm) (P=90, T=60) total elevation of structure are equal to 18cm and through experiment elevation were shorten 1cm at

Table 1: Description of experiments

Number of Row	1 Q (lit/s)	2 T (mm)	3 P (mm)	4 Arrangement	5 b (mm)	6 N	7 h_{water} (mm)	8 H (mm)	9 n	10 A_{ave} (mm)	11 h_{ave} (mm)	12 A_{ave}/h_{ave}
1	10	90	60	In-line	725	8	175	350	1	20.5	168.75	0.121
2	10	90	60	In-line	725	8	170	350	2	23	111	0.207
3	10	120	60	staggered	725	6	165	350	1	18.5	164.25	0.113
4	10	120	60	staggered	725	6	160	350	2	25	108	0.231
5	10	120	120	In-line	725	6	155	350	1	21	130.75	0.161
6	10	120	120	In-line	725	6	150	350	2	22	82.25	0.267
8	10	120	120	staggered	725	6	145	350	1	15.5	135	0.115
9	10	120	120	staggered	725	6	145	350	2	21	89	0.236
10	10	180	60	staggered	725	4	145	350	1	19.50	135.25	0.144
11	10	180	60	staggered	725	4	145	350	2	23.50	88.25	0.266
12	10	90	120	In-line	725	8	145	350	1	22.5	134.75	0.167
13	10	90	120	In-line	725	8	145	350	2	19.75	85.13	0.232

Table 2: Total description of experiment at step (2) at maximum elevation of blocks.

Number of Row	1 Q (lit/s)	2 T (mm)	3 P (mm)	4 Arrangement	5 b (mm)	6 N	7 h_{well} (mm)	8 H (mm)	9 n	10 A_{ave} (mm)	11 h_{ave} (mm)	12 A_{ave}/h_{ave}	13 S
1	10	90	60	In-line	725	8	140	180	1	18	165.5	0.109	0.00
2	10	90	60	In-line	725	8	70	110	2	20	96.00	0.208	0.00
3	10	120	60	staggered	725	6	135	170	1	17.500	158.75	0.110	0.00
4	10	120	60	staggered	725	6	80	110	2	20.00	108.00	0.185	0.00
5	10	120	120	In-line	725	6	100	140	1	19	127.75	0.149	0.00
6	10	120	120	In-line	725	6	55	90	2	21.5	81.5	0.264	0.00
7	10	120	120	staggered	725	6	110	140	1	13.5	137	0.141	0.00
8	10	120	120	staggered	725	6	60	90	2	19.25	87.875	0.219	0.00
9	10	180	60	staggered	725	4	110	140	1	17.000	136.00	0.125	0.00
10	10	180	60	staggered	725	4	55	90	2	17.500	81.75	0.214	0.00
11	10	90	120	In-line	725	8	105	140	1	19	135.25	0.140	0.00
12	10	90	120	In-line	725	8	50	80	2	18.25	83.125	0.220	.038

Table 3: Description of total experiment at minimum elevation of structures.

Number of Row	1 Q (lit/s)	2 T (mm)	3 P (mm)	4 Arrangement	5 b (mm)	6 N	7 h_{well} (mm)	8 H (mm)	9 n	10 A_{ave} (mm)	11 h_{ave} (mm)	12 A_{ave}/h_{ave}	13 S
1	10	90	60	In-line	725	8	80	60	1	2.00	104.50	0.019	0.462
2	10	90	60	In-line	725	8	40	40	2	5.50	64.25	0.086	0.377
3	10	120	60	staggered	725	6	90	70	1	2.50	113.75	0.022	0.385
4	10	120	60	staggered	725	6	40	30	2	2.00	64.50	0.031	0.535
5	10	120	120	In-line	725	6	70	60	1	1.75	92.625	0.019	0.352
6	10	120	120	In-line	725	6	40	30	2	2.25	63.625	0.035	0.528
7	10	120	120	staggered	725	6	75	70	1	3	98.75	0.030	0.291
8	10	120	120	staggered	725	6	40	40	2	2.25	64.625	0.035	0.381
9	10	180	60	staggered	725	4	90	80	1	2.000	113.50	0.018	0.295
10	10	180	60	staggered	725	4	35	40	2	1.000	60.50	0.017	0.339
11	10	90	120	In-line	725	8	60	50	1	2.25	87.625	0.026	0.429
12	10	90	120	In-line	725	8	35	30	2	2	64	0.031	0.531

each step. This process continued till all wave domain were disappeared totally and for (n=2) total runs are equal to 82 runs of total experiment at step (2) (submerged structure) for maximum. Elevation at wave formation. At algorithm n=1, n=2 have been shown at Table (2): in which discharge at column (1) distance of T, P at column (2),(3), type of algorithm at column (4) have been presented. At column (5), column (6): flow width and aggregation of blocks have been

Illustrated Maximum wave domain and flew depths at flume were shown at column (9), column (10) and column (11). (Respectively)

Finally, none dimensional equation of wave domain was presented at column (12).

A summary of total experiment at step (2) (submerging condition), at time of minimum elevation of wave formation have been driven at Table(3), all

parameters of recent table is like Table (2), expect column(9), which shown minimum elevation of blocks at submerged condition in which wave of (n=1, n=2) have been possible to form and with increasing more elevation, wave didn't form.

Observation: At around environment many different types of waves are exist such as Mechanic wave, sound wave or Electromagnetic waves. At all environments waves distribute because of compressing of environment [2]. Shape changing and wave movement wave divided two sections: One longitude of diffusion and cross sectional diffusion longitude of wave may cause particle movement happened at direction of wave but cross sectional wave could cause movement wave occur at vertical direction of particle movement, at the type of wave couldn't move at particle directions subsequently.



Fig. 2: View of block structure algorithm at step1 and2

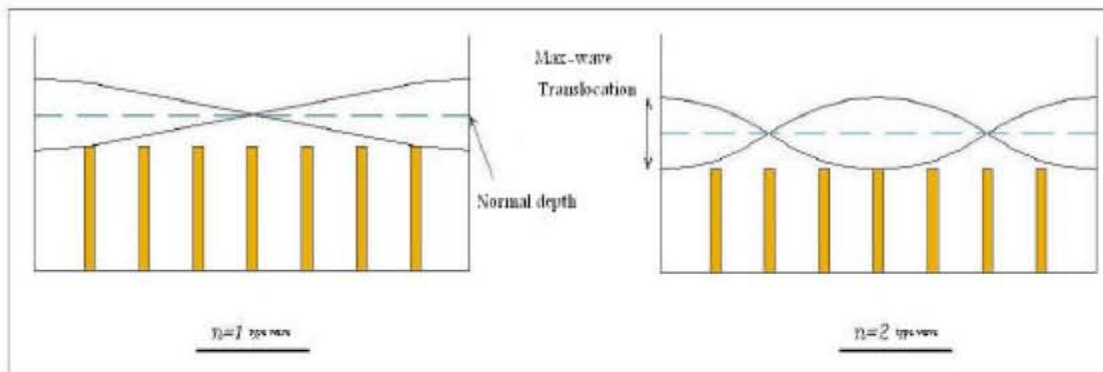


Fig. 3: Wave type of n=1, n=2 at laboratory flume

[2]. Width wave (at the research) is of cross sectional movements. Length of vertical wave is direct relation with flume width (at maximum range of wave domain) and because of the behavior, this type of wave are been distinguishable. Relational length of wave and flume width is as following ($\tilde{\epsilon}$: wave length, b : flume width)

Besides wave type (1) at submerging condition is

$$\begin{aligned} \lambda_{n=1} &= 144 \text{ cm} \\ \lambda_{n=2} &= 72 \text{ cm} \end{aligned} \quad \xrightarrow{b=72 \text{ cm}} \quad \begin{aligned} \lambda &= 2b \rightarrow n=1 \\ \lambda &= 1b \rightarrow n=2 \end{aligned}$$

At each of 6 algorithm ,after investigation, all block structures were been submerged with gradual decreasing of depth, initial depth of wave type n=1 with domain start with decreasing more depth wave domain increase gradually until to maximum level and suddenly decreased.

With considering depth decreasing at 2 or 3 depths after exiting of block structure, were continued. Thus at initial experiment (test), at some runs maximum domain of wave have been occurred after block exiting. (Therefore at initial experiment wave type of n=1 were been observed experimentally)

At next runs, with decreasing height of structures (almost about 1cm) decreasing process of wave type of n=1 is seen Morley and gradually were move to minimum level and disappeared.

Fluctuation of water Surface decreased to zero and wave type of n=2 start of course ,at experiment with more number of blocks, after reaching domain of wave (type n=1),suddenly wave type .(n=2) were been appeared with considering all above description ,at initial experiment for each test with decreasing of water depth ; firstly wave type n=1 were been seen and steeply, with decreasing depth of structures , wave (n=1) were disappeared.

With cutting more elevation of structures, domain of n=2 firstly increased. Then it will be decreased and finally at specific elevation of block height, at each experiment, wave domain (at type n=2) have been disappeared perfectly.

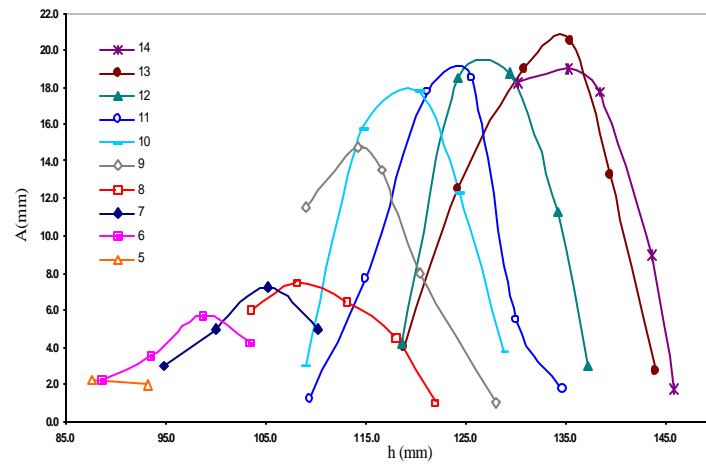


Fig. 4: Changing process of wave domain $n=1$ against flow depth changing at different elevation of block structures

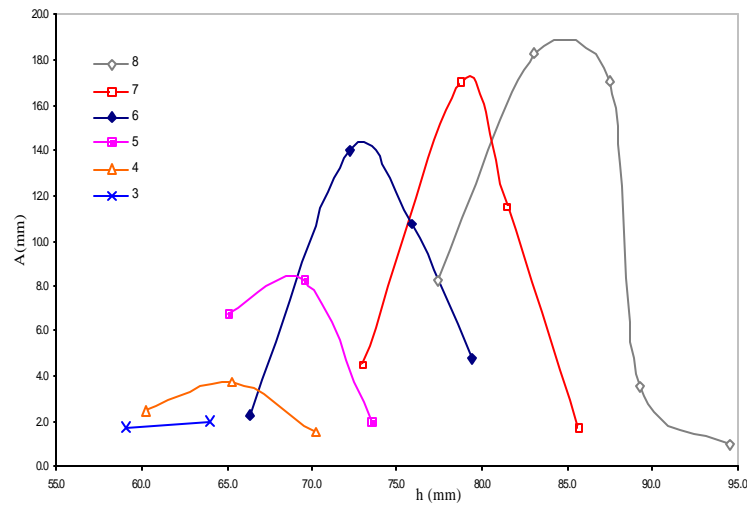


Fig. 5: Changing process domain of wave ($n=2$) against flow depth changing at different elevation of block structures

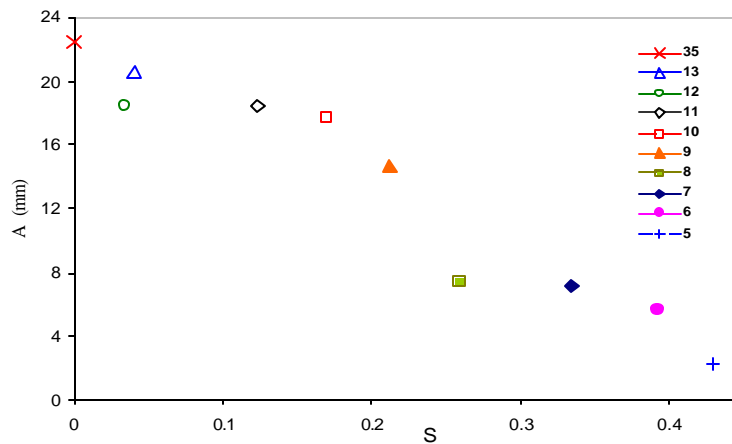


Fig. 6: Changing maximum domain of wave type $N=1$, against submerging ratio at different elevation of block structures

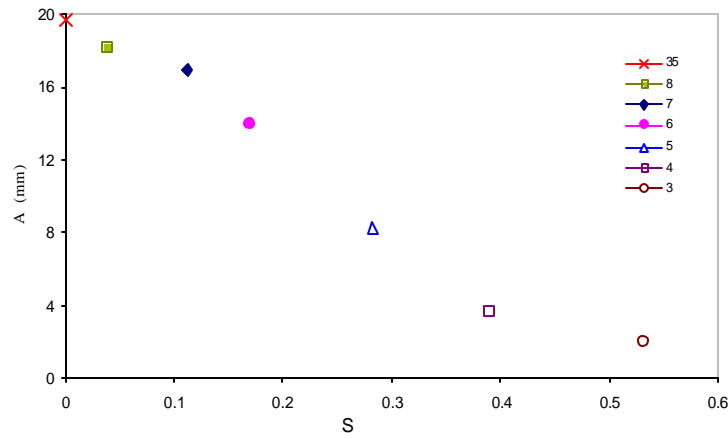


Fig. 7: Changing maximum domain of wave type N=2, against submerging ratio at different elevation of block structures

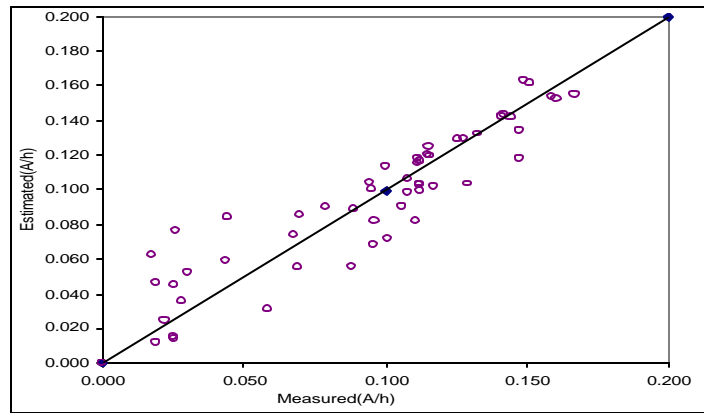


Fig. 8: Comparison between measured $\left(\frac{A}{h2}\right)$ and calculating $\left(\frac{A}{h2}\right)$ for wave

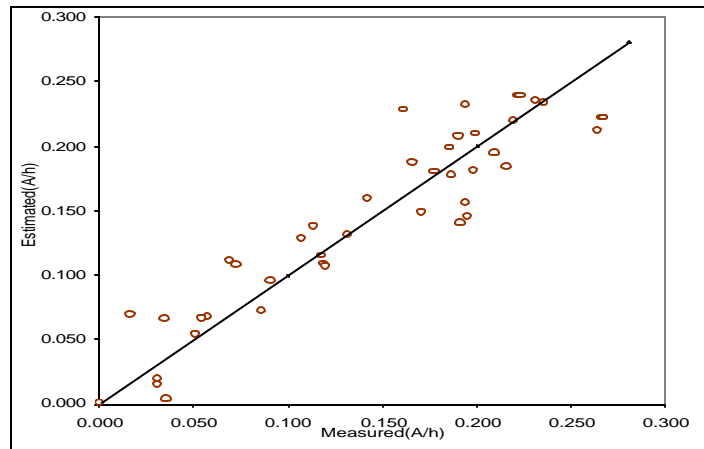


Fig. 9: Comparison between measured $\left(\frac{A}{h2}\right)$ and calculating $\left(\frac{A}{h2}\right)$ for wave (n=2)

Table 4: Summary of experiment at step 2 for row arrangement (T=90, P=120)

Number of Row	1 Q (lit/s)	2 T (mm)	3 P (mm)	4 Arrangement	5 b (mm)	6 N	7 h_{well} (mm)	8 H (mm)	9 n	10 A_{ave} (mm)	11 h_{ave} (mm)	12 A_{ave}/h_{ave}	13 S
1	10	90	120	In-line	725	8	105	140	1	19	135.25	0.140	0.000
2	10	90	120	In-line	725	8	105	130	1	20.5	135.5	0.151	0.041
3	10	90	120	In-line	725	8	100	120	1	18.75	129.375	0.145	0.072
4	10	90	120	In-line	725	8	100	110	1	18.5	125.5	0.147	0.124
5	10	90	120	In-line	725	8	95	100	1	17.75	120.375	0.147	0.169
6	10	90	120	In-line	725	8	80	80	1	7.5	108	0.069	0.259
7	10	90	120	In-line	725	8	50	80	2	18.25	83.125	0.220	0.038
8	10	90	120	In-line	725	8	75	70	1	7.25	105.125	0.069	0.334
9	10	90	120	In-line	725	8	45	70	2	17	78.75	0.216	0.111
10	10	90	120	In-line	725	8	70	60	1	5.75	98.625	0.058	0.392
11	10	90	120	In-line	725	8	40	60	2	14	72.25	0.194	0.170
12	10	90	120	In-line	725	8	60	50	1	2.25	87.625	0.026	0.429
13	10	90	120	In-line	725	8	40	50	2	8.25	69.625	0.118	0.282
14	10	90	120	In-line	725	8	35	40	2	3.75	65.375	0.057	0.388
15	10	90	120	In-line	725	8	35	30	2	2	64	0.031	0.531

At Table (4), summary of experiment at row arrangement of T=90, P=120, for investigating of wave domain at N=1 and N=2 were been presented. All parameters are like table 2, 3 but Column(14).

Submerging ratio (average flow depth minus block height average flow depth) have been calculated, (for n=1, n=2)

At Figure (4, 5), changing domain of wave type (n=1, n=2) against depth at flow at different elevation of structures (T=90, P=120) have been shown besides. At Figure (6, 7) maximum changing domain of wave type N=1, N=2, against submerging ratio of row algorithm were been shown (P=120, T=90)

At this study, withusingdimensional analysis, relation between maximum domain of wave at (n=1, n=2) and other effecting factors have been driven as below.

$$\phi(A_1, A_2, h, T, P, D, N, n, B, S) = 0$$

With using Buckingham theory this equation was been lurch:

$$\phi\left(\frac{A}{h_1}, \frac{A}{h_2}, \frac{T}{D}, \frac{P}{D}, Nr, n, \frac{D}{h}, S\right) = 0$$

At These Functions:

$\left(\frac{A}{h_2}\right)$: Maximum relative domain of submerging block structures.

$\left(\frac{A}{h_1}\right)$: Maximum relative wave domain at non submerging condition.

Nr: Number of row

S: Submerging Ratio

$\left(\frac{D}{h}\right)$: block structures diameter per block elevation.

With study of these parameters, it has been figure out a logical relative between $\left(\frac{A}{h_2}\right), (S), \left(\frac{A}{h_1}\right)$ are exist.

Therefore, with using SPSS software Equation of 1, 2 for relative maximum domain of wave at submerging condition were driven as below.

$$(A/h)_2 = 1.427 \times ((A/h)_1 \wedge .875) \times (1.583 - \exp(S)) \quad (1)$$

$$(A/h)_2 = -.0687 + (.492 \times \exp(-(A/h)_1)) + (.533 \times \exp(-S)) \quad (2)$$

CONCLUSION

- At submerging condition; Maximum wave domain at (n=1, n=2) and Non dimensional domain of recent wave is less than none submerging of block structures.
- At submerging of structures with gradual decreasing of structure's Depth maximum range o wave domain at (N=1, N=2) were decreased deduction ally.

- At submerging condition of structures, with declining of decreased completely.
- At submerging condition of preventing structures depth and flow depth and Increasing submerging Ratio, Maximum domain of waves (at non dimensional relation) were decreased normally.
- With using dimensional analysis and using SPSS software logical equation for estimating of maximum wave domain at open channel were deducted.

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