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Analysis of Knock-Down Weir Model Shear Stability against Wall Rudeness based on Soil Type Variation

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Abstract An increase in seawater that experiences high tides can cause tidal flooding. Tidal flooding in the Semarang area requires quick and precise handling, so an emergency dam is needed to deal with seawater overflow or tidal flooding. This study discusses the Knock-Down weir as a practical emergency weir. This study also aims to test the shear stability of the Knock-Down weir model against wall roughness based on variations in soil types, namely: masonry, gravel, sand, and clay. The Knock-Down weirs can be arranged vertically, horizontally, and as needed. The method used is descriptive qualitative. There are four forms of Knock-Down weir arrangement and the safest against wall roughness in various types of soil is prioritized. They are (1) L shape filled with sand + water, (2) Form I filled with sand + water, (3) Form I filled with water, and (4) Shape L filled with water. The results of the research on the safest Knock-Down weirs on shear stability are (1) L shape filled with sand + water, at a height of 1m weirs, shear stability against masonry (3,13), shear stability of gravel (2.09), shear stability to sand (1.67), shear stability against clay (1.25).

Keywords Shear Stability, Knock-Down Weir, Soil Type

1. Introduction

1.1. Background

Global warming followed by climate change has become a new disaster, and one of the impacts of climate change is rising seawater to the ground [1] which can result in tidal flooding [2]. In the northern region of Java Island, it is prone to flooding due to the condition of Java Island's sloping topography [3][4]. Rob occurs when high tide inundates the land that has a sea-level height at the time of the highest sea level [5][6].

The North Semarang area is one of the sub-districts in Semarang City. This area emerged as a trade and industrial area, thus tidal flooding [5][7], causing traffic jams and at some points causing road damage. Tidal flooding in the North Semarang City area has been going on for a long time predicted to continue to expand if not handled well [5]. The flood problem in Semarang City is very complex, so it cannot be solved by one party alone. Therefore, the government and the community must work together to overcome them [8-11].

Based on the above background, it is necessary to control flooding with fast and appropriate handling to withstand the overflow of tidal water, reduce the rate of sedimentation carried by water. Several studies have discussed water flow control, including using intelligent control [12-14]. One of the tidal flood controllers is using an emergency dam.

1.2. Research Purposes

This study discusses practical emergency weirs, namely emergency weirs that can be arranged vertically, horizontally and can be arranged as needed, namely Knock-Down weirs[15][16]. This study aims to analyze the shear stability of the Knock-Down weirs against wall roughness based on variations in soil types, namely: masonry, gravel, sand and clay.

This study uses a qualitative descriptive method. In the analysis of the shear stability of the Knock-Down weir, 9 units are arranged and assembled in a form: (1) L shape filled with sand + water; (2) Form I filled with sand + water; (3) Form I filled with water; (4) Shape L filled with water.

The purpose of this study is to focus on shear stability analysis intended to determine the ability of the weir body in the installation arrangement and the height of the material content of the weir body greatly affects the shearing lift.

From the 4 Barrier Knock-Down weir arrangements, one of the most suitable and safe forms for shear stability will be obtained with variations in soil type conditions: masonry, gravel, sand, and clay.

1.3. The Shape of the Knock-Down Weir Structure

The shape of the Knock-Down weir arrangement has dimensions of b x l x h = 70 cm x 70 cm x 50 cm, with nine units and the structure of various forms, the form of 1 filled with sand + water can be seen in Figure 1; the form of 2 containing sand + water can be seen in Figure 2; the form of 3 containing water can be seen in Figure 3; the form of 4 filled water can be seen in Figure 4. The model of the vertical installation section can be seen in Figure 5; the horizontal one of the installations can be seen in Figure 6.

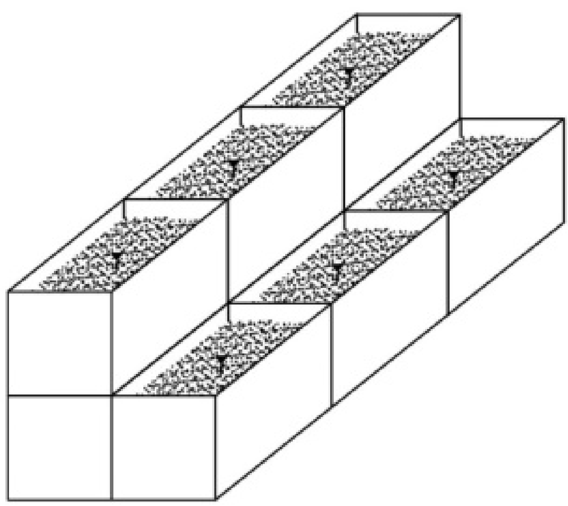

Figure 1. Form 1

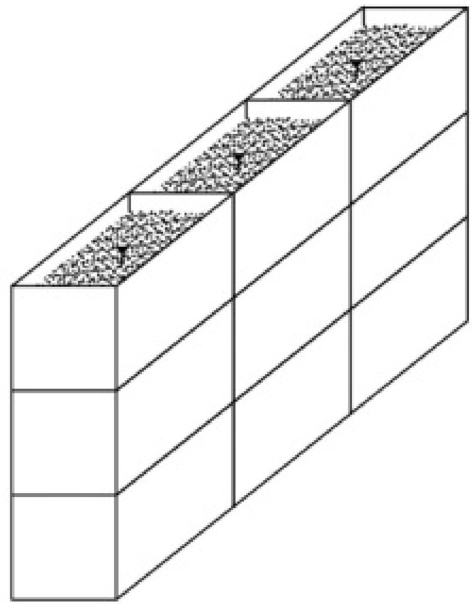

Figure 2. Form 2

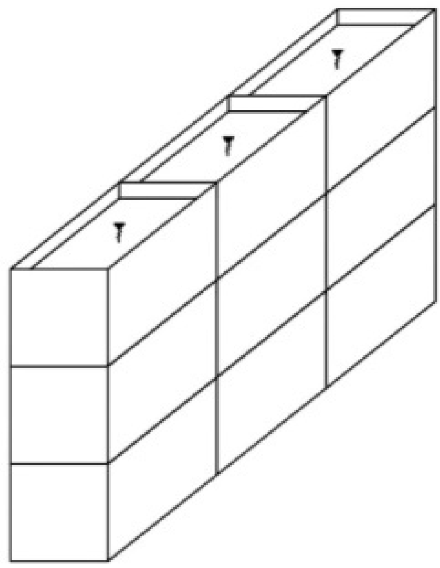

Figure 3. Form 3

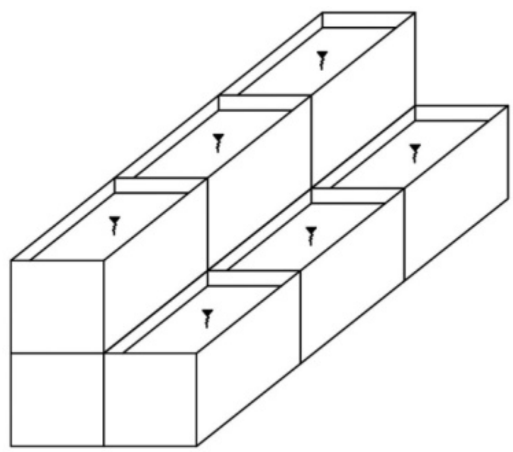

Figure 4. Form 4

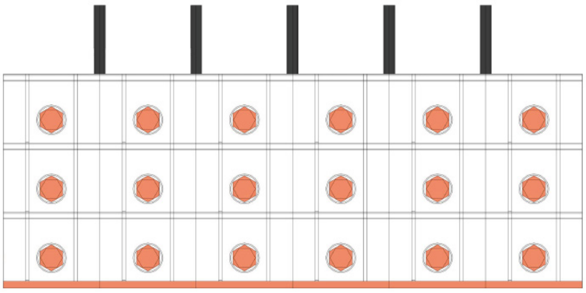

Figure 5. Vertical cross section

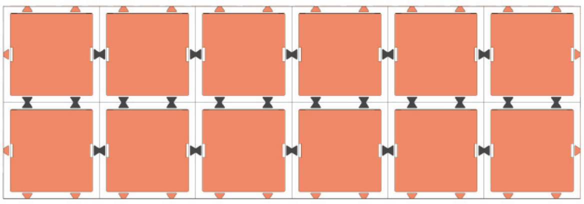

Figure 6. Horizontal cross section

2. Literature Review

2.1. Vertical Force Due to Weight of the Weir it Self

Weight of weir is calculated based on building dimension and type of material used [17]. Moment which occurs is all weight of force multiplied with distance to view point (weak point).

Formula:

$$G = V \times \gamma \quad (1)$$

Where V: Volume (cm^3), ɣ: Material Density (g/cm^3)

2.2. Horizontal Force Which is the Hydrostatic Force

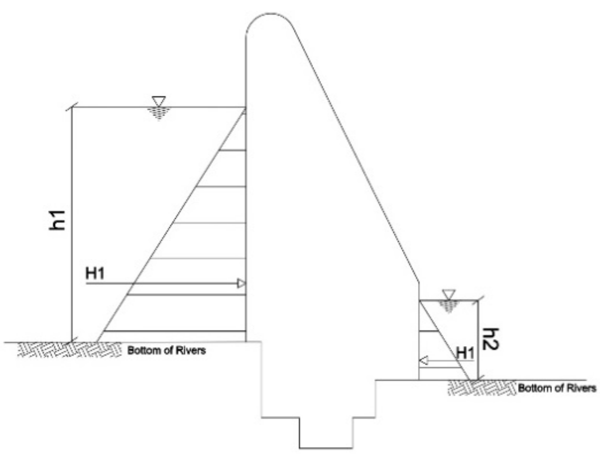

Figure 7. Schema of hydrostatic force on a weir

It is the force acting through the center of gravity of the cross section or the force acting from both weir surfaces, the upstream and downstream. The horizontal component Wh and the component Wv of the hydrostatic force are the force acting on the vertical projection of the surface of the weir. The schema of the hydrostatic force on the weir can be seen in Figure 7, the magnitude of which for each unit width is [6][11].

Formula:

$$H = [\tfrac{1}{2} \times \gamma_w \times h^2] \quad (2)$$

Where ɣw: Specific gravity of water (g/cm^3), h_1: Upstream water depth (cm), h_2: Downstream water depth (cm).

2.3. Stability against Overturning

Stability against overturning is determined from the weakest point of the weir, then from the point the working forces are calculated that overturning can be predicted. Meanwhile, the forces that hold it from the overturning include the weight of the building itself and also the hydrostatic force which is opposite to the force itself where it may cause the overturning. Thus, the examination of the overturning must meet the requirements [8]. The Estimated value of coefficient of friction can be seen in Table 1, safety factor for shear stability can be seen in Table 2, for the values of n, e, w, d and b (original soil in the field) can be seen in Table 3.

Formula:

$$SS = \frac{f.\sum V}{\sum H} > 1,2 \quad (3)$$

Where SF: safety factor, $\sum M_t$: number of holding moment (ton meter), $\sum M_g$: number of overturning moment (ton meter)

Table 1. Coefficient of Friction

Material	F
Pair of stones on masonry	0,60 – 0,75
Good quality hard stone	0,75
Gravel	0,50
Sand	0,40
Clay	0,30

Source [18][19]

Table 2. General Safety Factor (SS)[20][21]

Types of Failure	Types of Foundation	SF
Shearing	Earth work, weir work, backfilling work etc.	1,2-1,6
Shearing	Construction of retaining wall	1,5-2,0
Shearing	Retaining wall,	1,2-1,6 1,2-1,5
Shearing	Coffer dam, temporary supported excavations	2-3 1,7-2,5 1,7-2,5
Permeation	Foot plate foundation	3-5

Table 3. Values of n,e,w and ɤd for Original Land of Field [20][21]

Types of soil	n (%)	e	w (%)	ɤ d (g/cm^3)	ɤb (g/cm^3)
Uniform sand, not solid	46	0,85	32	1,43	1,89
Uniform sand, solid	34	0,51	19	1,75	2,09
Mixed grained sand, not solid	40	0,67	25	1,59	1,99
Mixed grained sand, solid	30	0,43	16	1,86	2,16
Soft clay, slightly organic	66	1,90	70	-	1,58
Soft clay, very organic	75	3,0	110	-	1,43

3. Research Method

The method used is quantitative by testing the so it can be used in the field. The analysis technique begins with collecting primary data including field observation and hydraulic data, but secondary data are obtained from previous analyses and literature reviews. The research flow chart can be seen in Figure 8.

3.1. Methodology Flow / Research Flow

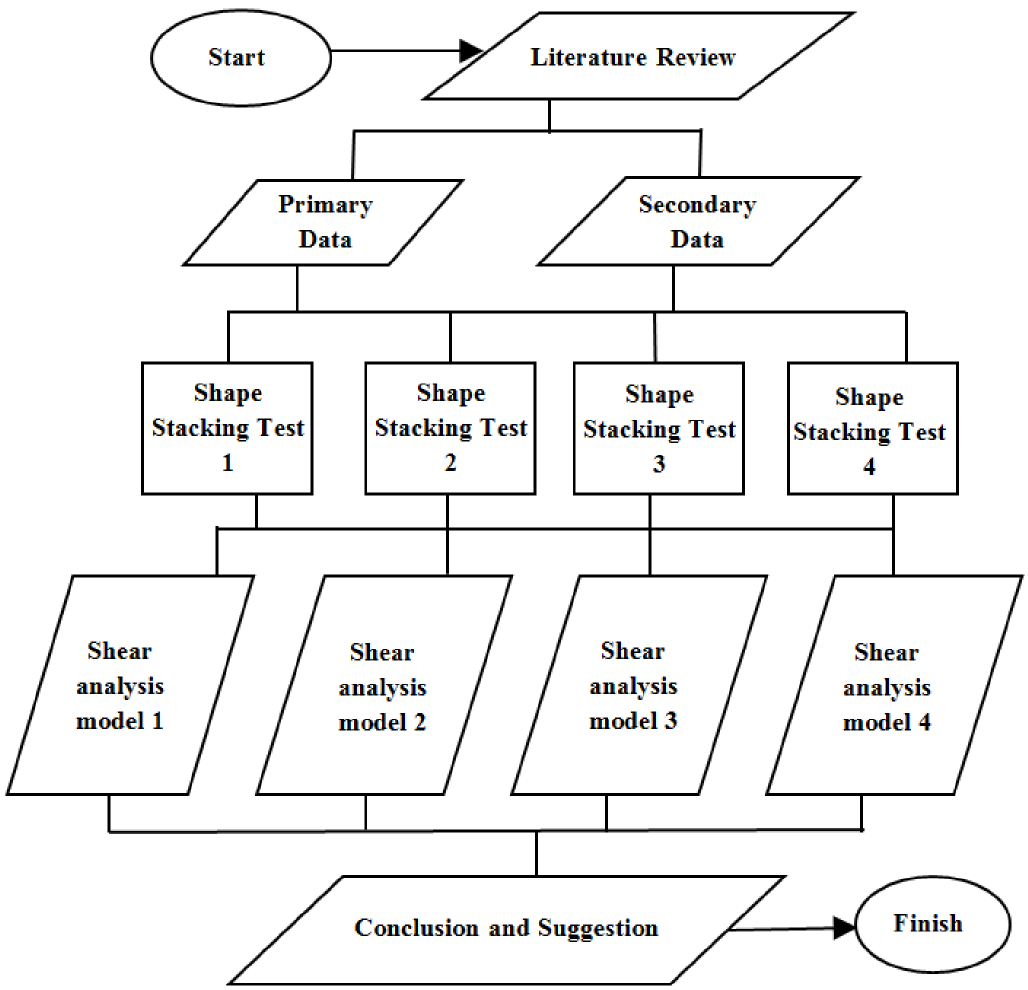

Figure 8. Research Flow

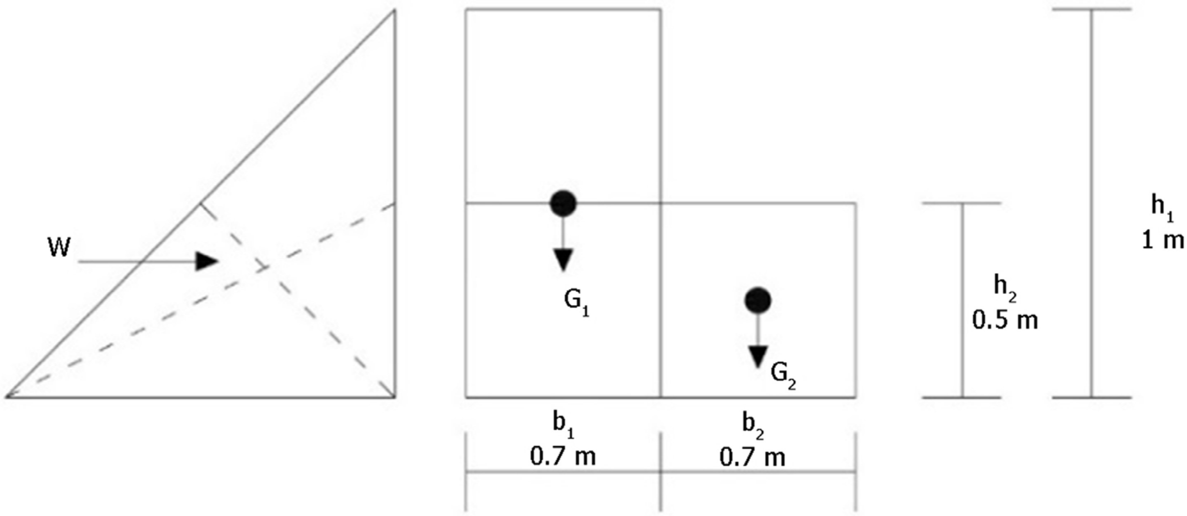

Figure 9. Schema of shape form 1

Table 4. Shear stability of form 1 (L filled with sand + water)

h (m)	**SF Shear**			
	Masonry (f = 0,75)	Gravel (f = 0,50)	Sand (f = 0,40)	Clay (f = 0,30)
0,10	313,43	208,95	167,16	125,37
0,20	78,36	52,24	41,79	31,34
0,30	34,83	23,22	18,57	13,93
0,40	19,59	13,06	10,45	7,84
0,50	12,54	8,36	6,69	5,01
0,60	8,71	5,80	4,64	3,48
0,70	6,40	4,26	3,41	2,56
0,80	4,90	3,26	2,61	1,96
0,90	3,87	2,58	2,06	1,55
1,00	3,13	2,09	1,67	1,25

4. Research Results

4.1. Form (1)

The force scheme of form 1 model L filled with sand + water can be seen in Figure 9.

- Analysis of shear stability of form 1 (L content of sand + water) on wall roughness based on soil type roughness

The total horizontal force working on the variation is as follows:

$$\sum H = \tfrac{1}{2}.\gamma_w.h^2 \quad (4)$$

The total vertical force working is as follows:

$$\sum v = b_1.h_1.\gamma_b + b_2.h_2.\gamma_b \quad (5)$$

$$SS = \frac{(f.\sum v)}{\sum h} = \frac{f.(b_1.h_1.\gamma_b + b_2.h_2.\gamma_b)}{\frac{1}{2}\gamma_w.h^2}$$

$$= \frac{2.f}{h^2}(b_1.h_1.\gamma_b + b_2.h_2.\gamma_b)$$

Example of shear stability calculation model L filled with sand + water, with h=(m):

$$SS = \frac{2.0,75}{1^2}(0,70\ .1\ .1,99 + 0,70\ .0,50\ .1,99) = 3,13$$

The value of shear stability safety of form 1 can be seen in Table 4, and the graph can be seen in Figure 10.

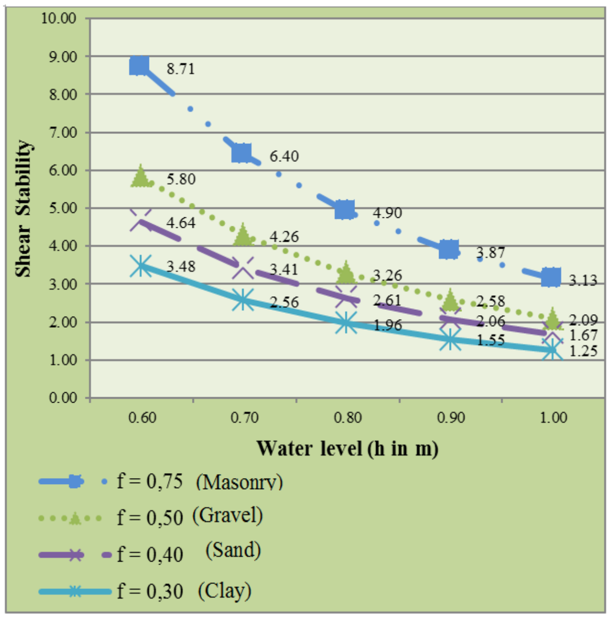

Figure 10. Graph Shear Stability of Form 1

4.2. Form 2

The force scheme of form 2 model 1 filled with sand + water can be seen in Figure 11.

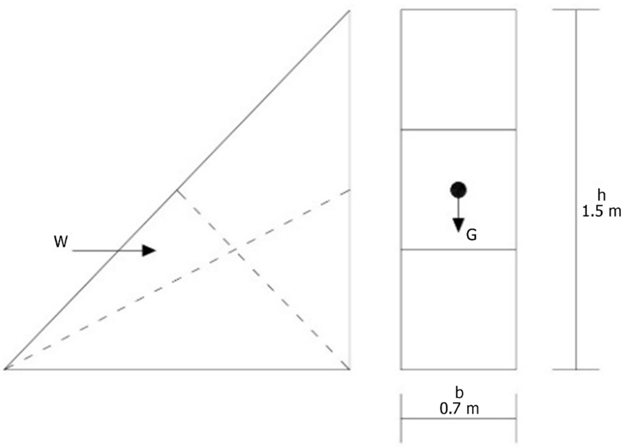

Figure 11. Schema of shape form 2

- Analysis of shear stability of form 2 (I content of sand + water) on wall roughness based on soil type roughness

The total horizontal force acting is as follows:

$$\sum H = \frac{1}{2}.\gamma_w.h^2 \quad (6)$$

The total vertical force working is as follows:

$$\sum v = b.h.\gamma_b \quad (7)$$

$$SS = \frac{(f.\sum v)}{\sum h} = \frac{f.(b.h.\gamma_b)}{\frac{1}{2}\gamma_b.h^2} = \frac{2.f}{h^2}(b.h.\gamma_b)$$

Example of calculating shear stability I sand + water content (h=1.5 m):

$$SS = \frac{2.0,75}{1,50^2}(0,70\,.\,1,5\,.\,1,99) = 1,39$$

The value of the shear stability safety of form 2 can be seen in Table 5, and the graph can be seen in Figure 12.

Table 5. Shear stability of form 2 (I filled with sand + water)

h (m)	SF Shear			
	Masonry (f = 0,75)	Gravel (f = 0,50)	Sand (f = 0,40)	Clay (f = 0,30)
0,10	313,43	208,95	167,16	125,37
0,20	78,36	52,24	41,79	31,34
0,30	34,83	23,22	18,57	13,93
0,40	19,59	13,06	10,45	7,84
0,50	12,54	8,36	6,69	5,01
0,60	8,71	5,80	4,64	3,48
0,70	6,40	4,26	3,41	2,56
0,80	4,90	3,26	2,61	1,96
0,90	3,87	2,58	2,06	1,55
1,00	3,13	2,09	1,67	1,25
1,10	2,59	1,73	1,38	1,04
1,20	2,18	1,45	1,16	0,87
1,30	1,85	1,24	0,99	0,74
1,40	1,60	1,07	0,85	0,64
1,50	1,39	0,93	0,74	0,56

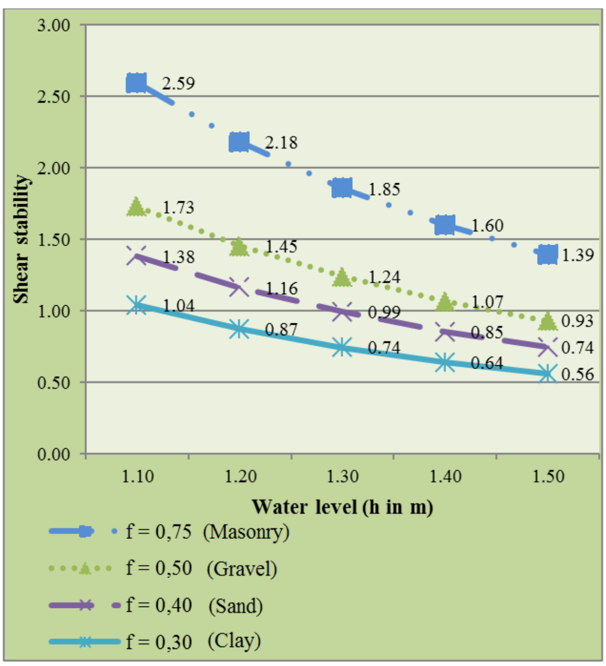

Figure 12. Graph Shear Stability of Form 2

4.3. Form 3

The force scheme of form 3 model 1 filled with water can be seen in Figure 13.

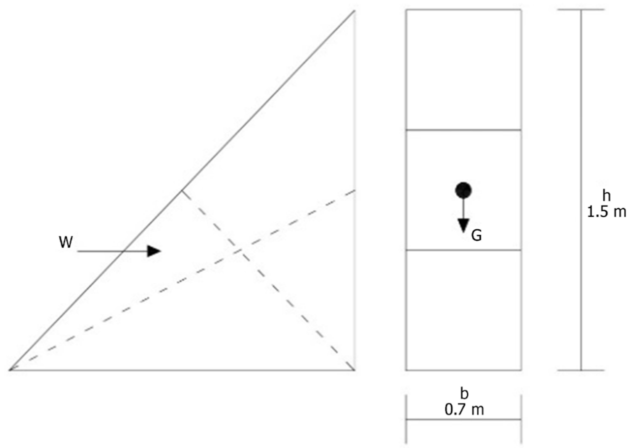

Figure 13. Schema of shape form 3

- Analysis of shear stability of form 3 (I content of water) on wall roughness based on soil type roughness

The total horizontal force working is as follows:

$$\sum H = \frac{1}{2}.\gamma_w.h^2 \tag{8}$$

The total vertical force working is as follows:

$$\sum v = b.h.\gamma_w \tag{9}$$

$$SS = \frac{(f.\sum v)}{\sum h} = \frac{f.(b.h.\gamma_w)}{\frac{1}{2}\gamma_w.h^2}$$

$$= \frac{2.f}{h^2}(b.h.\gamma_w)$$

Example of calculating shear stability I filled with water with h = 1.5 m:

$$SS = \frac{2.0,75}{1,50^2}(0,70\,.\,1,5\,.\,1) = 0,70$$

The value of the shear stability safety factor for form 3 can be seen in Table 6, and the graph can be seen in Figure 14.

Table 6. Shear stability of form 3 (I filled with water)

h (m)	SF Shear			
	Masonry (f = 0,75)	Gravel (f = 0,50)	Sand (f = 0,40)	Clay (f = 0,30)
0,10	157,50	105,00	84,00	63,00
0,20	39,38	26,25	21,00	15,75
0,30	17,50	11,67	9,33	7,00
0,40	9,84	6,56	5,25	3,94
0,50	6,30	4,20	3,36	2,52
0,60	4,38	2,92	2,33	1,75
0,70	3,21	2,14	1,71	1,29
0,80	2,46	1,64	1,31	0,98
0,90	1,94	1,30	1,04	0,78
1,00	1,58	1,05	0,84	0,63
1,10	1,30	0,87	0,69	0,52
1,20	1,09	0,73	0,58	0,44
1,30	0,93	0,62	0,50	0,37
1,40	0,80	0,54	0,43	0,32
1,50	0,70	0,47	0,37	0,28

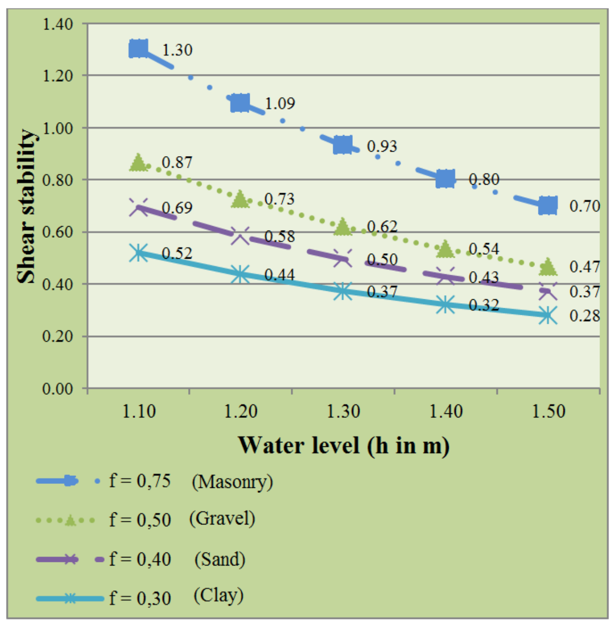

Figure 14. Graph Shear Stability of Form 3

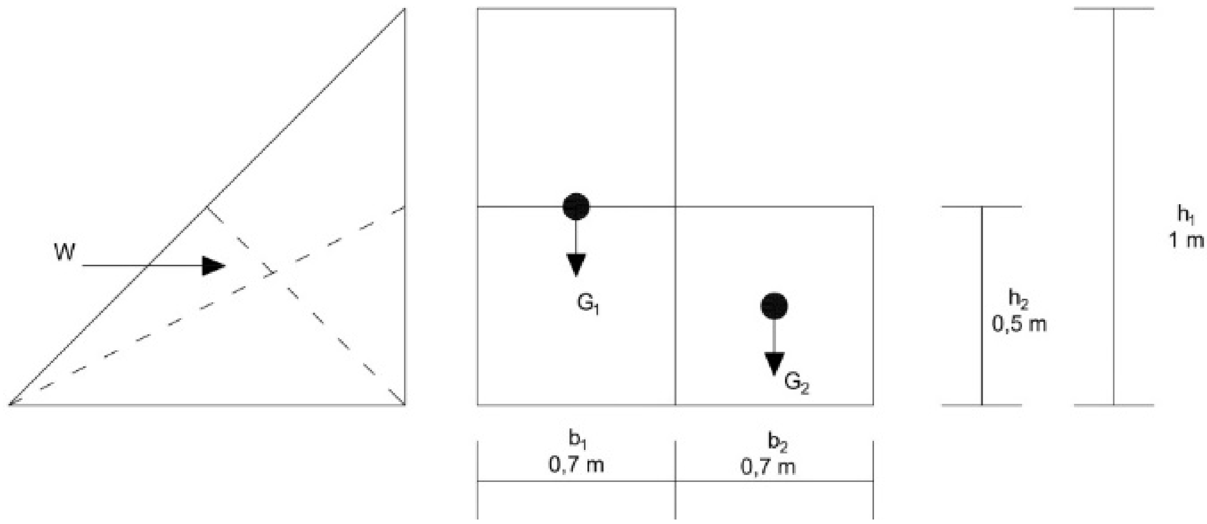

Figure 15. Scheme of shape form 4

Table 7. Shear stability of form 4 (L filled with water)

h (m)	SF Geser			
	Masonry (f = 0,75)	**Gravel (f = 0,50)**	**Sand (f = 0,40)**	**Clay (f = 0,30)**
0,10	157,50	105,00	84,00	63,00
0,20	39,38	26,25	21,00	15,75
0,30	17,50	11,67	9,33	7,00
0,40	9,84	6,56	5,25	3,94
0,50	6,30	4,20	3,36	2,52
0,60	4,38	2,92	2,33	1,75
0,70	3,21	2,14	1,71	1,29
0,80	2,46	1,64	1,31	0,98
0,90	1,94	1,30	1,04	0,78
1,00	1,58	1,05	0,84	0,63

4.4. Form 4

For the force scheme of form 4 model L filled with water, it can be seen in Figure 15.

- Analysis of shear stability of form 4 (L content of water) on wall roughness based on soil type roughness

The total horizontal force working is as follows:

$$\sum H = \frac{1}{2}.\gamma_w.h^2 \tag{10}$$

The total vertical force working is as follows:

$$\sum v = b_1.h_1.\gamma_w + b_2.h_2.\gamma_w \tag{11}$$

$$SS = \frac{(f.\sum v)}{\sum h} = \frac{f.(b_1.h_1.\gamma_w + b_2.h_2.\gamma_w)}{\frac{1}{2}\gamma_w.h^2}$$

$$= \frac{2.f}{h^2}(b_1.h_1.\gamma_w + b_2.h_2.\gamma_w)$$

Example of shear stability calculation model L filled with water (h=1m):

$$SS = \frac{2.0{,}75}{1^2}(0{,}70\,.\,1\,.\,1 + 0{,}70\,.\,0{,}50\,.\,1) = 1{,}58$$

The value of the shear stability safety point of form 4 can be seen in Table 7 and the graph can be seen in Figure 16.

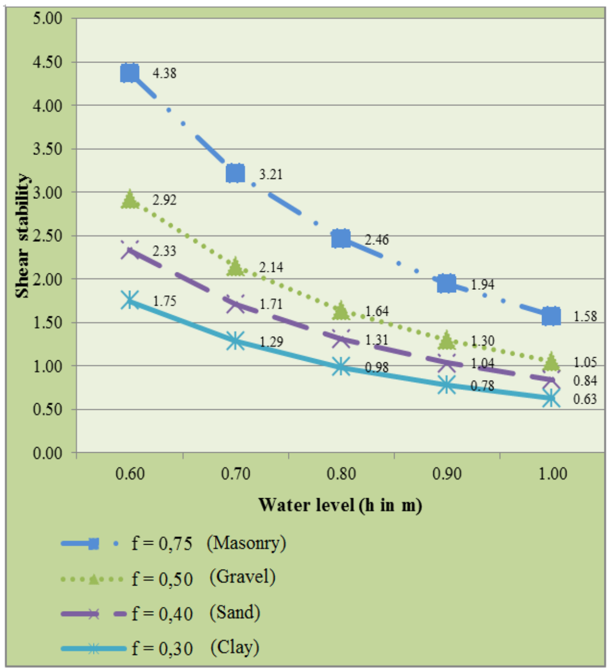

Figure 16. Graph Shear Stability Form 4

5. Conclusions

Based on the 4 forms of the structure and body of the Knock-Down weir, the results of the study of the shear stability of the Knock-Down weir model on the roughness of the walls based on variations in soil type obtained a form that is safe against shifting, namely the arrangement of the Knock-Down weir, namely number (1) L shape filled with sand + water based on the analysis obtained at the height of the weir body size of 1m shear weir stability against masonry shows a value of 3.13; against gravel shows a value of 2.09; against sand shows a value of 1.67, and for clay, it shows a value of 1.25. While the safety requirements for shear stability are Sf shear > 1.2

6. Suggestion

(1) Knock Down Weir models can be made of plastic, they can be PVC (*Polyvinyl Cloride*), HDPE (High-Density Polyethylene) etc. which are waterproof and are expected to have a minimum plastic thickness of 0.8 mm.

(2) Further research is needed using the Plaxis application.

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