Development and Testing of Bed Sediment Samplers

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Abstract : This study is focused on sediment transport that gives impact to hydraulic parameters such as unit discharge, mean flow velocity and slope gradient.Hence, the design and development of grab sampler by considering the economic aspect is important in order to identify the performance of sampler based on 45° angle and 60° angle of the sampler with different condition of water flow and other parameters such as distance of pulling the sampler, increase the water flow depth and reverse flow of water towards samplers. The effectiveness towards sediment sampling for both sampler is different due to given parameters. In general, 60° angle of sampler shows better results in analysis.

Introduction

The process of land surface is worn away by action from natural forces such as water, wind, gravity and ice is known as soil erosion. Hence, soil erosion caused when sediment detached from the soil mass, then it will transported primarily by flowing water or wind and eventually deposited as sediment. The four factors that cause the inherent erosion potential of an area such as soil characteristic, topography, vegetation cover and climate that is from a rainfall event [1].

Basically, there are fundamental controls that related to the amount and size of sediment moving through river channel such as its capacity. Capacity of sediment is defined a maximum amount of sediment can transport in traction as bed load. Other corresponding elements that control sediment, including competence and sediment supply. The competence is referred as the size of sediment in capabilities to moving the sediment along the river while, sediment supply is the size and amount of sediment that applies for transportation process of sediment.

Sediment samples are collected due to various reasons such as biological, chemical, physical, and toxicological analysis, Taft, R.A [2]. In hydraulic, when there is the flow of water and sediment movement, it is giving erosion, scour, transport, suspension, dispersion and deposited of sediment. It is important to understand the behavior of the sediment, usually for address to some aspect, such a local scour possible happened at hydraulic structure and deposition of sediment in flow zones that can reduce the capacity of the storage reservoir due to sediment concentration exceeds the sediment transport capacity.

Generally, for collecting bottom sediment, there are two types of sampler used that is a grab sampler for assemblies, surface sediments and core sampler for collecting sediment at depth profiles of any river. Grab samplers due to ease of use and has a large quantity of sample that can be obtained, while for core sampler was suited for long term assessing. The type of sampler apply was depending on the purpose of study.

In trading, they are a lot of this sampling equipment. For grab sampler, the common sediment grab sampler used is Van Veen grab, Ekman grab, Petersen grab and Ponar grab. This entire device has similarity that is the design that uses a set of jaws to control the sediment intake. However, Kajak- Brinkhurst is one of the well-known sediment cores sampling that has been used. The weight of core sampler is sufficient to fully penetrate the sediment without any free fall.The purpose of this study is to create new local products which are comparable to others import product in the market.

Previous Studies

Ideally, grab samplers should be able to collect an undisturbed bottom sample with minimal disruption to the surface layer. The typical grab sampler, regardless of type, is held in the open position during descent and activated upon reaching the bottom by, USEPA [3]. Schlieper [4], reports that there is a weakness with a Petersen grab design that the tensile closing action creates a secondary lifting force at the central axis that two jaws pivot around, resulting shallower bite (5 cm or less) especially in firmer sediments".

The van veen grab has unique scissors like closing action generated by lifting wire that provides better leverages while helping embed the jaws to sediment. But, the sampler has large access doors for convenient removal of upper sample layers. The mesh that covering on sample doors allows water to pass hence reducing the pressure that disturbs the flock layer on surface of sediment. All grab samplers run the risk of sample leakage if the rocks or other debris are present that are capable of preventing the complete closure of jaws .

Holmes and Shipek samplers utilize one or two rotating semi-secular scoops to collect sample materials instead of jaws. The advantage is the lifting wire rotate the scoops after the sampler has settled on the bottom , but the major disadvantages is the 180-degree rotation of scoop severely disrupts the stratified configuration of the material.

Table 1: Previous research findings according to several types of grab sampler device

Researcher	Findings	Remarks
[5] Smith JR, and J.D	The spade corer is a more efficient sampler rather than Smith grab sampler due to greater depth of corer and it collect deeper sample	A sample was taken while the ship is anchored and sample size maintained 60 cm depths for spade corer and average 12 cm depth of penetration.
[6] Ulf Lie, M. M.	The data gained from False Bay indicate 0.1 m² Van Veen Grab is efficient in sampling the benthos and give good replication if it is skillfully handled, if the ship anchored and if the weathered not too bad.	40 kg, 0.1 m² Van Veen Grab is used as a sampling device in water depths 1-2 m with six samples where the sediments were allowed to settle about 5 minutes.
[7] Holmes, R.R	The methods used have its own limitation. As in sand-bed system in the transitional regime, the velocimetry method is not applicable. While for virtual velocity, the necessary length of time for sand-bed will less than gravels.	Two indirect method used is: I. Bed form velocimetry and II. Virtual velocity of the bed material

Proposed Design

The point of this study was to design and develop a new grab sampler. The design consideration is (i) materials used as a body part of the sampler, (ii) the diameter of the tube sampler, (iii) the angle of direction pull and, (iv) the angle between grab samplers. After that, the product was analyzed based on its performance. The performance of this grab sampler was evaluated based on the volume of sediment collected for both sampler due to parameter such as velocities of water and water flow depth. The overall process is as shown in Figure 1.

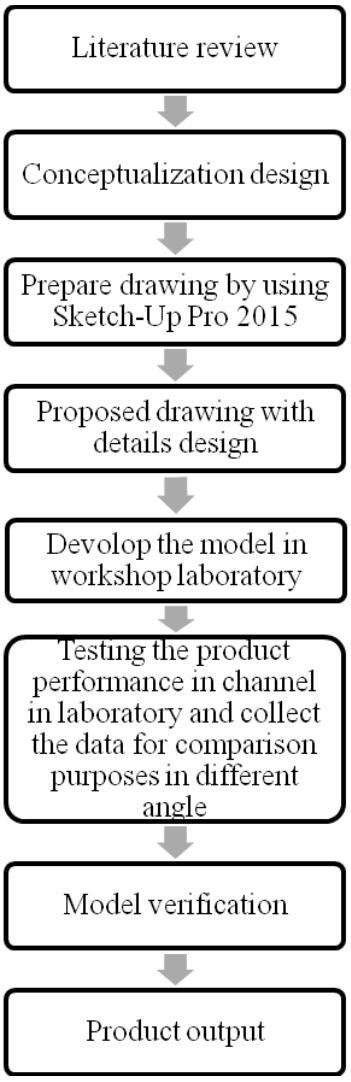

Figure 1: Flowchart of research design

Dimension of Grab Sampler

The dimension of the grab sampler is the finalized from the proposed design and is ready for fabrication of the model then the sampler is testing at the channel. Figure 2 shows of 45° angle of grab sampler while Figure 3 indicates the 60° angle of grab sampler;

Figure 2: 45° angle sampler

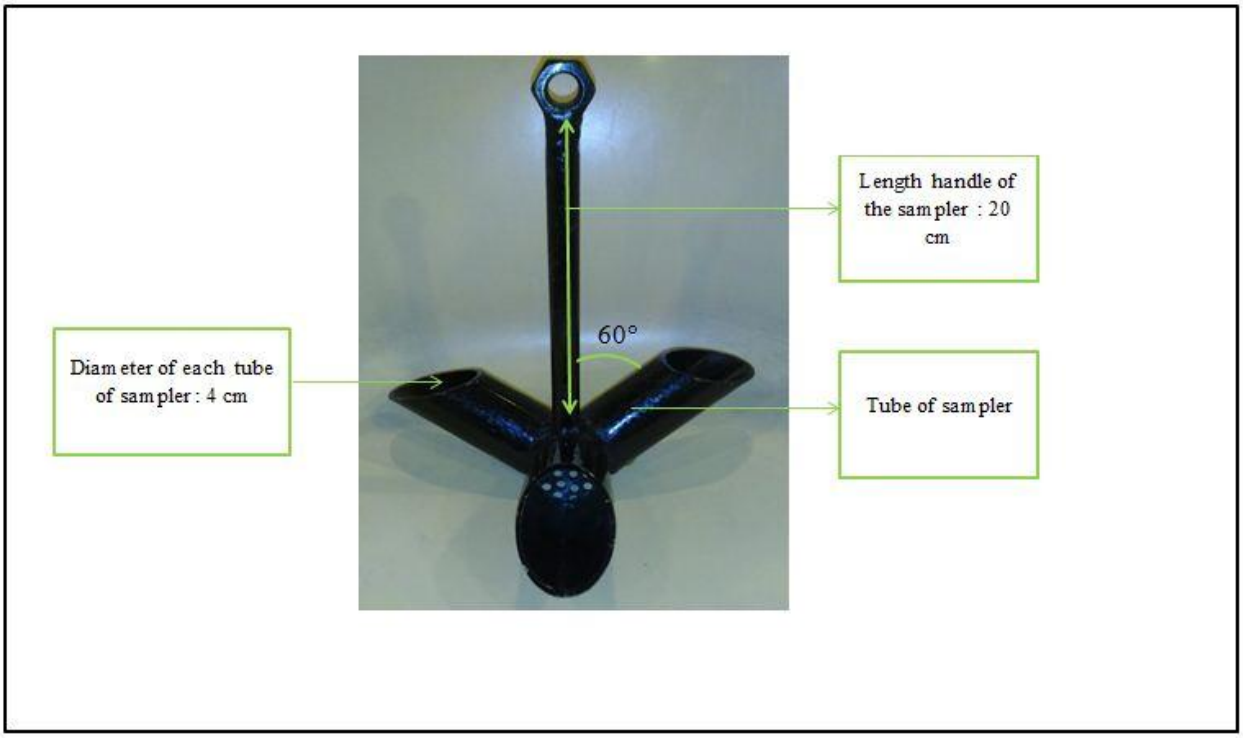

Figure 3: 60° angle sampler

Fabrication and Testing (methodology of studies)

The procedure to developed grab sampler basically gets from the conceptual design for sampler with 45° and 60° angle of the sampler . After that, the model is ready for testing based on several parameters and the results is used in analysis part.

Production (Fabrication)

The production of samplers in workshop was started by cutting the steel that a thickness of 5 mm and a diameter of 10 cm into several parts. When all the elements are ready, the fabrication of the sampler was started with rotation angle 45^{o} between them. The same procedure for sampler with angle of 60°.

Figure 4: The steel was cut into several components

Figure 5:The fabrication of the sampler

Testing

Testing of the sampler was to test the performance of grab sampler based on volume of sediment trapped, percentage difference of volume between angle of 45° and 60°. Other than that, the testing of the sampler was based on different length of the sampler is taken and with different flow of water.

The testing of the sampler consists of few phases. The first phase was the testing performance of 45° angle and 60° angle of sampler in two conditions of water flow i) when there is no water flow, ii) when there is exists in water flow. After that, the result is compared and discussed.

Other than that, the next phase of testing was running for the different length by pulling the grab sampler from the initial point.The length was adjusted to see whether if the length of pulling sampler increased will affect the sediment trapped.Then, the testing was continued by increase the height of water level of 4 cm from 2cm and finally the test was done in reverse flow of water flow.

Figure 6:Testing sampler model on the channel

Results and Discussion

The results and analysis of the sampler will discuss further about the performance for both sampler of 45° and 60° angle. The performance based on the mass of sediment trap based on condition flow of water that is when there is flow of water and without flow of water. Furthermore, it is also concentrates on the impact of sediment trap by considering the different length in directions of pull of the sampler, the difference in water depth and reverse flow of water.

Sediment retained for 45° and 60° angle

After the analysis is carried out between the 45° angle and 60° of the sampler, the result analysis compares to differentiate whether the most effective sampler in order to trap sediment and to determine the other properties of the sampler.

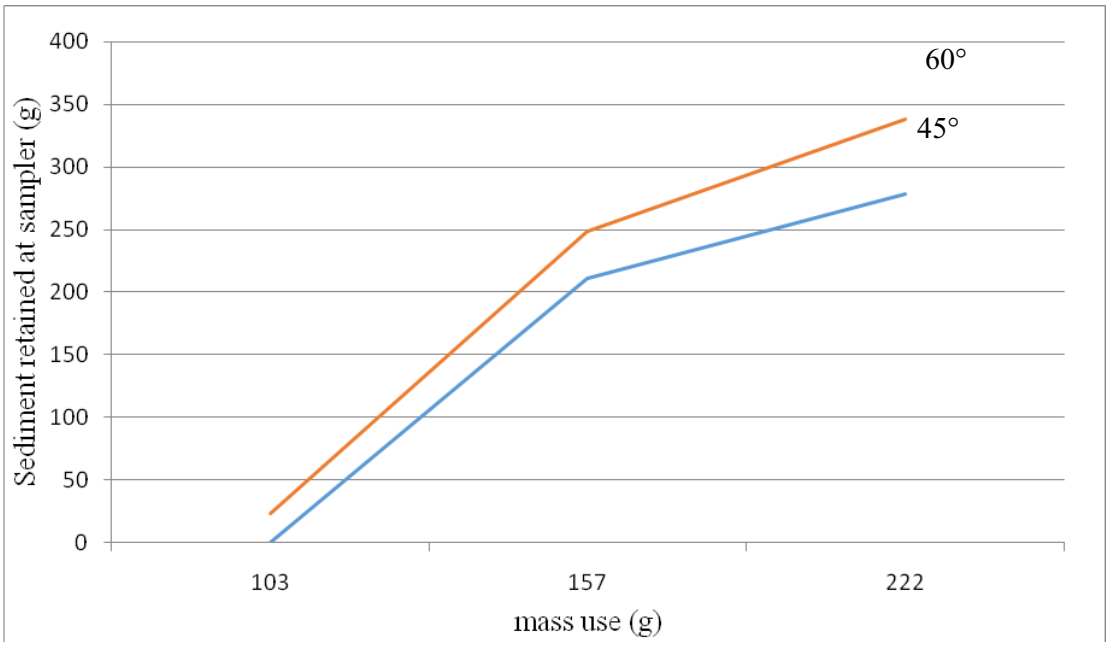

Figure 7:Sediment retained between 45° angle and 60° angle of sampler without flow of water

Figure 7 shows the comparison of sediment retained between 45° angle and 60° angle of sampler without flow of water. The comparison is based on the condition when there is no water flow during the testing of the sampler. There is some difference in the performance of sampler towards scouring the sediment in the channel between 45° angle and 60° angle. The 60^{o} angle has higher value at the same mass as compared to 45^{o} is due to 60^{o} angle have a higher opening surface area compared to 45^{o} angle, so it is can grab more sediment and give higher efficiency compared to 45^{o} angle of the sampler. It can be concluded that, without water flow, the performance of the 60° sampler is better compared with 45° angle of sampler because the performance of grab the sediment is higher.

Sediment retained between 45° angle and 60° angle of the sampler with flow of water

In order to define the sampler performance, the analysis is further with comparison between 45° angle and 60° angle of the sampler with existing of water flow.

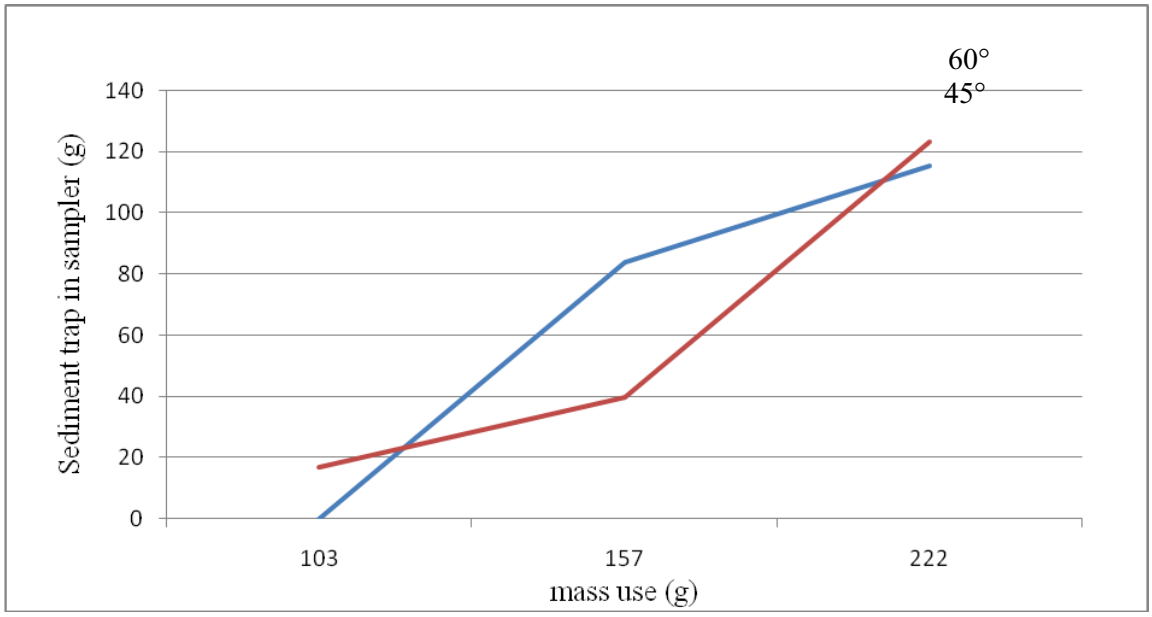

Figure 8:Sediment retained between 45° angle and 60° angle of the sampler with flow of water

In Figure 8, it shows the comparison of sediment that retained between angle 45° angle and 60° angle of the sampler with existing flow of water. In general, the height of water depth is about 2 cm, while the direction of pulling the sampler is constant until the end of the experiment for both sampler.

The graph shown when the minimum mass is attached at the sampler, the performance of sediment collected in 60° angle of the sampler is higher than 45° angle of the sampler.Instead, when the maximum mass is used that is 221.78 grams, the volume of sediment trap also increases in 60° angle of sampler compared with 45° angle only can retain sediment around 115 grams. Consequently, this is due to the opening surface area for 60° angle is sizable than 45°. Thus it proved that the geometry of the sampler is important. Overall, when there is existing of water flow in channel, the effectiveness of the sampler is different due to pressure from the velocity of water. Again, the 60° angle of the sampler is better than 45° sediment collected.

Grab sampler at 4 cm water depth

Water flow is the movement of water with existing of velocity with per unit time. As the water flow increase, it will cause an increase in velocity hence, it will affect the performance of the sampler. In this study, the water flow is used as parameter to define the performance of the sampler.

In general, the flow of water will indicate the behavior of the sampler to collect the sediment. Correspond to this, the test is related to the increases in water depth of 4 cm while others parameter such as the distance of pulling the sampler is fixed and the test is run for both 45° and 60° angle of samplers according to different mass used. The purpose is to see whether there are any changes if the water depth is doubled from the previous study on 2 cm water depth in condition of existing water flow.

In this case, the Figure 4.8 shows the comparison of 45° and 60° angle of grab sampler and the results is 45° angle of sampler obtained a high volume of sediment trapped in contrast with 60 ° angle of the sampler. As the mass of use is increasing, the sediment collected rises for 45° angle of the sampler.

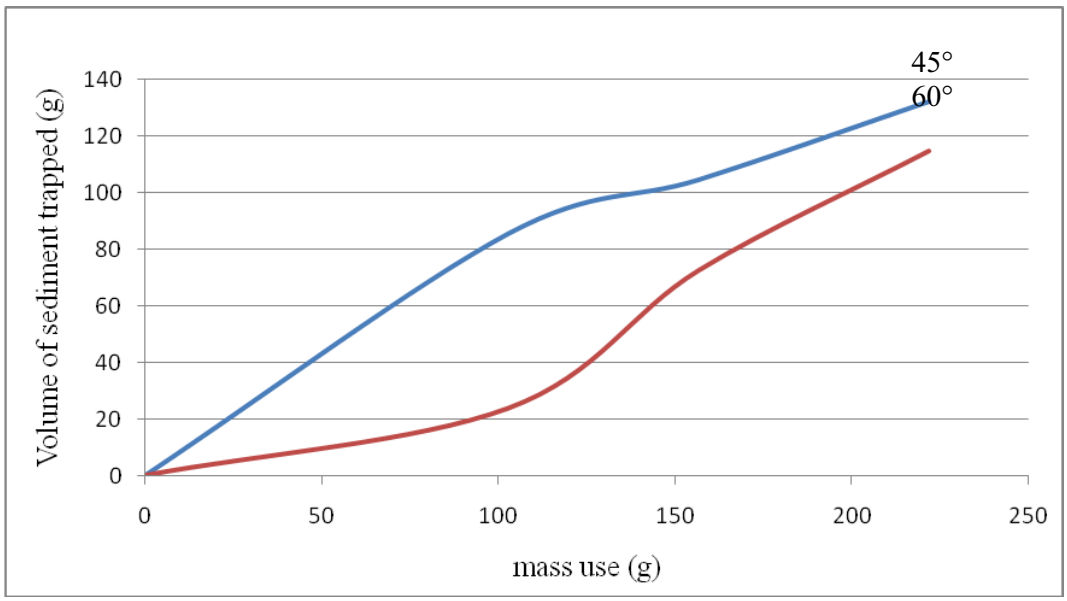

Figure 9:Comparison of 45° and 60° angle of grab sampler at 4 cm water depth

There is slightly different between both sampler regarding to the small opening tube shape of the 45° angle, hence it can create a movement during scouring process. The 45° angle of sampler tends to rotate while moving in addition of water velocity help in order to make all the sampler tube will be filled up with the sediment. This is causing the 45° angle of sampler can gain more sediment in 4 cm water depth.

In a word, the both sampler has a unique characteristic in the same condition. Therefore, the movement of 45° angle of sampler coupled with high velocity of water will produce more appropriate way of sampling the sediment.

Volume of sediment trapped at 45° and 60° angle of sampler with the condition of opposite direction flow of water

Table 2:Volume of sediment trapped at 45° and 60° angle of sampler with the condition of opposite direction flow of water.

Trials	Volume of sediment trapped (g)	
	45° of sampler	60° of sampler
1	101.32	115.98
2	102.03	123.65
3	112.01	126.68
4	112.64	115.98
5	132.64	124.56
6	125.65	117.66
Mean	114.382	120.752

In the first place, the study only focused on the sediment that is dragged along the channel with the same flow of water. The direction of water flow will contribute to the different performance of the sampler. Hence, this study is further in the opposite direction of water flow. The Table 2 shows the volume of sediment trapped at 45° and 60° angle of sampler with the condition of opposite

direction flow of water. The other parameter is kept constant such as the level of water depth and the distance to pulling the sampler.

In detailed, the sampler of 60° angle sampler has a wider opening surface of the shape, hence when the water flow is opposite direction with the pulling of the sampler, it will cause increases in the effectiveness of the sampler to trap the sediment. As a conclusion, the wider opening area will gain more sediment to trap inside it.

Conclusion

The results obtained from the laboratory testing on the sampler of 45° angle and 60° angle of the sampler will point out the important finding towards this research. The conclusion of the performance of the sampler is concluded as below;

Without the flow of water

The comparison of sediment trapped between 45° angle and 60° angle of sampler without flow of water is based on the condition when there is no water flow during the testing of the sampler. There is some difference in the performance of sampler towards retaining the sediment between 45° angle and 60° angle. As a result, without the flow of water, the performance of the 60° sampler is better compared with 45° angle of the sampler.

With the flow of water

The existing the flow of water will influence the mobilization of the sampler in the channel due to velocity of water. Therefore, it significantly affects the performance of the sampler and causes a loses volume of sediment as the sampler was pulling along the direction of scouring. In that case, when there is existing of water flow in channel, the effectiveness of the sampler is different due to pressure and velocity occurred from the water flow. Therefore, the 60° angle of the sampler is better than 45° sediment collected as the results is compared in the previous chapter.

Increase in water depth of 4 cm

The rising in water depth will cause the increase in velocity of water flow. Apart from that, the testing is considered for both sampler that is 45° angle and 60° angle of the sampler. In this analysis, the sampler of 45° angle indicates the effective performance compared to 60° angle of sampler because the surface area of 45° angle is smaller hence, it causes a movement of the sampler in the channel with high velocity occurred.

The opposite direction flow of water

The final testing is changing the direction of pulling the sampler that is opposite to the flow of water. From the results and discussion, the sampler of 60° angle has a wider opening surface of the shape, hence when the water flow is opposite direction with the pulling of the sampler, it will cause increases in the effectiveness of the sampler to trap the sediment. As a conclusion, the wider opening area will trap more sediment inside it.

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