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Procedia Engineering 53 (2013) 81 – 92

Procedia Engineering

www.elsevier.com/locate/procedia

Malaysian Technical Universities Conference on Engineering & Technology 2012, MUCET 2012
Part 3 - Civil and Chemical Engineering

Study on Characteristics of Sediment and Sedimentation Rate at Sungai Lembing, Kuantan, Pahang

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Abstract

River is important in human life. River is very useful and has various functions in human life such as for domestics, economics, connection for one place to others place and many more. The main function of the river is to flow the water to the water storage or sea. River also brings the sediment from upstream or from erosion process. Sediments may affect the characteristics and the rate of the river. The study of sedimentation rate is quite important for development our country. It also can avoid the problem which related to our human society such as flood and water quality. As example, the depth of river become shallow if the sedimentation occurred. It also will make the quantity of aquatic life will reduced. This study was carried out to determine the sedimentation rate for five locations in the study area at Sungai Lembing, Kuantan, using Duboys and Schoklitsch equation. The highest sedimentation rate using Duboys is 2.06 lb-sec/ft was obtained at Station 3 and the lowest sedimentation rate is 0.073 lb-sec/ft also at Station 3 but in different day. Meanwhile, by using Schoklitsch equation, the highest rate is 1.12 lb-sec/ft at Station 1 and the lowest rate at Station 5 with 0.263 lb-sec/ft. The results for Duboys indicated that the rate is related to the mean size of sediment and the cross section of the river. By using Schoklitsch, the results depend on the flow rate of the river. If the flow rate higher, the sediment rate will also increase. The sediment sample sieving test results was classified using U. S. Army Corps of Engineer (USACE). The major size at Sungai Lembing for every station is in range between 2 mm-0.5 mm (Medium sand) and the minor size of sediment for the five ungauged station is 0.25 mm- 0.0625 mm (very fine sand).

Selection and peer-review under responsibility of the Research Management & Innovation Centre, Universiti Malaysia Perlis

Keywords: *Sediment characteristic; sediment rate; Sungai Lembing*.

1. Introduction

Sedimentation is the process of letting the suspended material settles by the gravity. The example of the suspended material may be particles, such as clay or silts, originally present in the source water. Commonly, suspended material or floc is created from material in the water and the chemical used in coagulation or in other treatment processes, such as lime softening.

Sedimentation is accomplished by decreasing the velocity of the water being treated to a point below which particles will no longer remain suspension. In sedimentation process, there have many methods such as identify the sedimentation rate, sedimentation pattern and the characteristics of sedimentation.

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Selection and peer-review under responsibility of the Research Management & Innovation Centre, Universiti Malaysia Perlis
doi:10.1016/j.proeng.2013.02.013

The sedimentation rate is the process to design of classifier which also used to separate solids according to their size and density under free and hindered settling condition. The net sedimentation rates are estimated annually along established transects by direct survey of the river bottom.

2. Problem statement

The characteristics of the sediment along Sg. Lembing need to specify because it may affect the flow of the river. The characteristics of the river depend on the more factors. Regarding to the [1,2] said there have more natural factors which affect the sediment characteristics. So, this study will determine some of characteristics at Sg. Lembing and the factors that will affect it.

The study of sedimentation rate is still early in Malaysia but in others country such as United States it is more advance with appropriate equipment and application due to this problem. European Geophysical Society, used Radionuclide Mass Balances in order to determine the sedimentation rate [3]. But in Malaysia, our researches used other method such as using the theoretical formula.

The study of sedimentation rate is quite important for development our country. It also can avoid the problem which related to our human society such as flood and water quality. As example, the depth of river become shallow if the sedimentation occurred. It also will make the quantity of aquatic life will reduced. A residential at Sg. Lembing also will face flooding because the river becomes overflow due to sedimentation process.

3. Case Study

A study area for this project was located in Sg. Lembing in district of Kuantan, Pahang, East Coast of Peninsular Malaysia, about 45 km from University Malaysia Pahang (UMP) and 35 km from Kuantan town.

Figure 1 shows the location of the study area which located at Kampung Sg. Mas about 7 km from the main town of Sg. Lembing. The area was selected based on the natural factors and the condition of the river. This study area also located near to Chereh Dam, which have the biggest storage dam in Malaysia.

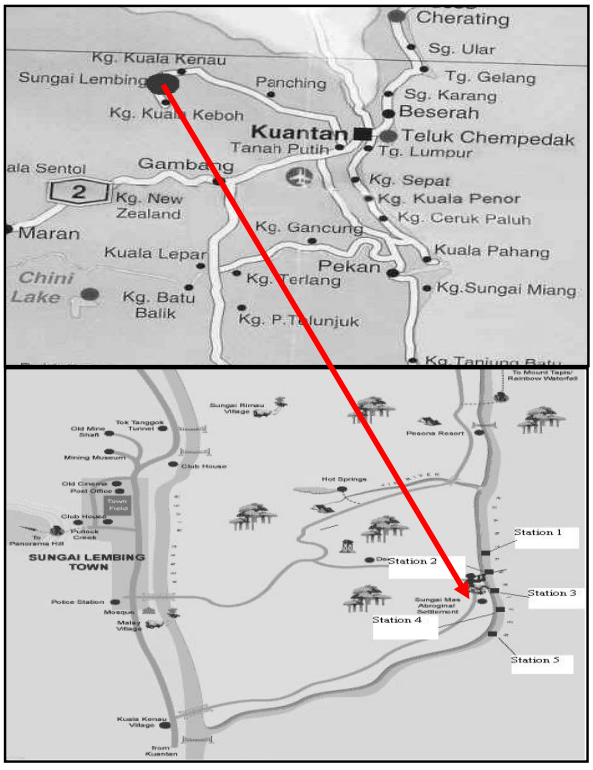

Fig. 1. Location of study area

3.1 Flow Measurement Station

This study area carried out at five ungauged stations starting from Station 1 until Station 5 (refer figure 2 till 6).

These five stations were located along Sg. Lembing which Station 1 and Station 2 located at upstream, Station 3 located at bridge and Station 4 and Station 5 located at downstream. The distance between stations to another station is about 150 km and the total length for measurement of flow is about 1 km. The location of this particular station was selected based on the several factors. The factors that have been considered during selecting this study area are natural factors, depth of stream flow and accessibility to the location.

Figure 2 show the location of the Station 1. This particular station located at the upper of the stream which have width about 35 m and it is the greatest width among the others stations. The depth of the stream is range between 0.3 m to 0.45 m. The velocity of the stream are highest compared to the others station and it is classified as steady flow.

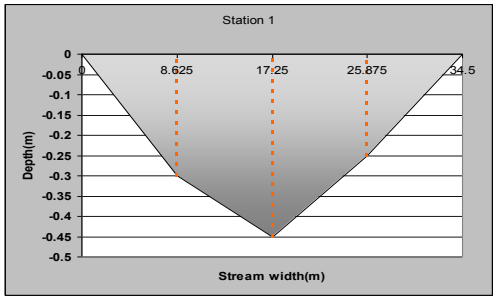

Fig. 2. Stream's cross section of Station 1

Figure 3 shows the Station 2 and its cross section. Distance between the stations to Station 1 is about 150 m. This station has a width about 34 m and the depth of the stream is range between 0.3 m to 0.75 m. The particular stream also classified as shallow stream.

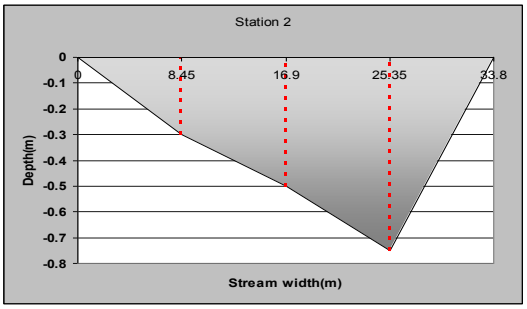

Fig. 3. Stream's cross section of Station 2

Figure 4 shows the Station 3 and its cross section. The depth of this station is range between 0.325 m to 0.75 m. The distance between these two is about 150 m. The velocity at the middle of this station is higher because it has one creek located near this station. The flow of this station classified as steady flow.

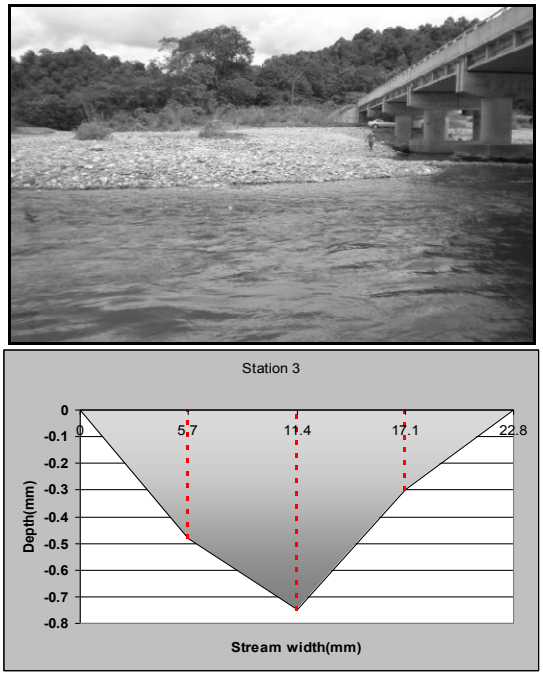

Fig. 4. Stream's cross section of Station 3

Figure 5 shows the Station 4 and its cross section. The depth of this station is range between 0.32 m to 0.8 m. The distance between station 4 to Station 3 about 150 m. The velocity at the middle of this station is higher because it has one creek located near this station and contains some big rocks. The flow of this station classified as steady flow.

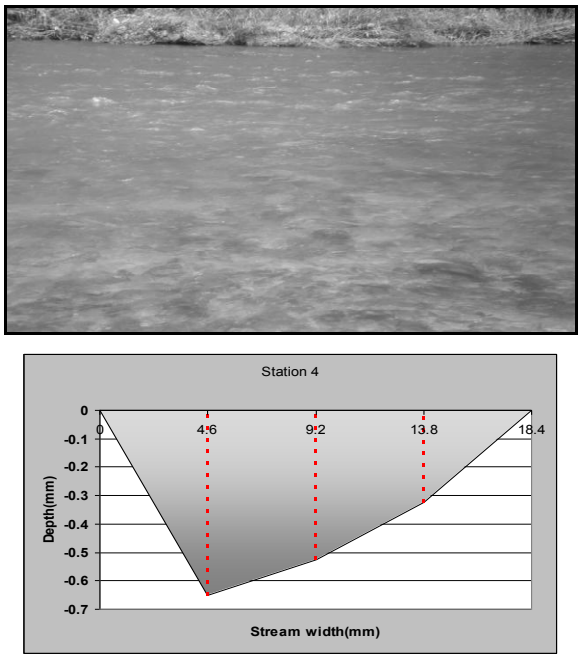

Fig. 5. Stream's cross section of Station 4

Figure 6 show the Station 5 and its cross section. The depth of this station is range between 0.5 m and 1.2 m. The width if this stream is about 25 m. The flow of this station is classified as steady flow.

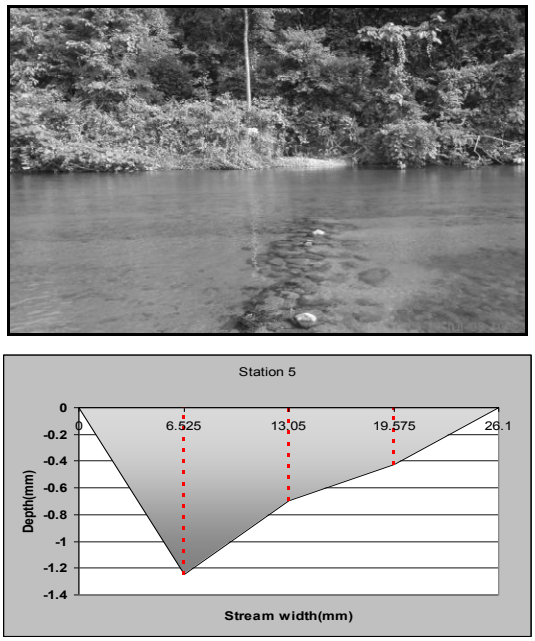

Fig. 6. Stream's cross section of Station 5

3.2 Sungai Kuantan River Basin

Sungai Kuantan basin located at the north east of Pahang state in Peninsular Malaysia with latitude N3º38'~ 4 º07' and longitude E102º51'~ 103º23'. The total are for this basin is 1638 km^2 and the total stream length is 86 km. The river originates from Gunung Tapis at the western border and it flows through the town of Sungai Lembing and Kuantan before

discharging into the South China Sea. Sungai Kuantan Basin is largely rural. The upper catchments are largely dominated by the natural forest. The middle and lower are dominated with oil palms and slightly amount of rubber plantations. Sungai Lembing is still under rural condition, so the amount of residential area live in that area still in small quantities than a capital town of Kuantan, the latter administrative capital and commercial centre of the Pahang State.

The basin has an average annual rainfall with 2470 mm and the mean annual discharge at Bukit Kenau(582 km^2) is 37.7 m^3/s. The main tributaries of Sg. Kuantan are Sg. Chereh, Sg.Kenau, Sg.Belat, Sg. Reman and Sg. Riau (Figure 70. The main reservoir for the basin is Chereh Dam which located at Sg. Chereh which work as water storage tank and prevent the flooded.

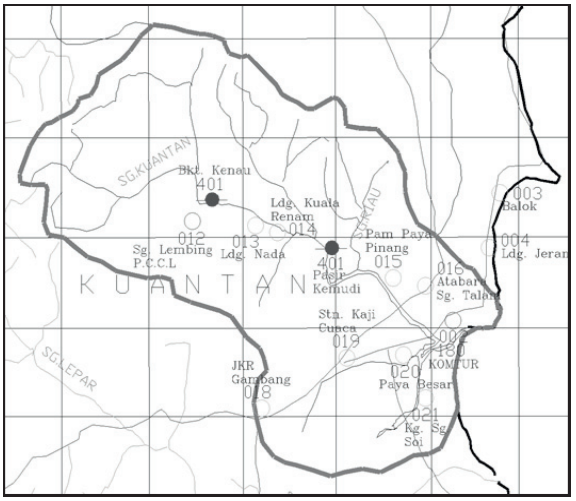

Figure 7: Kuantan Catchment Area Map (DID, 2007)

4. Sediment Characteristics

Sediment characteristics can influence the rate and the pattern of the river condition. There have some natural factors may affect the condition of the river such as particle size, chemical composition, fall velocity and many more. In this study case, the size of sediment, fall velocity and the sediment density have been choice to determine the characteristics of sediment.

4.1 Size of Sediment

The condition of Sungai Lembing River contained big rocks such as boulders (> 256 mm), cobbles (256 mm-64 mm) and gravel. Most of sediment at that area fully with sand, the sediment size between 6 mm to 1 mm. The size of sediment was determined by using sieve analysis at the laboratory. Figure 8 and Figure 9 show the distribution size of sediment for 5 stations in Day 1 and Day 2.

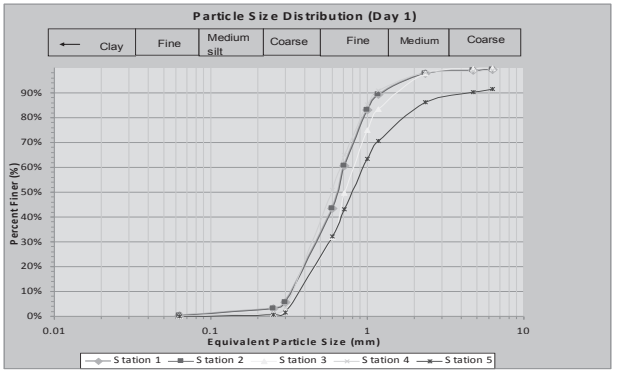

Fig. 8. Distribution Size for Day 1

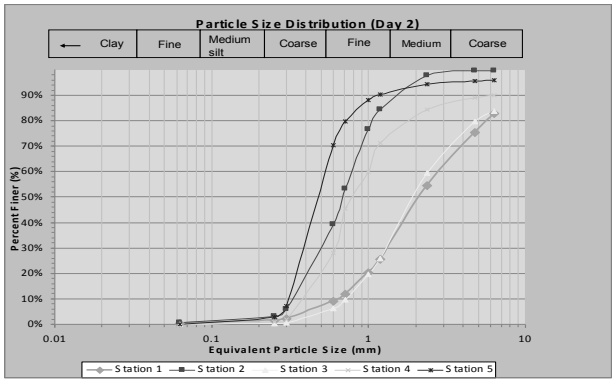

Fig. 9. Distribution Size for Day 2

From the Figure 8 and Figure 9, the distribution size for Station 1, Station 2 and Station 4 are not much changing compared to Station 1 and Station 5 for both day. It is because the river gauging for day 1 has made before the flooding. The river gauging for day 2 have been done after the flooding. So, the flooding will affect the natural factors of the river such as erosion and broken of the embankment. In others words, the soil and the rocks will travel to the other place and as result the sedimentation will occurred at the place.

4.2 Fall Velocity

The fall velocity of sediment will be determined by using formula, [4]. Table 1 and 2 shows the results of fall velocity for day 1 and day 2.

Table 1. Fall velocity for Day 1

Station	Mean Size(mm)	Fall Velocity (m/s)
S1-S2	2.984	8.0
S2-S3	0.683	0.42
S3-S4	0.78	0.547
S4-S5	0.67	0.4037

Table 2. Fall velocity for Day 2

Station	Mean Size(mm)	Fall Velocity (m/s)
S1-S2	2.63	6.22
S2-S3	0.746	0.50
S3-S4	3.029	8.25
S4-S5	0.505	0.23

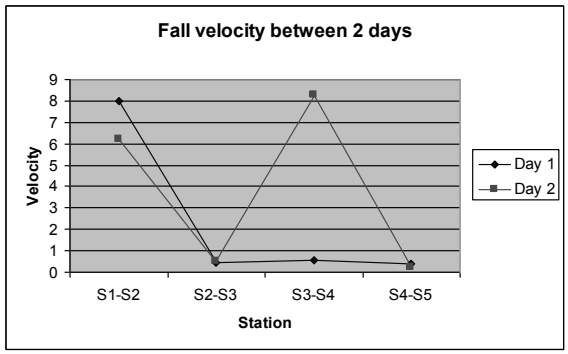

Fig. 10. Graph of Fall Velocity for 2 days

Figure 10 show a comparison fall velocity between first and second day. From the figure the fall velocity are same for the three station but it's different for the station 3 to station 4. Based on the calculation, the mean size of the sediment will effect to the fall velocity. As the mean size become greater, the fall velocity may be increased. The drastic changes of mean size because the erosion occurred near to the bridge. So, some of the gravel and coarse sand falling down to the river and some of will be moving together with water flow.

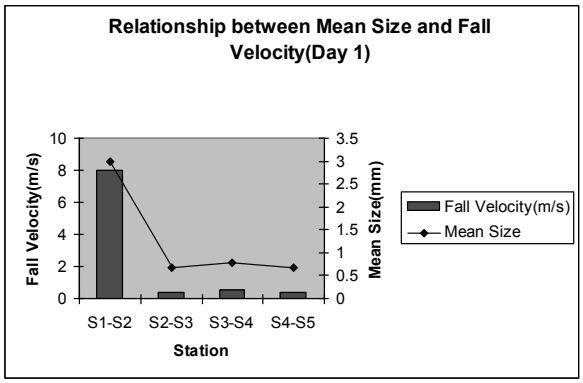

Fig. 11. Relationship Mean Size and fall velocity (Day 1)

Figure 11 show the relationship between mean size and velocity. From the figure, noted that the fall velocity will increased if the numbers of mean size become greater. The maximum fall velocity are recorded at the station 1 with 8 m/s and the minimum velocity was recorded at station 4 to station 5 with 0.4037 m/s. the range between highest and lowest is about 7.6 m/s. The average velocity for day 1 is 2.34 m/s.

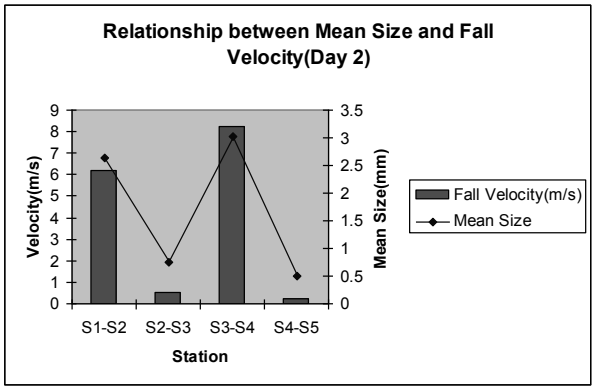

Fig. 12. Relationship Mean Size and fall velocity (Day 2)

Figure 12 show the relationship between mean size and velocity. From the figure, noted that the fall velocity will

increased if the numbers of mean size become greater. The maximum fall velocity was recorded at the station 3 with 8.25 m/s and the minimum velocity was recorded at station 4 to station 5 with 0.23 m/s. the range between highest and lowest is about 8 m/s. The average velocity for day 2 is 3.8 m/s.

4.3 Density

Practically all sediments have their origin in rock material and, hence, all constituents of the parent material usually can be found in sediments. Based on the study cases, the major sizes of sediment are in range between 2 mm- 0.25 mm (Refer Figure 8 and Figure 9).

The density of most sediment smaller than 4mm is 2650 kg/m^3 (specific gravity, s = 2.65) [4].

5. Sediment Rate

Based on flow and size of sediment data, the sediment discharge for the five stations can be forecasted by using Duboys and Schoklitsch formula. Before the calculation for Duboys, the data for size of sediment is significant to get the sediment discharge. The data for flow are used to calculate the Schoklitsch formula

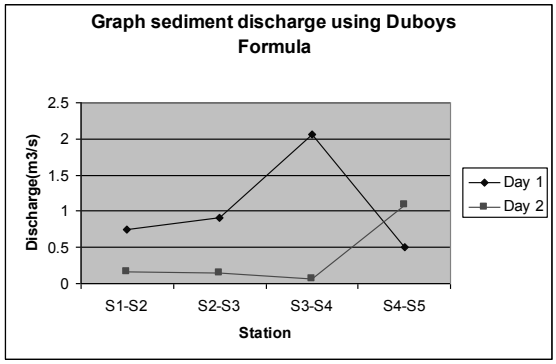

Fig. 13. Graph for sediment discharge for first and second day

Figure 13 show the rate for sediment at 5 locations within two days. The highest discharge is recorded at day one with 2.06 lb-sec/ft and the lowest rate is recorded at day two with 0.074 lb-sec/ft. An average for day 1 is 1.05 lb-sec/ft and for day 2 is 0.369 lb-sec/ft. The range between the highest and the lowest rate for first day is 1.555 lb-sec/ft and for second day is 1.007 lb-sec/ft. In order to get the value for sediment discharge, some of information should be considered such as channel slope and mean size of sediment. So, the rate is not same even at the same station.

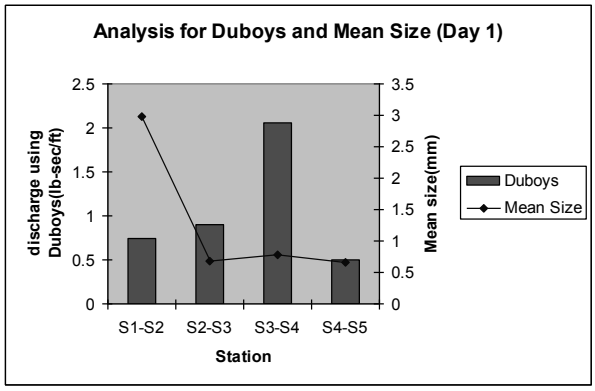

Fig. 14. Relationships between Duboys and Mean Size (Day 1)

As mentioned before, the mean size is not give a much effect to the sediment discharge because some others factors should be considered. The sediment discharge at Station 3 to Station 4 shows the highest value than other station. The mean size at Station 1 shows the highest value with 2.63 mm than other stations.

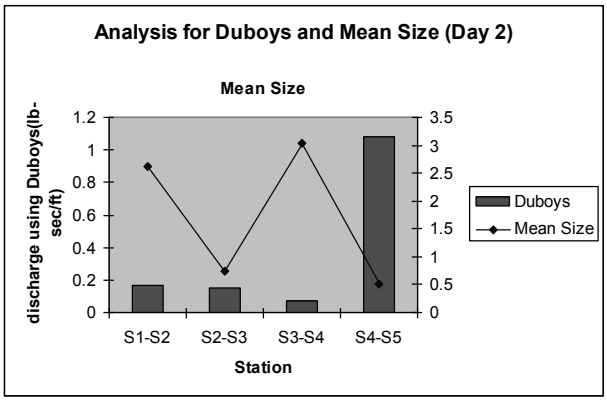

Fig. 15. Relationships between Duboys and Mean Size (Day 2)

Figure 15 show the relationship between Duboys and mean size of sediment. The sediment discharge for Station 4 to Station 5 shows the highest value with 1.08 lb-sec/ft, the factor that effect to the rate of sediment is the mean size of the sediment. If the mean size decreased, the critical shear stress increased. So, the values of sediment discharge become higher.

Table 3. Sediment discharge for first day using Schoklitsch formula

Station	Flow Rate (m^3/s)	Sediment discharge (lb-sec/ft)
S1-S2	6.187	1.12
S2-S3	3.55	0.495
S3-S4	2.421	0.279
S4-S5	2.924	0.263

Table 4. Sediment discharge for second day using Schoklitsch formula

Station	Flow Rate (m^3/s)	Sediment discharge (lb-sec/ft)
S1-S2	5.806	0.923
S2-S3	4.04	0.634
S3-S4	5.289	0.907
S4-S5	4.55	0.706

Table 3 and Table 4 show the sediment discharge calculated using Schoklitsch for 5 stations at Sungai Lembing, Kuantan.

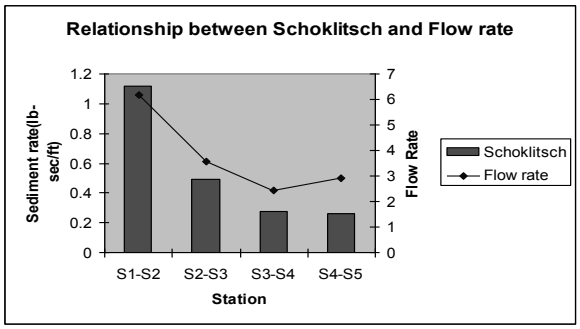

Fig. 16. Relationship between Schoklitsch and flow rate (Day 1)

Station 1 show the highest flow and sediment discharge among the other station with 6.187 m/s and 1.12 lb-sec/ft. as

shown in Figure 16. The factors that affect the sediment discharge at this station is a depth of the river is shallow that other station. In addition, the sizes of the rock also contribute to the maximum value of the flow rate among the other stations. The lowest sediment rate show at Station 4 with 0.263 lb-sec/ft. the rate for this station is minimum because the size of sediment contain the very finer sand so it taken the long time for that particle to submerge to the bottom of the river. The others factor may affect the discharge is the flow at the station is too low compared to others station.

Figure 17 shows that the sediment rate at station 1 till 5 was increased. It happens due to the heavy rain and higher flow rate on that day.

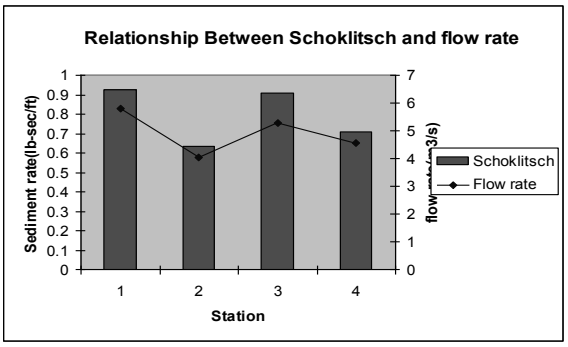

Fig. 17. Relationship between Schoklitsch and flow rate
(Day 2)

6. Conclusion

Study of sediment is needed to ensure weather that area is suitable to build residential are or not. This study also can determine the factors contribute flooding. Based on DID, Sg. Lembing is the one place have highly probability to faced flooding among the others places.

Based on the calculation using Duboys and Schoklitsch formula, it show that the maximum rate using Duboys formula is 2.06 lb-sec/ft which located at the Station 3. Meanwhile, the minimum rate is 0.073 lb-sec/ft which located at same located at same station but different day. The results for this formula are quite different because the rate is related to the size of sediment. If the sizes become bigger, the rate for sediment to submerged into the bottom become higher.

The results of rate using Schoklitsch formula are quite different than using Duboys Formula. It because by using Schoklitsch formula, the flow of the water should be considered in order to get the results. As the results, the maximum flow for flow rate using Schoklitsch formula is 1.12 lb-sec/ft while the minimum rate is about 0.495 lb-sec/ft. Both rate occurred in Station 1 and Station 2.

Data for size sediment at the five locations have been analysis by using mechanical shaker at the laboratory. From the analysis, the mean size of the sediment was determined. The major size of sediment was recorded at Station 1, Station 2, Station 3, Station 4 and Station 5 is 2 mm-0.5 mm (Medium sand) and the minor size of sediment for the five ungauged station is 0.25 mm- 0.0625 mm(very fine sand). The station that shows the highest medium sands is about 50% from the weight of sample which located at Station 3. Meanwhile, the lowest of medium sand is about 10% which located at station 1. The data of size sediment is quite important because can know the size of material that submerged in the bottom of the river. If the size of sediment it's bigger, the depth of the river becomes shallow and as a result a flood will occurred in high rate.

Fall velocities of sediment also are some important thing should be considered. It because the researcher can know the velocity for sediment will be submerged into the base of the river. From the analysis, the maximum of fall velocity is about 8.0 m/s, located at Station 1. Meanwhile, the minimum fall velocity is about 0.23 m/s was recorded at Station 4. The factor may affect the fall velocity is mean size of sediment. As the mean size become greater, the fall velocity in meter per second also will increase.

The density of sediment still in initial level and the researchers need to find new techniques and appropriate equipment in order to get accurate density. [4], said that the density for the sediment smaller than 4 mm is 2650 kg/m^3 with specific gravity is 2.65. Based on the analysis of sediment types, the major size of sediment at Sungai Lembing is range between 2mm-0.5mm (medium sand). So the most density from for Station 1 until Station 5 is 2650 kg/m^3.

Acknowledgment

The authors gratefully acknowledge the University Malaysia Pahang, Malaysia, for providing the Research Short Grant

(RDU 070335) [5,6].

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