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A STUDY OF SEDIMENT LOAD: CASE STUDY AT PARIT BOTAK CHANNEL, BATU PAHAT, JOHOR, MALAYSIA

ZARINA MD. ALI[1], DWI TJAHJANTO[2], NAZAHIYAH RAHMAT[3], MOHD IDRUS MOHD MASIRIN[4], SABARIAH MUSA[5], ISMAIL ABD MANAN[6]
[1,2,3,5] Department of Water and Environmental Engineering
[4] Department of Geotechnics and Highway Engineering
Faculty of Civil and Environmental Engineering
Universiti Tun Hussein Onn Malaysia
86400 Parit Raja, Batu Pahat, Johor
Malaysia
[1]zarinaa@uthm.edu.my, [2]dwi@uthm.edu.my, [3]nazahiya@uthm.edu.my [4]idrus@uthm.edu.my
[5]sabariah@uthm.edu.my

ABSTRACT

Such drainage channels in the State of Johor, especially located in rural area are facing sedimentation seriously due to unlined channel. A field research at Parit Botak Channel has been carried out to study the sediment load and its transport during tides effect. Samples were made along the channel from upstream up to estuary yielding that most of soils are marine clay (BS 1201: Part 2:1973), flow of channel varies from 9.7 to 89.91 m^3/s, correlation between turbidity and suspended sediment R^2 is 90%, and correlation between flow rate and sediment transport R^2 is bigger than 92%.

Keywords: Drainage system; Sediment load; Transport.

INTRODUCTION

Currently, many unlined drainage channels are facing significant problems either caused by flood flow or human activities. Parit Botak as unlined drainage channel is selected to be studied as it is facing serious sedimentation in the channel. Similar with unlined drainage channel, the stream riverbed is destructed as well. Even more, characteristically the stability of riverbank is also affected by floods and erosion will happen increasingly in long term process. Many problems of river management rise from the adequate prediction of sediment behaviour during flood flows. Some of this uncertainty comes from the complex nature of drainage system and the incomplete understanding of the links between runoff and sediment sources both within and outside the river channel. Study on sedimentation is more to be acquainted with the behaviour of sediment load in a river where it is based on the types of riverbed. It is found that those alluvial rivers always under non-equilibrium conditions and the sedimentation process is higher than the gravel bedded rivers due to the variables inflow, sediment supply and human activities [1, 2]. Sediment transport is classified into wash load and bed material load. The wash load is composed of very fine particles that do not exist in riverbed materials. The bed material load is composed of suspended load and bed load. The suspended solid is measured and it is supposed to include the wash load and part of suspended load [3]. The movement of sediment in the stream systems is a function of many parameters related to the flowing water and characteristics of sediment [4]. Besides, variable source areas of sediment, non-uniformity of channel geometry and flow, dynamic/adjusting channels and tidal effects at the estuary also influence the sediment transport [5, 6].

Purpose of the Study. The purpose of this study is to determine the sediment transport in the channel and to obtain the relationship between flowrate and suspended transport and turbidity with suspended solid. Parit Botak channel was selected as the channel is facing serious sedimentation. This study is important for maintaining the channel to ensure that the social economic of surrounding people can be monitored. It also concerns the relation of suspended sediment and turbidity in determining the level of sedimentation and discharge of water. Sediment transport can be used to solve the engineering and environmental problems related to the flood control and human activities at the area.

Case Study. Parit Botak channel is indicated to be eroded channel which is located in Rengit village nearby District of Batu Pahat, Johor. The location of study area is shown in Fig. 1 as far as 35 km from Batu Pahat town (01^o 51' 00 North Latitude, 102^o 55' 60 East Longitude). Some areas have been developed into residential and small industrial area, but previously they were agricultural land.

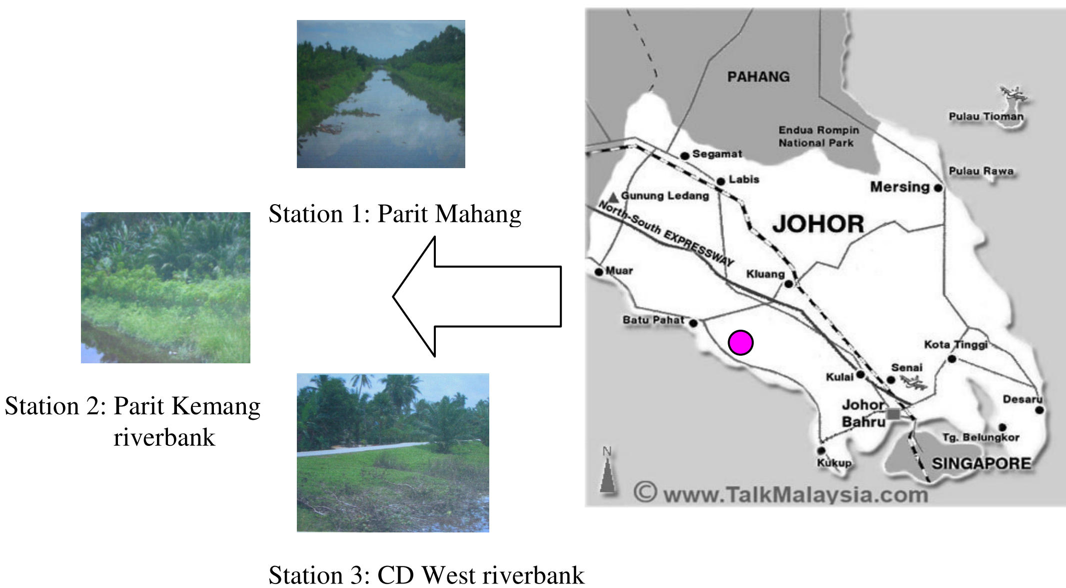


Figure 1: Location of Study Area

The channel flows from Parit Haji Hamid (1.886^o North, 103.152^o West) for left bank and (1.886^o North, 103.153^o West) for right bank and ended at the downstream of Parit Botak river (1.710^o North, 103.081^o West) for left bank and (1.710^o North, 103.081 West) for right bank. Table 1 shows the three selected locations of in-situ measurement along the channel.

Table 1: Location of In-situ Measurement

Station	Coordinate				Height from datum (m)	Remarks
	Left Bank		Right Bank			
	North	East	North	East		
1	1.786^o	103.108^o	1.784^o	103.109^o	5.75	Located at the upstream, and near to agricultural land
2	1.768^o	103.107^o	1.786^o	103.109^o	5.15	Located at the middle of river and near to the small area for industrial activities
3	1.733^o	103.105^o	1.732^o	103.106^o	4.10	Located at joined of 2 rivers and near to agricultural land and palm oil estate

MATERIALS AND METHODS

Data were collected at three selected locations along the Parit Botak channel. The measurement was carried out in-situ within one month time (30-04-2004 to 20-05-04) for four samplings. The samplings were based on three different types of tidal conditions (low, middle and high tides for river profiles), velocity of water and soil samples. While, the laboratory test was prepared for determining the soil characteristics.

In-situ Measurement. The in-situ measurement is divided into three works:

(i). *River characteristics:* In determining the sediment in river, some of river characteristic have been investigated such as distance between stations, shape of bed channel, cross section of river, width of river, type of channel, type of meandering, depth of flow, sediment characteristics and distribution of soil particles.

(ii). *Velocity:* The velocities of river were determined by three levels based on the depth of water. If the depth of water d is less than 0.5 m, the velocity will be measured at 0.6d. But, if d is higher than 1.0 m, the measurement will be determined at 0.2d, 0.6d and 0.8d. This study used 0.2d and 0.8d since the depth of flows is between 0.5 m to 1.0 m. Valeport BFM001 current meter was selected as the apparatus in measuring the velocity. Therefore, flowrate of river can be calculated by mean-section method.

(iii). *Soil sampling:* A grab sampler has been used to collect samples of soil in the channel to determine the soil characteristics.

Laboratory Analysis. The laboratory analysis is divided into three works:

(i). *Wet sieving and Hydrometer analysis:* Particles sizes distribution were obtained from the wet sieving and hydrometer test which is based on Yang, et al, (1996). It mentions that particle sizes distribution analyses would be made for both bed material and measured suspended load. This analysis has been carried out for the soil sample to find out the density of soil and also the distribution of particles sizes in range of (60-2 μm). Actually, this test not usually performs if less than 10 percent of material passes the 63-μm sieve.

(ii). *Suspended sediment:* Organic and non-organic particle with a 0.001 mm size are called suspended particles. Determination of suspended solid is to identify the volume of suspended sediment in the river (organic and inorganic particles) that is transported by water.

Photometric method or Nonfilterable Residue has been used to calculate the value of suspended solid using HACH DR 890 apparatus.

(iii). *Turbidity:* Soil sample has been tested by using HACH DR 890 to determine the value of turbidity. The relationship between turbidity and suspended solid and between discharge and suspended transport will be elicited by correlation method. Analysis on the development of sediment transport and loading were done based on the low and high water level.

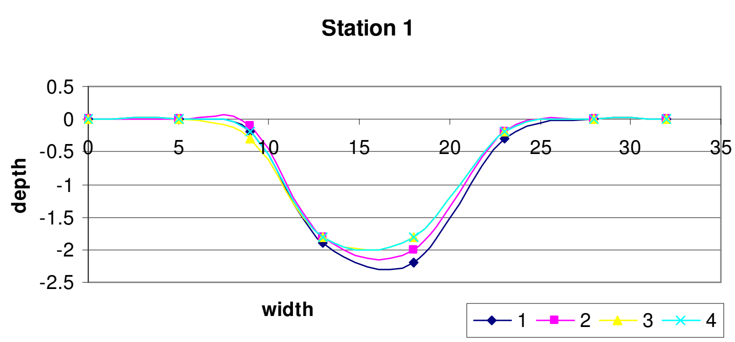
RESULTS AND DISCUSSION

In-situ Measurement. As a result, Table 2 summarizes the value of flowrate and measurement of bed level for all stations. Flow rates were founded varies from 9.70 m^3/s to 89.81 m^3/s due to the tides conditions. However, the levels of bed channel measured are in the range of 1.8 to 2.30 meter from the water surface. Furthermore, the bed level is decreasing according to the number of sampling.

Table 2: Flowrate and Bed Level of Three Stations

Station	Number of sampling	Tides Condition	Flowrate (m^3/s)	Bed level (m)
1	1	Low	86.26	2.20
(Parit	2	Moderate	23.12	2.00
Mahang)	3	Low	58.10	1.90
	4	High	27.90	1.80
2	1	Low	89.81	2.30
(Parit	2	Moderate	49.93	2.10
Kemang)	3	Low	77.47	2.10
	4	High	9.70	1.90
3	1	Low	63.38	2.00
(CD	2	Moderate	36.59	2.10
West)	3	Low	32.94	2.10
	4	High	69.40	1.90

The channel profiles have been illustrated in Fig. 2 to show the changes of channel shape by referring the stations.



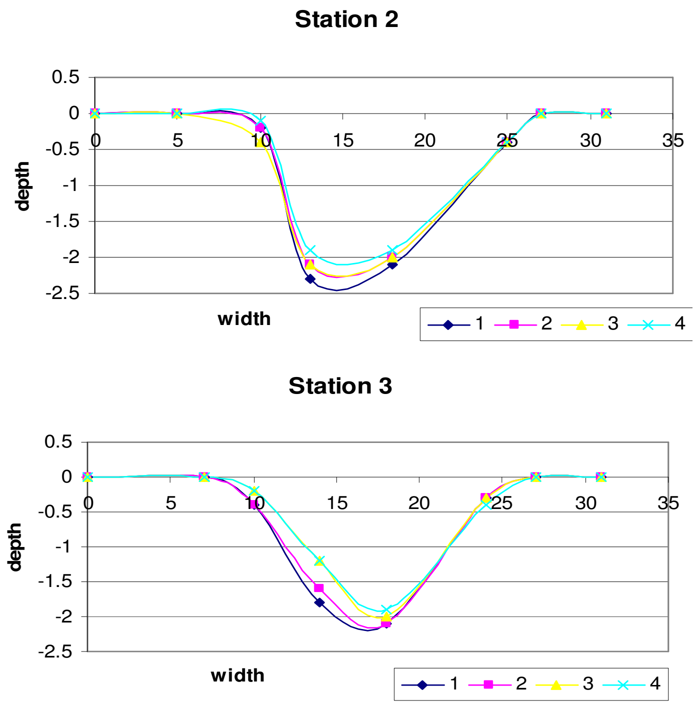


Figure 2: The Profile of Channel at Station 1, Station 2 and Station 3

Fig. 2 shows the height of bed level at station 1, station 2 and station 3 decreasing by number of sampling. The difference between 1st sampling and 4th sampling is about 0.1 m to 0.4 m. From the figure, the cross sections at the stations change due to the erosion process especially at station 1 and 2 occurred at the left and right bank of channel. While station 3 profile shows that the riverbank at the left section had an addition of volume at 4th sampling.

Laboratory Analysis. The results of analysis of soil sample show that particle of soil of less than 0.002 mm dominated the soil distributions which are illustrated in Fig. 3 (a), (b) and (c). While the density of soil was measured as 1.65 g/cm^3 for all stations.

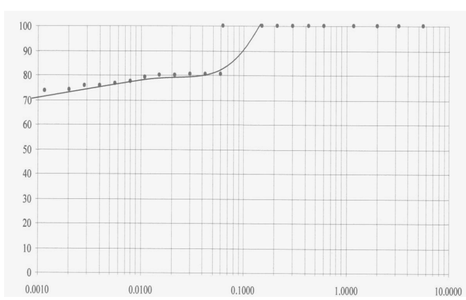


Figure 3 (a): Sieve Analysis Result at Station 1

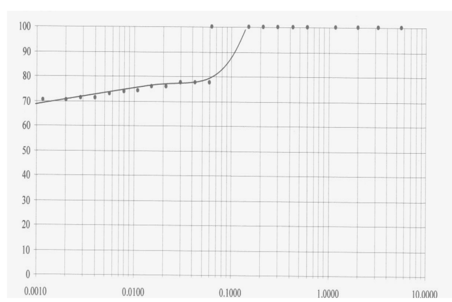


Figure 3 (b): Sieve Analysis Result at Station 2

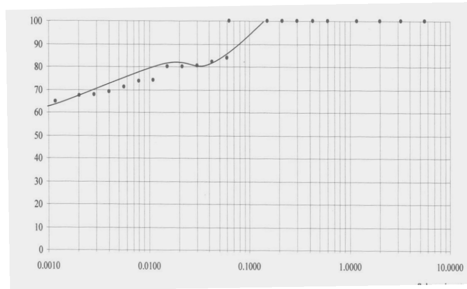


Figure 3 (c): Sieve Analysis Result at Station 3

The clay soil (<0.002 mm) dominated 73% of soil distribution size in Fig. 3 (a). Besides, the soil also conquered 70% and 65% of distribution size in station 2 and 3 in Fig. 3 (b) and 3 (c) respectively.

Overall, the distributions of soil were dominated by clay soil from 65% to 73 %. Moreover, the average of particles size, D_{50} were recorded in between of 0.001 mm and 0.002 mm. The moisture content has been configured at each station as more than 75 % which is plotted in Fig. 4. Thus, 78.53 % has been calculated as the average of moisture content.

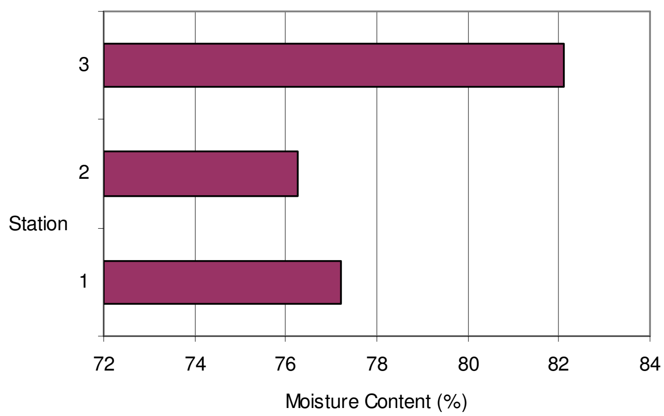


Figure 4: Moisture Content

Therefore, the soils can be categorized as soft marine Clay by referring to soil classification in BS1201: Part2:1973. On the other hand, Table 3 tabulates the result of suspended solid and turbidity from the soil sample.

Table 3: Suspended Solid and Turbidity of Soil Sample

Station	Number of sampling	Suspended solid	Turbidity
1	1	110.5	168.0
(Parit	2	87.0	122.
Mahang)	3	87.2	121.2
	4	125.5	170.7
2	1	160.2	183.8
(Parit	2	12.2	175.7
Kemang)	3	103.2	136.8
	4	186.7	217.3
3	1	229.7	264.2
(CD	2	268.3	293.7
West)	3	243.7	214.5
	4	224.3	255.8

Table 3 shows that the suspended solid varies from 87 mg/L to 125.5 mg/L at station 1, 103 mg/L to 186 mg/L at Station2, and more than 200 mg/L at station 3. Meanwhile, the turbidity values of 75% were reached higher than 150 NTU. At every third sampling, the values were quite lower than others due to low tides condition.

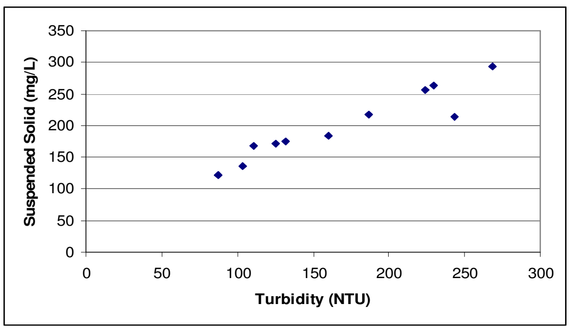


Figure 5: Relationship between Suspended Solid and Turbidity

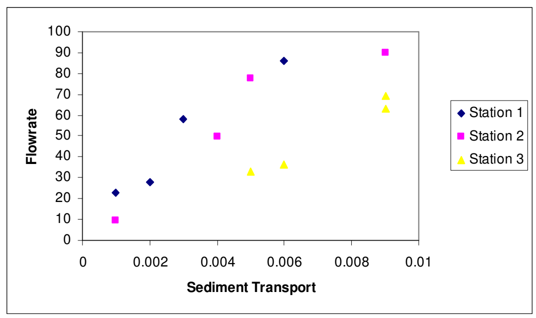


Figure 6: Relationship between Flowrate and Sediment Transport

The relationship between turbidity and suspended solid is shown in Fig. 5 where R^2 is equal to 0.9038. It also states that the relationship is directly proportional and depends on each others. While, Fig. 6 shows the relationship between flowrate of channel with sediment transport at the stations. The sediment transport has been calculated by

$$Q_s = \frac{QS}{\rho 1000^2} \quad (1)$$

where, Q_s = sediment transport, Q = flowrate (m^3/s), S = Suspended Solid (SS) in mg/L and ρ = density (g/cm^3) [3].

The correlation values for those stations were 97%, 92.6% and 99.2 % respectively. It shows that when the flowrate increased in station 1 and 2, the increments of suspended transport are low.

CONCLUSIONS

1. This study demonstrates the turbidity of water is directly proportional with the suspended solid.
2. The flowrate has played as the major part in transporting the solid sediment to other section of channel.
3. The distribution of soil particles which is dominated by soft clay marine also has contribution in transporting the solid sediment.
4. The bed level and cross section of channel have changed within one month observation.

SUGGESTION

Maintenance works and water quality control is required in order to keep the effectiveness of channel.

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