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Investigating the Permeability of Dredged Sediment Material on Sengguruh Reservoir

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***Abstract*— *The dredging activity of sediments in reservoirs is often carried out to maintain the lifetime of the reservoir from sedimentation, one of which is the Sengguruh Reservoir, in Malang Regency, East Java Province, Indonesia. The dredged sediment has wet initial conditions in dispossal area (spoilbank). Limited amount of spoilbank requires emptying of spoilbank quickly so that dredging activities can be continued. In emptying the spoilbank it is not easy because the sediment conditions are still wet for a long time. Thus an investigation is needed regarding the sediment material properties specially related to the permeability coefficient. Investigation was carried out by Investigation was carried out by sampling at spoilbank, analysis of grain and soil type, testing of permeability coefficients in the laboratory and microstructural testing by using Scanning Electron Mcroscope (SEM).*

Keywords* — *Permeability coefficient*, SEM, *Sediment.

I. Introduction

Sengguruh Reservoir is the first reservoir in the Brantas river system (Brantas River Basin). It functions to protect the Sutami Reservoir from sedimentation as well as to generate electrical energy in the amount of 2 x 14.5 MW [1] PJT I. Currently the effective reservoir capacity of the Sengguruh reservoir is only 24% of the initial conditions. For this reason, sediment dredging activities are needed throughout the year, but these activities are limited by the amount of spoilbank that cannot be added due to land issues.

In order for the existing spoilbank to be utilized more optimally it is necessary to empty spoilbank. In practice emptying is difficult to do quickly because the sediment conditions in the spoilbank after dredging are still wet and require a long drying time. This inhibits dredging activities, because the annual need for dredging should be at least 300,000 m^3 / year cannot be done consistently [1] PJT I.

Sediment soil is a soil material that also has a certain permeability level. Permeability is the nature of porous material that allows the flow of seepage from liquid in the form of water or oil to flow through the porous cavity. [2] Christady. Soil pore vary for different types of soil. In addition, there is a correlation that can be stated empirically between the size of the soil grain and the soil permeability coefficient [3] Irawan et al.

In this paper, we will discuss the causes of the drying time of sedimentary soil in the spoilbank of Sengguruh Reservoir, namely by investigating the permeability coefficient (k), soil type and microstructure of the material using SEM.

II. Materials and Method

Research Sites

The location of this study was carried out at spoilbank of Sengguruh Reservoir, Malang Regency, East Java Province, Indonesia.

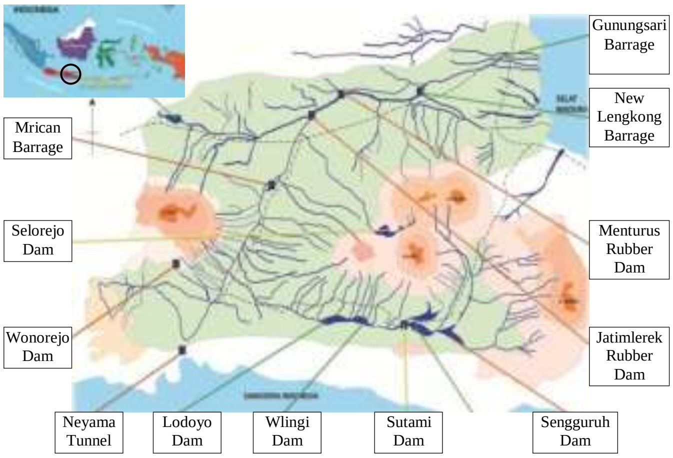

Fig. 1. Brantas River Basin Map

Fig. 2. Location of Sengguruh Reservoir

Analysis Method

The following are the step of study:

1. Prepare the test pit with dimension 5.0 m x 5.0 m and 2.0 m depth.
2. Fill the test pit with sediment
3. Core sampling at days 30 after filling.

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4. Permeability test (Falling Head: ASTM D-2434-68), grainsize analysis, consistency test, SEM test.
5. Conclusion

Test Pit Preparation

Fig. 3. Test pit

Test pit are made by digging land measuring 5.0 m wide x 5.0 m long x 2.0 m deep, then the pit's wall is protected with bamboo to prevent from collapse.

Fill the Test pit and core sampling

Fig. 4. Core sampling

Core sampling was taken after test pit filled with dredged sediment. Samples were taken at 3 different depths, 0.5 m, 1.0 m and 1.5 m.

Permeability test

Permeability test carried out in laboratory by ASTM standard using falling head method. For comparison, then the permeability coefficient is calculated using a formula proposed by Irawan [4] as follows:

$$y = 205.21e^{-0.081x} \quad (1)$$

where :
y : Permeability coefficient
e : euler number
x : Precentage of number 200 sieve passing

The equation (1) is can be applied to soil which have more than 25% fine grained.

SEM

SEM (Scanning Electron Microscopy) is a tool to get information related to sample structure with magnifications ranging from 10 to 3,000,000 x with a dept of fields 4 - 0.4 mm and resolution 1 - 10 mm. This assistance causes SEM to be used for research and industrial purposes [3].

By using SEM, it can be seen the shape of the granules individually or the collection of particles forming the soil and their grain interactions. A collection of particles (particle assemblages) is a collection of particles that have a clear boundary, consisting of one or more particle elements. The collection of particles includes matrices, aggregates and connectors [5].

III. Results and Discussion

As the results of the grain size test, it was found that the granules passed the number 200 sieve were more than 50%. The soil is fine grained if the granules pass no. 200 over 35% (USDA) or more than 50% (USCS). From those two criteria, it can be defined clearly as shown in Figure 5. (a) that the granules pass the number 200 sieve are included in the fine grain criteria.

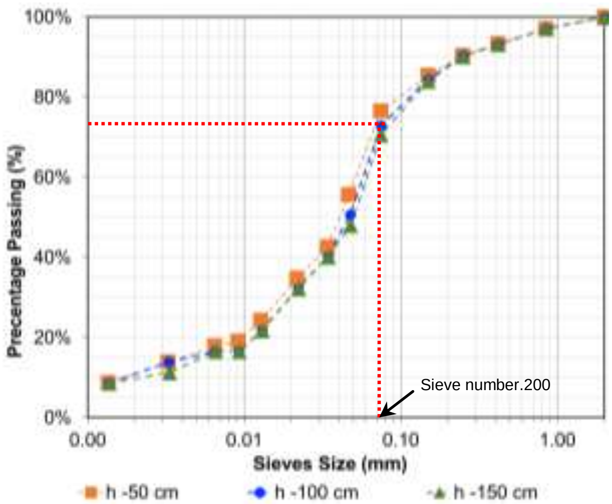

Fig. 5 (a). Grain size distribution

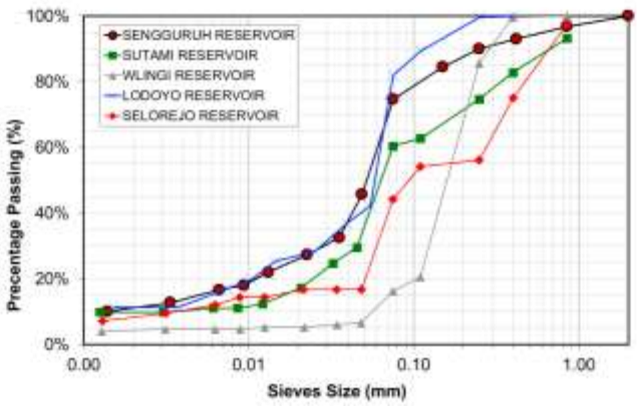

Fig. 5 (b). Sengguruh sediment grain size distribution compared with other reservoir in Brantas River Basin

When the size of the grain of sediment in the Sengguruh Reservoir compared with sediment in other reservoirs in the Brantas watershed, the Sengguruh Reservoir has finer grains.

TABLE 1. Consistency and soil type test results according to AASHTO

Depth (cm)	Sieve Number 200 passing	LL (%)	PL (%)	PI (%)	AASHTO Classifi-cation	explanation
-50	76.53%	49.60	27.53	22.07	A7-6	Clayey Soil
-100	72.92%	48.00	30.26	17.74	A7-5	Clayey Soil
-150	70.64%	48.00	32.83	15.17	A7-5	Clayey Soil

TABLE 2. Soil classification using USCS

Depth (cm)	Sieve Number 200 passing	LL (%)	PL (%)	PI (%)	USCS Classi ficati-on	explanation
-50	76.53%	49.60	27.53	22.07	CH	Clay High Plasticity
-100	72.92%	48.00	30.26	17.74	CH	Clay High Plasticity
-150	70.64%	48.00	32.83	15.17	CH	Clay High Plasticity

Based on table 1 and table 2, it is clear that there are granules of clay in sedimentary material. The smaller the size of the grain, the smaller the permeability coefficient. If plotted in the Irawan chart [4] using equation (1), the following results are obtained:

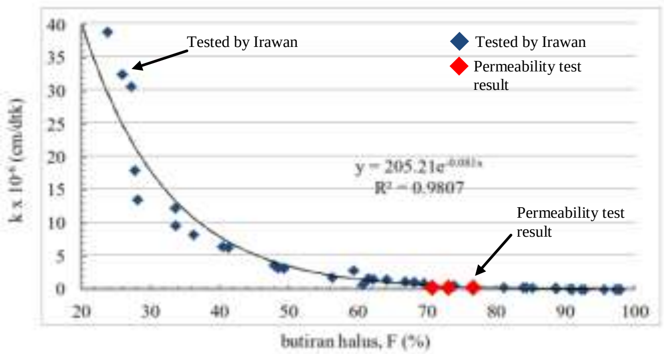

Fig. 6. The results of permeability test in the graph proposed by Irawan

TABLE 3. Comparison of K values obtained from calculations (empirical) and from testing

Depth (cm)	Sieve Number 200 passing	K using equation (1)	K (tested using falling head method)
(cm)	(%)	$x10^{-6}$ cm/s^2	$x10^{-6}$ cm/s^2
-50	76.53%	0.42	0.03
-100	72.92%	0.56	0.03
-150	70.64%	0.67	0.02

In Figure 6 and Table 3, the results of the test just slight different from the results of the calculation in the range of 10^{-6} cm/s^2. The permeability coefficient of the sengguruh reservoir sediment material is too small, which makes it difficult for the material to dry.

Scanning Electron Microscope (SEM)

The microstructure of sediment material using SEM can be illustrated in Figure 7.(a) – (c).

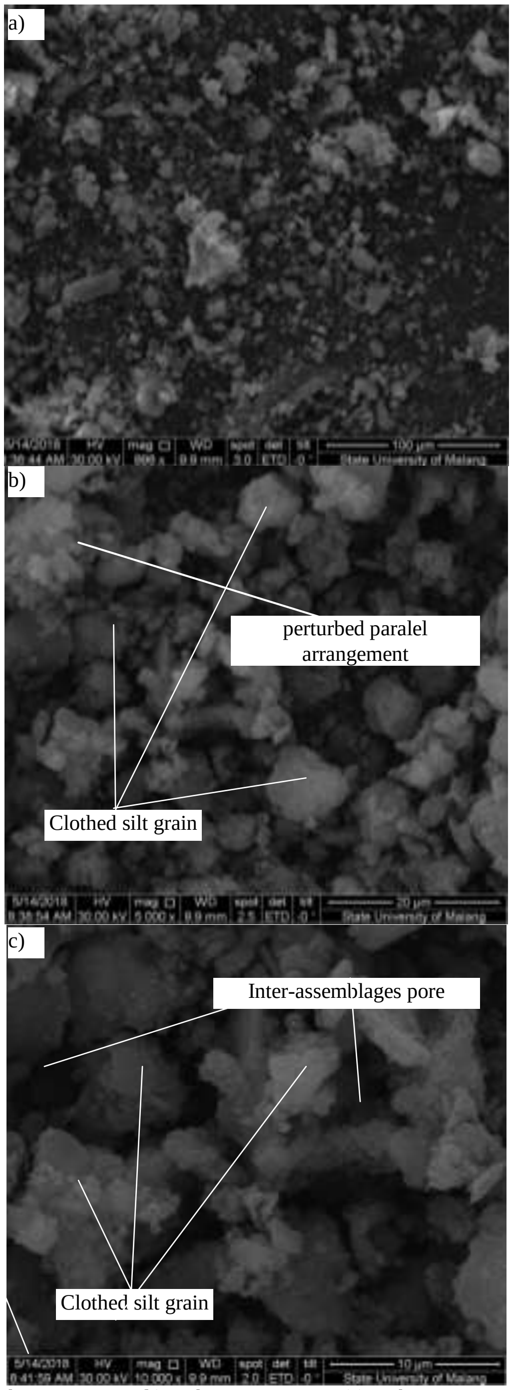

Fig 7 (a) Perbesaran 986 x, (b) Perbesaran 5,000 x, (c) Perbesaran 10,000 x

The results of SEM test on sediment soils indicate that most of them are a assemblages of granules, not individual granules. Those are consists of silt clothed grains, and the collection of these assemblages. The structural material is not 100% clay, but it shows that the silt granules are covered by smaller grains. This causes water to be difficult to get out from the soil. The pores and conectors between the those assemblages also shown clearly. Thus it can be proved that the sediment material is clayey soil according to the AASHTO classification.

IV. Conclusion

The sediment material in the Sengguruh Reservoir Spoilbank is fine-grained soil which has a very small permeability coefficient ranging from 10^{-6} cm / s^2. This causes difficult material to dry. From the classification results of AASHTO is clayey soil, and is supported by the results of SEM test even though it consists of quite small granules, but it is not 100% clay. This investigation is expected to be the initial information for future studies to solve the existing problems related to sedimentation.

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