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STRENGTH OF BRICK MADE FROM DREDGED SEDIMENTS

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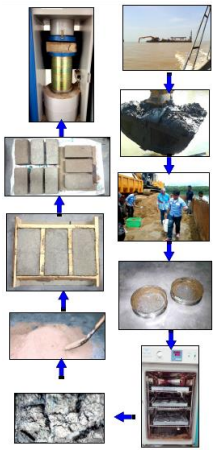
Graphical abstract



Abstract

Dredged sediment can be used in producing bricks for geotechnical engineering purposes including construction of foundations, retaining walls and roads. This study was conducted to determine the strength of brick made from dredged sediments and comparing them with the strength of normal brick. This study was conducted in an experimental form that involves collecting dredged sediment in the river of Sungai Bebar, Pahang, Malaysia and the river of Sungai Setiawan, Perak, Malaysia for analysis. It also involved the use of materials and equipment from laboratory to test the strength of brick. The results obtained from the analysis of data showed that the strength of brick exceeded the standard value for ordinary brick in Malaysia's standard. This support the fact that the brick made from dredged sediment can be used in Malaysian construction industry. The result of this study helps to reduce the volume of dredged sediment to be disposed and to avoid geo-hazards from dredging activities.

Keywords: Dredged sediments; brick; waste management

1.0 INTRODUCTION

Dredging is defined as the excavation of sediment from seabed, lake or river, and commonly performed for navigational purpose [1-2]. Suspended sediment usually has a micro-sized colloidal material and transported from one point to another [3-5]. Sediment composition is trigged from chemical and biology processes during this transportation process [3-5]. Geo-hazard occurs when the disposal of dredged sediment not being managed in a systematic manner, which leads to the requirement of sediment treatment. The treated sediment can be used in the construction of foundation, retaining wall and road.

Contaminated dredged sediments usually are difficult to be managed and require a systematic management system to protect the surrounding society and ecosystems [6]. Disposal of dredged sediment back into the river or the sea can be reduced by using the sediments into brick production. This is because bricks are used extensively in construction industry and have values and advantages. Bricks are commonly used in the construction to build foundation, retaining wall, highway and building [7-8].

The construction industry remains firm strong in Malaysia and has shown positive growth throughout the year, which was driven by the increases in the proposed residential projects [9-10]. At the same time, the increase has led to the increase of demand for bricks for construction activities. This is because in construction industry, brick is a particularly important building material in the making of construction walls, roads, parking lots etc. [11-12].

However, there is not much attention given to the overall demand of bricks. Demands for bricks as construction material has increased and this become a major problem in the construction industry [9]. Although there are various types of brick in the market, they still have weaknesses in terms of strength and quality. In addition, raw materials to produce bricks at present time are reducing and excessively producing bricks using the same raw material will cause adverse environmental impacts. As an alternative, dredged sediments can be used in the making of bricks.

In 2005, around 1 million cubic meter of sediments were dredged from Sungai Setiawan, Perak and was disposed unto the midst of the sea [10]. Moreover, in Sungai Bebar, Pahang less than 1

million cubic meters of sediments were dredged in 2014 and piled in one place. This shows wastage of good material for brick manufacturing. Therefore, to make use of the discarded dredged sediment, it can be used as an additive in brick production.

This study was conducted to identify several issues pertaining to the use of dredged sediment in the production of bricks. The objectives of this study are to identify the compression strength of bricks that made from dredged sediments and to compare it with the strength of ordinary brick. The scope of this study involves Sungai Bebar, Pahang and Sungai Setiawan, Perak based on the fact that frequent sediment dredging activities and rapid industrial activities happen in this areas.

Sediment samples taken from these sites will be brought into the Soil Mechanics Laboratory, Faculty of Business and Technology Management, Universiti Tun Hussein Onn (UTHM) for further investigation. The sediment sample that taken from both rivers will be tested and used in the production of bricks. Data on different mix ratio will be taken and compared according to their respective categories and analyzed to achieve the objectives of this study. Reuse of the sediments that have been dredged from the bottom of the river is important because it can help solve the problem of disposal of sediments that may trigger geo-hazards on the river ecosystem and local community activities. It also can be used as a reference because It also helps to meet the growing demand for bricks in the construction industry.

1.1 Brick

Brick is the world's oldest building material, this is proved with the discovery of brick at central-west region, where construction is carried out at 4000 years century ago [11]. There are different kind of bricks that are produced and each type depends on the type of raw material used in the process of brick manufacturing. Bricks are mostly in rectangular shape and it is made of inorganic materials that are hard and durable. In addition, the usage of bricks in construction industry able to save cost and time [12-13].

1.2 Size and quality of the bricks

Brick is made of clay, sand and cement. According to Malaysia standard MS 76 : Part 2: 1972, it described that brick is a unit used to build wall in buildings with the standard measures of 333.7 mm long, 225 mm wide and 112.5 mm high [14-15].

In terms of quality of the bricks, it can be categorised into three categories which is internal, special and general. A special type of brick is normally used as retaining wall, while common or general type of bricks is suitable for the construction of the outer surface of the building. Basically, the size of the bricks is different according to its types and suitability. Brick size should be in accordance to Malaysia standards (BS 3921, 1985).

1.3 Characteristics of the bricks

The characteristics of a quality brick are as per described below:

i. Bricks that have been burned with perfect, ripe and balanced enable the brick to be firm and durable.
ii. Bricks that are burned usually will change to red color and can hear punding iron sound when tapped to each other.
iii. Possess uniform shape and same size so that easier for bricks binding works.
iv. The brick diffusion rate usually does not exceed 1/6 brick volume or not more than 15% to 25% if soaked in water for 24 hours.
v. Average weight for one unit of brick should be between 2.3 to 3.3 kg.

1.4 Compressive Strength

Compressive strength is the ability of the bricks to withstand the compressive forces without failure or cracking. This is done by using compression testing machine and standards to be met by a brick is as shown in Table 1, based on the Malaysian Standard MS 7.6: 1972.

Table 1 Brick compressive strength

Type of brick	Class	Average minimum compression strength (N/mm^2)
Engineering brick	A B	69.0 48.5
Brick	15 10 7 5 4 3 2 1	103.0 69.0 48.5 34.5 27.5 20.5 14.0 7.0
Brick for layer /damb proof	DPC/L KL	As per requested
Regular Bricks and surface brick normal quality and Unique quality	-	5.2, Except if more high strenght is needed
Brick for internal wall	Bearing load 5.2 Nonbearing load 1.4	Except if more high strength is needed

1.5 Nature of the sediment

Sediment is produced by the weathering process of rocks and its particle void spaces filled with water and air. The weathering process that occurs cause the land to become into residual sediment, where residual sediment formed from the weathering process that does not move, while transportation took place due to the natural

transport agents such as gravity, water and glaciers [13].

1.6 Type of sediment

Sediment has different characteristics that can be identified by its physical properties [14]. Various types can be seen in dredged sediment such as gravel and sand that have coarse grained sediment, while silt and mud is classified as fine-grained sediment. Each type of this sediment is different because the area and the depth of the dredging is different.

1.7 Test on sediment samples

Sieve analysis usually performed in laboratory to identify the type and size of the sediments. Sieve analysis involves the distribution of grain size obtained from analysis of granule size and will be described quantitatively by the weight of the sizes of particles that have been separated according to different sizes [7].

2.0 MATERIALS AND SPECIMEN PREPARATION

The materials and specimen preparation is as shown in Figure 1.

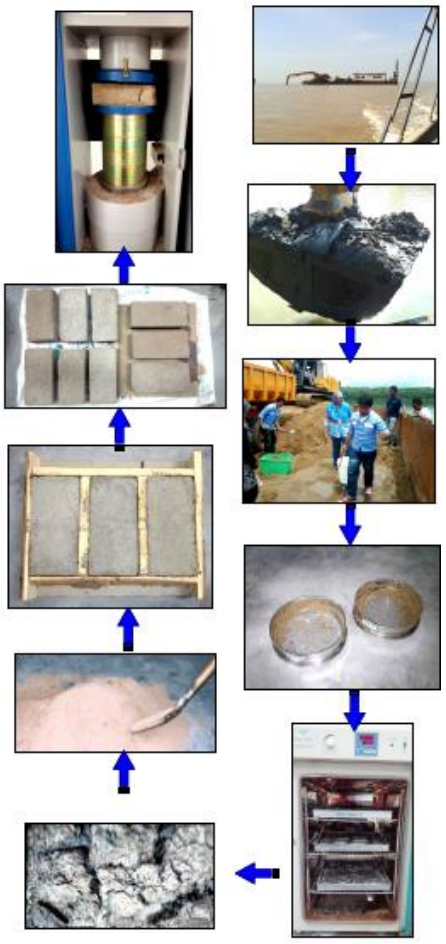


Figure 1 Materials and specimen preparation

2.1 Data collection

This research was conducted based on experimental design, involving material and equipment in the laboratories that is essential in order to test the bricks for strength. The research also involves the use of machinery and equipment, provision of samples and other necessary materials in the laboratory.

2.2 Site investigation and sampling of sediment

Site investigation is an important method for identifying areas suitability to obtain sediments that needed in this research. It should be done with knowledge on the dredging activities, the dredging location and the problems that will arise in that particular area.

Proper sampling technique needs to be done so that all the information in the laboratory is correct in order to conclude on meaningful results. This is because the techniques or methods of sampling analysis that is used will influence the outcome of the tests being done [13].

For this research, samples will be taken from the dredging location and then will be placed into a special container to prevent the sample to be exposed to environmental factors such as sunlight. Each activities at the site will be observed and recorded for evaluation.

2.3 Preparation of raw materials

Materials to be used in the production of bricks are portland cement (OPC), sand and water. While the dredged sediment is used as an additive to reduce the use of sand and cement in producing bricks.

2.3.1 Sediment

Sediment used in this study was taken from Sungai Bebar, Pahang and Sungai Setiawan, Perak. The sediment is taken after an approval was given from the supervisor and the laboratory assistant to go to the dredging area. This also involves authentication from Malaysia Maritime & Dredging Corporation Sdn Bhd, the company who is running the dredging projects at Sungai Bebar and Sungai Setiawan.

The dredged sediment that taken from both rivers was dried in the oven soon after sampling done. This process is done to remove the water from the dredged sediments. After the drying process, the dredged sediment from Sungai Setiawan, Perak was crushed using a grind machine that turned sediments into a powder form. Dredged sediment from Sungai Setiawan contains mud and water; this can prevent the sediment to be used directly in the brick mixing process. Therefore, it is necessary to put the sediments in the oven to be heated up to a temperature of 100 °C so that the water and other organic materials can be removed. The drying process will take about 24 hours before the sediment dredged is completely dried. After drying, it was removed from the oven and the sediment let to be cold and crushed into a powder form. While

the sediment dredged (sand) from Sungai Bebar, Pahang needed only to go through the process of sieving.

2.3.2 Sieve analysis

The samples collected act as a fine material that will be used in brick mixing. Sediment that will be used will go through the sieving process to separate sand and other materials during brick production. In accordance to EN 26 Part 1: 1991, the sediment should be sieved according to guidelines and dried for at least 24 hours before use. The purpose is so that the sediments became saturated and dried to avoid disturbing the water content in brick mixture. Sieve size used in these experiments is the size of 5 mm.

2.3.3 Cement

The cement used was from Portland cement category, as in accordance to MS 522 part 1: 1977. Cement is an important substance that acts to bind solids. Cement is made from a mixture of minerals such as limestone and clay while the cement composition is alumina, calcium oxide and silica [11]. The wet condition of the brick mix will solidify and harden after cement was added.

2.3.4 Water

Water that is used should be free from acid, alkali and organic matter. It should be clean from materials that can interfere with the hidration process and workability of the brick. The water content in the manufacture of bricks made from dredged sediment is 15% of the total weight of the bricks. The water content in the mixture should be controlled so that it will not affect the structure of the brick to be produced which will cause the brick particles to become weak.

2.3.5 Sand

Sand is an important component in brick manufacturing. The ratio of sand will be reduced depending on the increase of the percentage of dredged sediment in the production of bricks. The sand used should be free of organic material and dried so that the moisture content in the sand will not affect the bricks.

2.3.6 Mixing process

The first step of mixing process is to mix the cement and water before the sand is added. The mixing is done in a container. The difference in production of this brick is dredged sediment also will be mixed with the cement based on the fixed percentage and finally will be mixed with water. Manual method will be used to mix the sediment, cement and water by using shovels and spatula. To avoid wastages and errors, materials that are used will be calculated.

The process of brick production will use wooden molds based on the size of the brick 215 mm x 102 mm x 65 mm. After the mixture has been prepared, it will be inserted into the mold after the mold being rubbed with oil. This oil acts as removal agent so that the bricks easy to be removed from the mold when completed.

Mold will be placed on a vibrating table and mixes will be added in stages so that the material completely fills the mold used. Then, it is left for 5 minutes to allow the mixes to become compressed bricks. Bricks that were produced will be left for 24 hours so that it is easier to remove the bricks from molds. The mold should be opened slowly so that the bricks do not have cracks or be broken. The bricks will be placed in the laboratory and left to dry in room temperature. The brick will also be placed in open area and exposed to the sunlight then watered to assist the process of hardening of the bricks. This is called curing process.

2.4 Experimental Method

The experimental method involves three types of different percentage of dredged sediment to produce bricks. For sample 1, the percentage content of the dredged sediment is 15%, sample 2 using dredged sediment percentage of 20% and the percentage of the sample 3 using dredged sediment by 25% (Table 2). All types of bricks using the same methods, techniques and the same mold but the difference is the dredged sediment percentage in each mixtures.

Table 2 Percentage of dredged sediment

No.	Cement (kg)	Sand (kg)	Dredged sediment (kg)	Dredged sediment (%)
Sample 1	0.100	0.680	0.120	15
Sample 2	0.100	0.640	0.160	20
Sample 3	0.100	0.600	0.200	25

2.5 Compression Test

Compression tests will be carried out to all bricks during days 7 and 28. The tests was performed using a compression machine brick.

3.0 RESULTS AND DISCUSSION

Table 3 shows the compressive strength of brick made from sediment dredged from Sungai Bebar and Sungai Setiawan (sample 1). The compressive strength of brick that mixed with dredged sediment by 15 % was tested. These samples used dredged sediment from Sungai Bebar has increased in its compressive strength from day 7, with an average value of strength 9.2 N / mm², to an average strength of 10.6 N / mm² at day 28. As for Sungai Setiawan, the strength of brick made from dredged sediments at day 7 shows the average strength of 6.3 N / mm² and increased at day 28 to 7.1 N / mm². The strength of sample 1

from Sungai Bebar and Sungai Sitiawan recorded the highest average strength of brick compared to sample 2 and the sample 3.

Table 4 shows the compressive strength of sediment dredged from Sungai Bebar and Sungai Setiawan for (sample 2). The strength of the brick that mixed with dredged sediment by 20% was tested. Compressive strength of sample 2 that is made using sediment dredged from Sungai Bebar increased from day 7, with an average value of strength 8.4 N / mm² to 8.9 N / mm² at day 28. As for Sungai Setiawan, on day 7 the strength is 4.9 N / mm² and increased at day 28 to 5.7 N / mm².

Table 5 shows the compressive strength of sediment dredged from Sungai Bebar and Sungai Setiawan for sample 3. The brick strength that mixed with dredged sediment by 25% was tested. Compressive strength of the samples using sediment dredged from Sungai Bebar increased at day 7, with an average value of strength 6.5 N / mm² to of 7.3 N / mm² at day 28. As for Sungai Setiawan, on day 7 the strength is 4.7 N / mm² and increased at day 28 to 5.2 N / mm². The strength of sample 3 had the lowest average strength to compare to brick strengths for samples 1 and 2.

Table 3 The average value of compressive strength at day 7 and 28 for Sample 1

Sample 1 (15% usage of dredged sediment)				
Dred. sed.	**Comp. strength (N/ mm²)**	**Ave. 7 days (N/ mm²)**	**Comp. strength (N/ mm²)**	**Ave. 28 days (N/ mm²)**
Sungai Bebar	8.9	9.2	10.2	10.6
	9.1		10.8	
	9.6		10.8	
Sungai Setiawan	6.0	6.3	7.2	7.1
	6.4		6.8	
	6.4		7.2	

Table 4 The average value of compressive strength at day 7 and 28 for Sample 2

Sample 2 (20% usage of dredged sediment)				
Dred. sed.	**Comp. strength (N/ mm²)**	**Ave. 7 days (N/ mm²)**	**Comp. strength (N/ mm²)**	**Ave. 28 days (N/ mm²)**
Sungai Bebar	8.2	8.4	8.7	8.9
	8.2		9.2	
	8.7		8.9	
Sungai Setiawan	5.2	4.9	5.8	5.7
	4.8		5.6	
	4.8		5.6	

Figure 2 shows the results of the compressive strength of the bricks made using sediment dredged from Sungai Bebar. The compressive strength of brick made from dredged sediments of Sungai Bebar have been compared with ordinary brick strength. The strength of the brick made from dredged sediments is decreasing as the percentage of sediment dredged increased. However, the strength of the bricks that used dredged sediment from Sungai Bebar is still above the ordinary brick strength of 5.2 N / mm².

Table 5 The average value of compressive strength at day 7 and 28 for Sample 3

Sample 3 (25% usage of dredged sediment)				
Dred. sed.	**Comp. strength (N/ mm²)**	**Ave. 7 days (N/ mm²)**	**Comp. strength (N/ mm²)**	**Ave. 28 days (N/ mm²)**
Sungai Bebar	6.4	6.5	7.2	7.3
	6.8		7.2	
	6.4		7.4	
Sungai Setiawan	4.2	4.7	5.1	5.2
	5.2		4.8	
	4.6		5.6	

Figure 3 shows the results of the compressive strength of the bricks made using sediment dredged from Sungai Setiawan. The result of the strength of the brick from Sungai Setiawan using dredged percentage of 15%, 20% and 25% have been compared with ordinary brick strength. The brick strength is decreasing as the percentage of dredged sediment increased. However, the strength of the bricks made from dredged sediment is still above ordinary brick strength of 5.2 N / mm², except the strength of the brick which is using dredged sediment with percentage of 25% that does not exceed the strength of ordinary brick, but have been recorded as an average strength as per ordinary brick.

Thus, it shows that the use of sediment dredged from Sungai Bebar and Sungai Setiawan in bricks using the percentage of 15%, 20% and 25% are suitable to be used as non bearing load wall. Brick made from dredged sediment of Sungai Bebar can be used also as load-bearing walls.

4.0 CONCLUSION

The first objective of this study is to identify the strength of brick that used dredged sediment. The strength of the brick produced by using 15% of dredged sediment from Sungai Bebar, Pahang possessed the highest strength with the average of 9.2 N / mm² for the curing period of 7 days and 10.6 N / mm² for a 28-day curing period. Meanwhile, the strength of the brick that is produced from 15% of sediment from Sungai Setiawan, Perak, also produced the highest strength with the average of 6.3 N / mm² for the 7 days curing period and 7.1 N / mm² for the 28 days curing period.

The second objective is to compare the strength of brick that used dredged sediment with the strength of ordinary brick. Strength of the bricks that are produced by sediment from Sungai Bebar, Pahang through mixing of dredged sediment with 15 %, 20% and 25% is higher than ordinary brick which is 5.2 N / mm². Whereas the strength of the bricks that use sediment from Sungai Setiawan, Perak also exceeded the strength of ordinary brick except the brick that used 25% which the average

strength produced only 4.7 N/ mm^2 on the 7 th day and 5.2 N/ mm^2 on the day to 28.

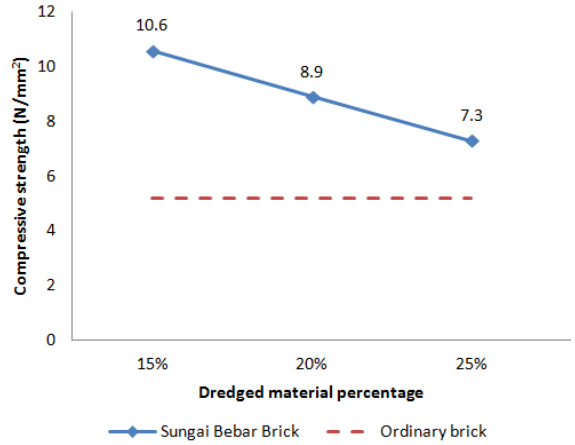


Figure 2 Strength of the brick from Sungai Bebar

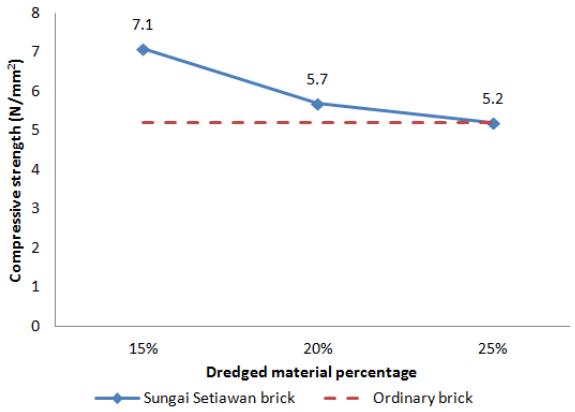


Figure 3 Strength of the brick from Sungai Setiawan

In conclusion, the strength of the bricks that are produced using dredged sediment from Sungai Bebar, Pahang and Sungai Setiawan, Perak can be used in the manufacturing of bricks and this will reduce the usage of sand in the production of the bricks. Results from this study will help to meet the demand of the construction industry in the use of brick in addition to reduce the impact of waste disposal and sediment that can harm the environment.

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