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Application of Drilling Mud Waste as Raw Material In Building Brick Making

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Abstract: *The objective of this research is to study the possibility of using water based drilling mud waste as raw material in the production of building brick making. The water based drilling mud wastes from a petroleum drill hole of Phitsanulok basin, an onshore Tertiary basin located in northern Thailand, had been collected, dried, ground, and analyzed its chemical composition by XRF and XRD analysis. Dried and ground drilling mud waste powders were molded into a square shape steel box size 6.5x16x4 cm. to make the building brick samples and sintered at1000°C, and were then tested according to the American Society for Testing and Materials (ASTM) C67-11 and the Thai Industrial Standard(TIS) 77-2545 B.E. to test their water absorption and compressive strength. The results of laboratory tests showed that the water absorption percent and the compressive strength of building brick samples could be met the acceptable limits and was classified into grade A brick according to the ASTM C67-11 and TIS 77-2545 B.E. standard. Therefore, the reuse of this waste material in the building industry will contribute to the protection of the environment through great advantages in waste minimization and beneficial income to the community through the utilization process in building industry.*

Keywords: *Water based drilling mud wastes, XRF and XRD analysis, Water absorption, Compressive strength, Building brick*

I. Introduction

In petroleum well drilling industry, drilling mud is used in a large amount and also resulted in large volumes of drilling mud waste. Drilling mud wastes were generated both from onshore and offshore wells. Onshore and offshore operators have employed a variety of methods for managing drilling wastes. In the offshore, options are limited to discharge, underground injection, and transport back to shore for disposal. Onshore operators have wider range of options, some wastes are managed onsite while others are removed to offsite commercial disposal facilities. Employed onshore waste management options include land-spreading, land-farming and landfill, evaporation and burial onsite, underground injection, incineration and other thermal treatment[1], bioremediation and composting, and reuse and recycling[2]. Water based mud is a water type mud with the basic elements consisted mostly bentonite and water. Bentonite is a clay mineral in montmorillonite group which its chemical composition is consisted of silica oxide (SiO_2), aluminum oxide (Al_2O_3), and water (H_2O)[3-4]. These compositions are similar to Kaolin and Ball Clay that are used as major raw material in ceramic industry.

Therefore, the idea to reuse the drilling mud waste as a raw material for building brick could decrease transportation cost in disposal process and could also add value to the waste from petroleum well drilling[5].

Though there are some research on using drilling mud waste as raw material in brick making, e.g, Orolinova Z., Mockovciakova A., Dolinska S. and Briancin J. (2012) [1], A.J. Souza, B.C.A. Pinheiro and J.N.F. Holanda.(2013)[2]and Medhat S. E. and Tarek A. O. (2010)[5]in Thailand, there is no any research on using drilling mud wastes as raw material in building brick making. Therefore, this research aims to study the possibility to use this waste material as one of raw material in building brick making industry in the future.

II. Materials and Methods

2.1 Drilling mud wastes
Sample collection

Water-based drilling mud waste samples used in this research had been collected from a petroleum drill hole of Phitsanulok basin, an onshore Tertiary basin located in northern Thailand. They were collected, packed in a gallon, and transported from the drilling site to the Geotechnology and Ceramic Engineering Laboratory of Suranaree University of Technology, NakhonRatchasima province.

Samples preparation

Water based drilling mud wastes were percolated out and dried under sunlight. The moisture was removed one more time in a hot-air oven at 100°C for at least 24 hours. The dried mud waste was sieved through a mesh no. 100. The dried mud waste retaining on the mesh of the size was ground by a milling machine, and sieved through the mesh again. Dried drilling mud waste powders from the oven were stored in a plastic box with a tight lid to prevent moisture.

Dried mud waste powder was unidirectional pressed and molded in a steel box size 6.5x16x4 cm to get building brick samples[6,8](Figure 1) for testing and measurements their chemical composition, compressive strength and water absorption[7]in the next steps.

2.2 Methodology

XRF and XRD analysis

Dried mud waste powder samples chemical composition was determined by X-ray fluorescence (XRF) method by using the XRF spectrometer. The objective of XRF analysis is to determine oxide concentrations in samples. Test method was semi-quantitative X-ray fluorescence spectrometry analysis. X-ray diffraction (XRD) was also conducted to analyze the compounds that were presented in the samples and adopted a detailed study on the crystal structure of the samples[9]. Sample holder is X-ray diffractrometer model Bruker-D2 Phaser.

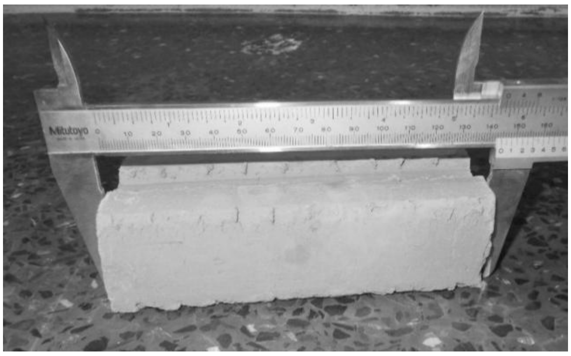

Figure 1 building brick samples

Compressive strength

Compressive strength is capability of material or structure to withstand the forces acting in a specific cross-sectional area in units Megapascal (MPa) or kilograms per square centimeter (kg/cm^2). Compressive strength of a compressible material can be calculated by equation 1[7].

$$C = \frac{W}{A} \tag{1}$$

Where C = compressive strength of the samples (MPa)

W = payload (N)

A = cross-sectional area of the tested part (mm^2)

Brick samples were taken to compressive strength machine at the Civil Engineering Laboratory, Suranaree University of Technology. The results were presented in maximum load of building brick in MPa unit.

Water absorption

For each brick sample the water absorption expressed as a percentage of the dry mass and it can be calculated by equation 2[7].

$$E_{(b,v)} = \frac{m_{2\,(b,v)} - m_1}{m_1} \times 100 \qquad (2)$$

Where m_1 = the weight of dry tile (grams)

M_2= the weight of the wet tile (grams)

The designation E_b is the water absorption determined using m_{2b} and E_v is the water absorption represent water penetration into almost all of the pores determined by using m_{2v}.

Where m_{2b} = the weight of the tile impregnated by immersion with boiling after (gram)

m_{2v} = the weight of the tile impregnated by immersion undervacuum (gram)

Classification of bricks

Building brick can be classified and featured by the maximum water absorption and the minimum compressive strength acceptable specimen tested. The classification and features of bricks are showed in Table 1[8].

Table 1 Classification and features of bricks according to ASTM C67-11 and TIS 77-2545 B.E. standard[8]

Quality	The minimum Compressive strength (MPa)		The maximum Water absorption (%)	
	Average	each lump	Average	each lump
A	21	17	17	20
B	17	15	22	25
C	10	9	not defined	not defined

III. Results and Discussion

3.1 Mud Wastes Elements and Mineral Composition

To investigate the element and the mineral compositions of the collected water based drilling mud wastes, the XRF and XRD analysis were conducted for this purpose. Tables 2 and 3 show the element and mineral composition of the collected water based drilling mud waste dried powder samples from the XRF and XRD analysis respectively.

Table 2 Elements (percentage) of drilling mud waste analyzed by X-ray fluorescence (XRF).

Element	Percentage	Element	Percentage	Element	Percentage
Na	0.48	Ca	-	Ga	-
Mg	2.26	Ti	1.22	Rb	-
Al	15.66	Cr	0.06	Zr	0.04
Si	59.39	Mn	0.21	Mo	-
P	0.12	Fe	15.36	Ba	0.2
S	0.1	Co	0.04	Ce	-
Cl	0.25	Ni	0.04		
K	4.57	Cu	0.02		

Table 3 Minerals compositions (percentage) of drilling mud waste analyzed by X-ray diffraction (XRD).

Mineral	Percentage
Quartz	42.82
Kaolinite	32.82
Barite	1.39
Albite	7.74
Calcite	14.21

3.2 Compressive strength

In this study, 5 building brick samples were measured their compressive strength according to the American Society for Testing and Materials ASTM C67-11 (Standard test method for sampling and test Brick and Structural Clay Tile) and the Thai Industrial Standard (TIS.) 77-2545 B.E. and results of the test are presented in Table 4.

Table 4 Results of compressive strength test of building brick samples.

Sample No.	Mass	Dimensions of specimen (cm)			Density	Section area	Load	Compressive strength	
	g	Width	Length	Height	g/cc	cm^2	kg_f	kg/cm^3	MPa
1	429.24	6.32	13.68	3.85	1.29	86.46	18890	218.49	21.43
2	440.85	6.25	13.82	3.87	1.32	86.38	18360	212.56	20.85
3	444.66	6.35	13.66	3.86	1.33	86.74	18190	209.7	20.56
4	443.3	6.31	13.55	3.88	1.34	85.5	18720	218.95	21.47
5	438.31	6.31	13.55	3.84	1.34	85.5	18550	216.96	21.28
average								215.33	21.12

Results of the compressive strength measurement indicated that the average compressive strength of 5 building brick samples was 21.12 MPa or 215.33 kg/cm^3. The high compressive strength character of the brick sample may result from its high silica content (59.39%) that make it has high compressive load resistance.

Therefore, according to ASTM C67-11 and TIS.77-2545 B.E. standard, the Brick samples made from water based drilling mud wastes can be classified into grade A brick since they have the average minimum compressive strength more than 21MPa (Table 4).

3.3 Water absorption

For the water absorption measurement, 15 building brick samples were measured their water absorption percent according to the American Society for Testing and Materials ASTM C67-11 (Standard test method for sampling and test Brick and Structural Clay Tile) and the Thai Industrial Standard (TIS) 77-2545 B.E. and results of the test are presented in Table 5.

Table 5 Results of water absorption of building brick samples.

Sample No.	Dry mass (g)	Boiled			Immersion		Water Absorption (%)
		1 hour	2 hours	5 hours	5 hours	24 hours	
1	431.58	500.06	498.36	504.96	496.37	498.48	13.42
2	448.64	514.35	519.6	518.52	512.28	515.19	12.92
3	454.75	524.72	515.1	520.92	507.73	515.2	11.73
4	427.76	504.71	506.47	504.69	487.91	488.66	12.46
5	444.68	512.4	512.57	511.32	498.48	510.11	12.83
6	438.6	506.76	497.18	510.40	504.43	507.52	13.58
7	441.91	506.92	510.45	511.32	502.97	510.26	13.40
8	429.6	499.16	496.48	505.10	483.58	502.20	14.46
9	454.85	509.48	513.27	521.44	508.30	510.48	10.99
10	446.03	515.14	514.45	518.25	508.27	511.54	12.81
11	451.6	509.2	527.9	536.20	520.28	522.34	13.54

Table 5 Results of water absorption of building brick samples (continued).

Sample No.	Dry mass (g)	Boiled			Immersion		Water Absorption (%)
		1 hour	2 hours	5 hours	5 hours	24 hours	
12	467.74	519.53	527.55	533.73	523.22	524.30	10.79
13	431.89	489.5	495.2	496.10	485.76	499.70	13.57
14	435.89	503.23	506.97	504.70	499.60	504.57	13.61
15	430.57	501.6	506.72	505.71	500.35	504.08	14.58
Average							12.98

The average water absorption of brick samples No.1-15 is 12.98 %. This low water absorption percent of the brick samples may cause from its low permeability character which is resulted from its high kaolinite, a clay mineral, content (32.82%). Therefore, according to ASTM C67-11 and TIS 77-2545 B.E. standard, the Brick samples made from drilling mud wastes can be classified into grade A brick since they have the average maximum water absorption percent less than 17 % (Table 5).

Since the minimum compressive strength and the water absorption percent of the brick samples both are met the acceptable limit and they are classified as grade A brick of the ASTM C67-11and TIS 77-2545 B.E. standard, it can be concluded that the building brick made from water based drilling mud wastes can be used as a raw material for the building brick making.

IV. Conclusion

The building brick made from dried and ground water based drilling mud wastes from a petroleum drill hole of the Phitsanulok basin, an onshore Tertiary basin located in northern Thailand, was analyzed its chemical composition by XRF and XRD method, and was measured its compressive strength and water absorption percent according to the ASTM C67-11and TIS 77-2545 B.E. Results of XRF and XRD analysis indicated that this water based drilling mud waste had high silica and kaolinite content which made the brick sample to have high compressive strength and low water absorption percent. Due to the compressive strength of 21.12 MPa and water absorption percent of 12.98 %, the building brick made from dried and ground water based drilling mud waste can be classified into grade A brick according to the ASTM C67-11and TIS 77-2545 B.E.

Not only the reuse of this waste material in the building industry will contribute to the protection of the environment through great advantages in waste minimization and less disposal cost to the company, but also the beneficial income to the community through the utilization process in building industry.

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