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Article

Influence of Different Additives at Various Contents on the Properties of Pottery Clay Body

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Abstract

The preparation of clay body is a highly important step during the production of local decorative pottery, especially the local unglazed low-fired terracotta. In this study, sand (size < 178 μm) and Bulrush pulp were employed as an additive blended with clay (size < 125 μm) in the preparation of clay body. Various sand contents (2 - 18 wt%) and pulp contents (1 - 14 wt%) were tested. The properties of each clay body were evaluated in terms of shrinkage, water absorption and modulus of rupture. The results obtained showed that higher sand or pulp content gave higher water absorption and lower shrinkage of clay body. The dried *MOR* value of pulp-clay body was much higher than that of sand-clay body at the same content. The maximum fired *MOR* value of sand-clay body (84.51 kg_f/cm^2) at sand content of 2 wt% was a little higher than that of pulp-clay body (80.44 kg_f/cm^2) at pulp content of 4 wt%. However, at a sand content ranging between 2 and 14 % or a pulp content ranging between 1 and 5 %, the fired *MOR* values of clay bodies were enhanced above that of local pottery clay body (60.14 kg_f/cm^2). From these results the pulp could adequately be used as an additive as well. Finally, a suitable sand or pulp content for producing smooth clay bodies was between 2 and 14 wt% or between 1 and 4 wt%, respectively, due to clay bodies obtained having more smooth texture and higher strength than local pottery clay body.

Keywords: Clay, decoration, porosity, pottery, pulp, sand, strength, shrinkage

Introduction

Earthenware pottery production has a long history, especially the unglazed low-fired red pottery made out of local clay blended with sand that can still been found at sites throughout Thailand. Such pots are well-known and inexpensive. In this study, the interest is in an important pottery production area, Ban Maying in Nakhon Si Thammarat province. The native potters who have been making pottery for several centuries are familiar with the traditional skill of shaping pots by throwing or coiling methods and firing them in traditional kilns. The clay raw material used in this area is dug from nearby Ban Tongnamkem. Clay bodies are always made from natural earthenware clay blended with local sand in a range of 8 to 20 wt%. However a problem that is often found in rural pottery production is the cracking of pots after drying or firing.

At present, several types of raw materials, for example glass, plastic, other clays and so on, are used extensively for producing high-quality domestic wares. However, it still appears that many people are more interested in natural terracotta with smooth and attractive shapes which are both beautiful and able to be used for different purposes such as for decoration, due to the lower price and the more natural pots. While most native potters in this rural area wish to develop their pottery products according to the demands of the consumers, they continue to work using the traditional practice of producing pottery. Besides the cracking of some products, another important problem that has been found in making decorative pots is that the texture of the prepared clay body is too rough to carve the various patterns because some large size non-clay contaminants, e.g. gravel, and wood bits, have not been removed from the local clay and sand. This is also a cause of cracking [1].

Generally, the earthenware clays of each region behave differently depending on the range and distribution of particle size and the presence of non-clay contaminants [1]. Clays need to be tempered with non-clay materials to prevent cracking due to excess shrinkage during drying and firing. For tempers, many different substances have generally been used such as organic material or various sands which are usually modified to be made suitable for firing [2]. For most local pots the clay body is usually a mixture of just clay and sand. So, a clay body which is formulated to have good qualities for making decorative pottery, i.e. a smooth texture, plasticity, high strength, etc, depends not only on the properties of the clay but also on the kind of additives used, as well as the ratio of the clay to the additive [1,3,4]. It is evident that the development of the clay body is one of the most important factors that affect the carving of the pots and the quality of the product. With respect to the use of raw materials for traditional pottery applications, few studies have been published on the raw materials used in making local pottery. Although some data sources have reported the effects of earthenware clay and sand mixed in the clay body on the quality of pots, quality changes of pots with particular sand at various compositions is also not consistent. This information is very necessary in order to understand the effect of the amount of sand used on the quality of the clay body. It can also be used to optimize the ratio of sand to clay for the production of local pots. Some researchers have found that the presence of organic matter in clay may significantly increase clay plasticity, porosity [5] and green strength, as well as promoting complete burning during firing. Several different pore-forming materials like wood sawdust, and organic residues have been used. Bulrush (Scirpus grossus L.f.) is generally found in marshes here and therefore is used as an additive in the clay body for this study. Our findings have far-reaching consequences for local potters.

The present work has been planned in order to reach the required smooth texture that the clay and sand used as an additive raw material must have particle sizes less than 125 and 178 μm, respectively. The goal of this research is to contribute to the understanding and improvement of the physical properties of green and fired pottery products, using clay bodies prepared by mixing clay with different additives at various weight percentages. That is, sand is used at weight percentages from 2 - 18 wt%, and compared with the use of pulp at weight percentages from 1 - 14 wt%. The effects of each additive mixed with clay on the properties of the clay body are evaluated in terms of strength, water absorption and shrinkage.

Materials and methods

Preparation of Bulrush Pulp

Bulrush (Scirpus grossus L.f.) was obtained from environmental sources. In this work the pulp of green Bulrush which is a non-wood organic matter was prepared as follows. The Bulrush tree was cut into pieces of 2 cm in length. The Bulrush pieces were mixed with an aqueous solution of 13 % (w/v) NaOH in a tank and cooked at boiling point for 3 h. After cooking, the resulting pulp and cooking liquor were separated and the pulp was then washed with water, in order to remove the residual sodium hydroxide. Then the pulp was dried in a tray dryer at 70 °C for 6 h, and stored in a closed bag for use as an additive in the clay body. The fiber length of the pulp which was used by mixing with clay was examined under a microscope. It was found that the average fiber length was 8.9 mm.

Preparation of Sand (size < 178 μm)

The local sand which was bought from a potter was washed with water and then dried in an oven at 110 °C for 4 h. The particle size distribution of the local sand was analyzed by using sieve analysis, as shown in **Figure 1**. In the preparation of sand having particle sizes less than 178 μm, the sand passing through an 80-mesh sieve was stored in a closed bag for use as an additive in the clay body.

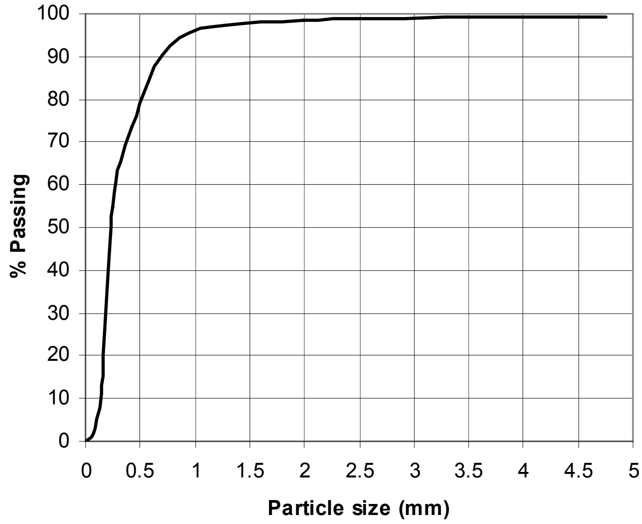


Figure 1 Particle size distribution of local sand.

Preparation of Clay (size < 125 μm)

The local clay was purchased from a potter at Ban Maying. The local clay obtained was analyzed using X-ray fluorescence spectrometry (Uniquant 2 software). The chemical composition of the local clay is given in **Table 1**. The particle size distribution of the local clay is shown in **Figure 2**.

In the preparation of clay having particle sizes less than 125 μm, the local clay was mixed with water and then agitated in a blunger at high speed about 6 h until it was a slip. The slip passing through a 120-mesh sieve was poured into a plaster mold to suck out the water until the clay could be released from the plaster mold. The clay obtained was then dried in an oven at 110 °C for 4 h and stored for use as a clay raw-material in all tests.

Table 1 Chemical composition of the local clay.

Composition	SiO_2	Al_2O_3	Fe_2O_3	K_2O	TiO_2	CaO	MgO	Na_2O	L.O.I. (1,000 °C)
wt%	58.70	17.10	9.00	2.66	1.30	0.33	0.74	0.32	9.32

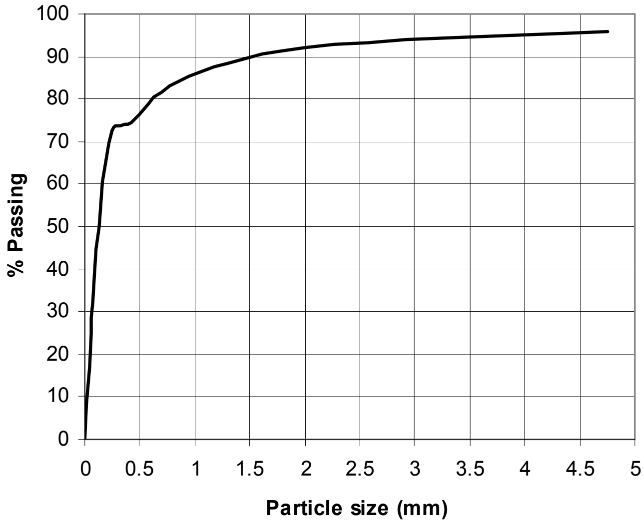


Figure 2 Particle size distribution of local clay.

Clay Bodies Study

In this study clay bodies containing clay (size < 125 μm), sand (size < 178 μm) and pulp, which were previously prepared, were used for the clay body preparation. The clay body formulated was a mixture of clay and only one additive such as pulp and sand. So, two series of tests were carried out with pulp or sand at various weight percents in each clay body. **Table 2** illustrates the experimental plan.

The first series of tests used sand at various weight percents in the clay body of 0 to 18 wt%. The properties of the clay containing no additive (S^{0}_{100} in **Table 2**) were also tested. For each test the sand was soaked in 55 wt% water, and then mixed with clay in an agitating tank for 3 h to spread sand over a clay body. After a smooth mixture was formed, it was poured into a plaster mould which would adsorb the moisture from the slip for about 24 h until the clay could be released from the plaster mould. Then it was wedged by hand in order to remove air bubbles from the clay body. The samples of clay body were formed as rectangular bars in a mold 10 cm long and 1.2 × 1.2 cm^2 in cross section area (width × thickness), 20 test bars of each test. The initial moisture content of the clay body used for forming the test bars was also evaluated. The samples were dried in an oven at 110 °C for 4 h, and then fired in an electric kiln at 900 °C for 8 h. The drying shrinkage and dried modulus of rupture tests were performed after drying. The firing shrinkage, water absorption and fired modulus of rupture tests were performed after firing.

Table 2 The experimental plan for the clay body tests, with the weight percents of each additive raw material, such as pulp (P) and sand (S), in the clay body.

	Additive-clay													
Sand-clay	S^{0}_{100}	S^{2}_{98}	S^{4}_{96}	S^{6}_{94}	S^{8}_{92}	S^{10}_{90}	S^{12}_{88}	S^{14}_{86}	S^{16}_{84}	S^{18}_{82}				
Pulp-clay	P^{1}_{99}	P^{2}_{98}	P^{3}_{97}	P^{4}_{96}	P^{5}_{95}	P^{6}_{94}	P^{7}_{93}	P^{8}_{92}	P^{9}_{91}	P^{10}_{90}	P^{11}_{89}	P^{12}_{88}	P^{13}_{87}	P^{14}_{86}

Note: Superscript and subscript symbols refer to weight percent of additive and clay, respectively.

The second series of tests concerned pulp at weight percents of pulp in the clay body of 1 to 14 wt%. For each test the pulp was first soaked in 55 wt% water for 30 min to make it softer. Afterwards the experimental procedure followed that used in the first series of tests with sand.

The local pottery clay body, the mixture of local clay and local sand unclassified by size, for making local pots at Ban Maying was bought direct from a potter. It was evaluated for initial moisture content, drying shrinkage, dried modulus of rupture, firing shrinkage, water absorption and fired modulus of rupture as above. These results were used as reference data for comparison with the results of this work. The experimental results of all tests were presented as mean values. Errors between experimental data and mean values were presented as standard errors.

Clay Body Testing

Measurement of Initial Moisture of Clay Body

The initial moisture content of clay body used for forming the test bars was evaluated. The moisture content based on wet basis is the weight of water present in the sample per unit weight of the sample. Each of the 3 samples was weighed and then dried in an oven at 110 °C for 24 h. Then each sample was weighed again. The moisture content was calculated according to the following equation:

$$\%Moisture\,content\,(w.b.) = \frac{W_i - W_d}{W_i} \times 100 \quad (1)$$

where W_i is the initial weight of the sample and W_d is the weight of the dried sample. The average value of the initial moisture content was reported.

Measurement of Water Absorption of Clay Body

Ten samples were fired at 900 °C and then weighed. They were boiled in water for 2 h, and then taken out. Each sample was weighed again. The percentage of water absorption was calculated as follows:

$$\%Water\ absorption = \frac{W_{Sat} - W_c}{W_c} \times 100 \quad (2)$$

where W_c and W_{Sat} are the weight of sample after firing and after boiling in water (saturated), respectively.

Measurement of Shrinkage of Clay Body

The measurements of shrinkage of the clay body, that is, the drying shrinkage, the firing shrinkage and total shrinkage were performed by manually measuring the change in length of the 10 body samples obtained after drying at 110 °C for 4 h and after firing at 900 °C for 8 h, respectively. The percentages of the drying and firing shrinkage of the clay body were calculated by the following equations:

$$\%Drying\ shrinkage = \frac{L_w - L_d}{L_w} \times 100 \quad (3)$$

$$\%Firing\ shrinkage = \frac{L_d - L_c}{L_d} \times 100 \quad (4)$$

and total shrinkage was calculated by

$$\%Total\ shrinkage = \frac{L_w - L_c}{L_w} \times 100 \quad (5)$$

where L_w is the original length of sample after forming, L_d is the length of sample after drying, and L_c is the length of sample after firing.

Measurement of Modulus of Rupture of the Clay Body

The strengths of dried samples and fired samples were tested by using a Universal testing machine (Lloyd 500). Fifteen samples in the bar form were tested and then the *MOR* value calculated by the following equation:

$$MOR = \frac{3PL}{2bd^2} \quad (6)$$

where *MOR* is the modulus of rupture (kg_f/cm^2), P is the breaking load (kg_f), L is the distance between knife edges on which the sample is supported (cm), b is the average specimen width (cm) and d is the average specimen thickness (cm).

Results and discussion

Properties of Clay and Local Pottery Clay Body

The properties of clay (size < 125 μm) and local pottery clay body are shown in **Table 3**. For the clay body made from clay, there were shortcomings in the clay such as low fired strength, while the clay body of local potters had more green strength and fired strength. It indicates that the addition of sand gave greater green and fired strength, more porosity and lower shrinkage. From observations, the surface of the pottery made from local pottery clay body is much coarse and hard to carve various patterns on the surface because of the large size of non-clay contaminants in local sand and local clay. So the study in development of the appropriate clay body for this work was to use the small-sized sand for mixing with small-sized clay in order to create a clay body having fine texture easy for sculpting the smooth figures on the green ware.

Effect of the Amount of Sand

To evaluate the properties of the sand-clay bodies obtained from mixing clay with sand, the first set of experiments was carried out by increasing the weight percentage of the sand in the clay body from 0 to 18 wt% (**Table 1**). The effects of the sand on the sand-clay body properties are shown in **Table 4**. These results are shown in **Figures 3 - 5**.

Table 3 Properties of clay and local pottery clay body.

Mechanical properties	Clay	Local pottery clay body
Moisture content (% wb)	21.64±0.74	16.90±0.36
Water absorption (%)	11.86±0.52	18.37±0.47
Drying shrinkage (%)	10.29±0.33	8.10±0.40
Total shrinkage (%)	12.50±0.54	9.06±0.61
Dried MOR (kg_f/cm^2)	17.97±1.41	23.10±1.52
Fired MOR (kg_f/cm^2)	46.51±2.54	60.14±4.65

Note: the values in **Table 3** represent mean±standard error

Table 4 Physical properties of sand-clay bodies (mean± standard error).

Sand content (wt%)	Initial moisture of green body (% wb)	Properties of sand-clay bodies				
		% Water absorption	% Drying shrinkage	% Total shrinkage	Dried *MOR* (kg_f/cm^2)	Fired *MOR* (kg_f/cm^2)
0	21.64± 0.74	11.86± 0.52	10.29± 0.33	12.50± 0.54	17.97± 1.41	46.51± 2.54
2	20.21± 0.64	13.33± 0.42	10.03± 0.32	11.29± 0.42	21.34± 3.23	84.51± 3.87
4	19.87± 0.85	13.64± 0.35	9.32± 0.40	9.76± 0.31	26.63± 1.11	80.60± 4.55
6	18.52± 0.78	14.28± 0.32	8.87± 0.43	9.32± 0.35	24.52± 4.60	74.21± 9.87
8	17.94± 0.56	15.36± 0.24	8.17± 0.45	8.65± 0.19	22.92± 1.97	69.32± 1.56
10	17.29± 0.30	15.96± 0.26	7.57± 0.32	8.12± 0.30	21.19± 1.36	68.49± 1.32
12	16.97± 0.52	16.61± 0.29	7.48± 0.38	8.01± 0.16	20.57± 1.80	63.00± 5.04
14	16.43± 0.48	17.65± 0.23	7.36± 0.29	7.87± 0.18	19.95± 1.59	61.73± 1.73
16	15.56± 0.29	18.59± 0.27	7.14± 0.21	7.45± 0.27	19.34± 1.09	57.41± 4.72
18	15.31± 0.34	19.26± 0.26	7.08± 0.33	7.38± 0.10	18.41± 1.46	52.86± 1.30

Figure 3 shows the values of drying shrinkage and total shrinkage of sand-clay bodies at various sand contents. It is found that the drying and total shrinkage decreased with increasing sand content, and that the drying shrinkage was a little less than the total shrinkage in all experiments. The drying shrinkage was much greater compared to the firing shrinkage (data not shown). **Figure 4** shows the values of water absorption of fired sand-clay bodies. For larger amounts of sand, the water absorption increased, i.e. water absorption was 13.33 % at 2 % sand and 19.26 % at 18 % sand. From the results above, it can be concluded that higher sand content gave higher water absorption and lower shrinkage of the sand-clay body.

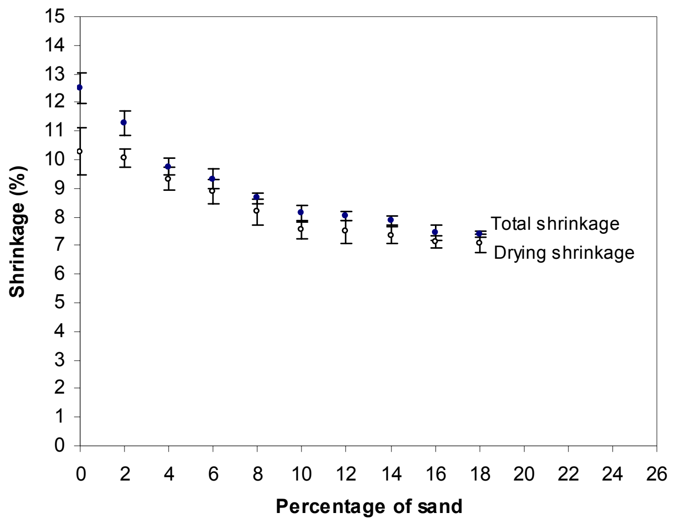


Figure 3 Influence of sand content on linear shrinkage of dried and fired sand-clay body.

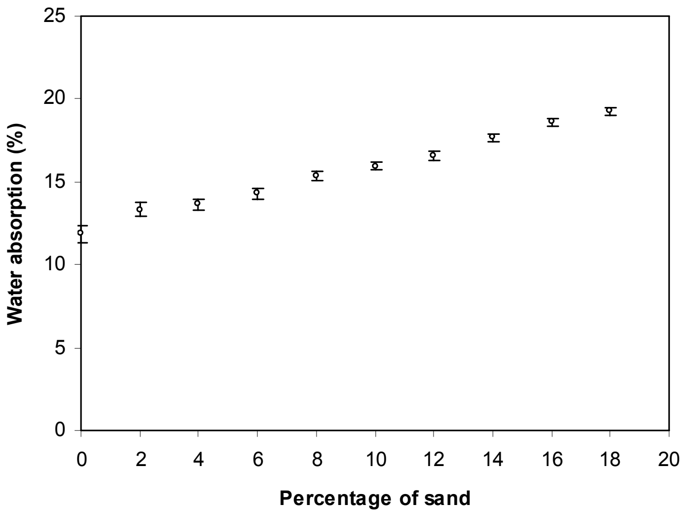


Figure 4 Influence of sand content on water absorption of sand-clay body.

The strength of dried and fired sand-clay bodies are represented in **Figure 5**. It is obvious that, for all experiments, the dried *MOR* values (18.41 - 26.63 kg_f/cm^2) were significantly lower than the fired *MOR* values (52.86 - 84.51 kg_f/cm^2).

For the fired sand-clay bodies, the highest fired *MOR* value was 84.51 kg_f/cm^2 at 2 % sand. When considering the fired *MOR* values above 80 kg_f/cm^2, it was evident that, with respect to fired *MOR* maximization, the optimum amount of sand blended with clay was in the range of 2 - 4 % sand because only a small difference in the influence of amounts of sand on the fired *MOR* value was observed (84.51 and 80.61 kg_f/cm^2, respectively). But, the fired *MOR* values, at higher amounts of sand (6 - 18 %), decreased from 74.21 to 52.68 kg_f/cm^2. From increasing amounts of sand from 2 to 14 %, the fired *MOR* values of the sand-clay bodies were higher than that of local pottery clay body (60.14 kg_f/cm^2 in **Table 3**). This means that the addition of sand in combination with clay could be used in a wide range 2 - 14 % because the fired sand-clay bodies obtained have a fired strength higher than the local pottery clay body.

The first set of tests showed that the sand having particle sizes less than 178 μm can be used as an additive to improve the clay body appropriate for making decorative pottery, due to its smooth texture and high strength, thus reducing obstructions in surface decoration on green ware and also the problem with cracking.

Effect of the Amount of Pulp Mixed in the Clay Body

In order to evaluate the potential of using pulp as an additive, a second set of experiments was also carried out at various amounts of pulp mixed with clay from 1 to 14 wt% (**Table 1**). The values of shrinkage, water absorption and strength of pulp-clay bodies are shown in **Table 5**. These results are shown in **Figures 6 - 9**.

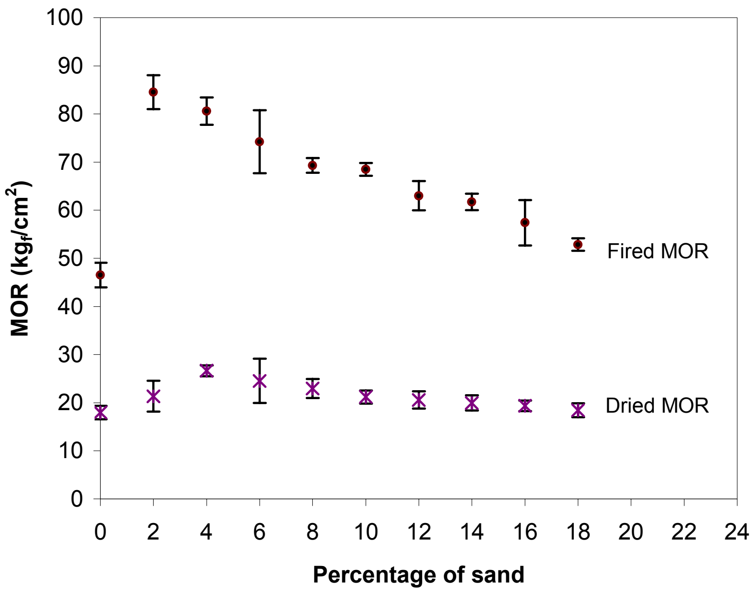


Figure 5 Influence of sand content on *MOR* value of sand-clay body.

Table 5 Physical properties of pulp-clay bodies (mean ± standard error).

Pulp content (wt%)	Initial moisture of green body (% wet basis)	Properties of pulp-clay bodies				
		% Water absorption	% Drying shrinkage	% Total shrinkage	Dried *MOR* (kg_f/cm^2)	Fired *MOR* (kg_f/cm^2)
0	21.64 ± 0.74	11.86 ± 0.52	10.29 ± 0.33	12.50 ± 0.54	17.97 ± 1.41	46.51 ± 2.54
1	22.81 ± 0.60	13.15 ± 0.32	9.82 ± 0.61	11.40 ± 0.37	18.55 ± 0.86	62.87 ± 3.31
2	24.15 ± 0.53	13.88 ± 0.36	9.70 ± 0.57	10.48 ± 0.35	25.09 ± 0.94	66.92 ± 3.83
3	25.16 ± 0.28	14.28 ± 0.30	9.21 ± 0.60	9.81 ± 0.36	31.75 ± 0.96	71.13 ± 1.47
4	25.90 ± 0.35	14.70 ± 0.29	8.42 ± 0.54	8.79 ± 0.32	44.05 ± 1.06	80.44 ± 3.27
5	26.06 ± 0.36	15.35 ± 0.28	8.03 ± 0.48	8.27 ± 0.33	57.26 ± 1.17	76.23 ± 2.76
6	26.88 ± 0.44	17.09 ± 0.34	7.30 ± 0.47	7.61 ± 0.31	63.98 ± 1.55	59.56 ± 0.89
7	27.09 ± 0.29	19.02 ± 0.31	7.04 ± 0.43	7.36 ± 0.32	53.10 ± 2.75	51.92 ± 1.87
8	27.50 ± 0.61	21.21 ± 0.26	6.71 ± 0.44	6.94 ± 0.30	48.49 ± 0.80	45.62 ± 1.98
9	27.78 ± 0.30	22.36 ± 0.28	6.39 ± 0.48	6.60 ± 0.32	48.95 ± 1.67	41.66 ± 0.97
10	28.10 ± 0.41	23.08 ± 0.32	6.23 ± 0.40	6.44 ± 0.31	48.17 ± 1.84	39.22 ± 0.73
11	28.42 ± 0.46	24.10 ± 0.31	6.11 ± 0.43	6.27 ± 0.63	48.13 ± 2.48	27.94 ± 2.43
12	29.63 ± 0.37	24.57 ± 0.29	5.88 ± 0.38	6.07 ± 0.48	48.87 ± 2.04	27.41 ± 1.78
13	29.95 ± 0.50	25.49 ± 0.27	5.75 ± 0.40	5.95 ± 0.51	48.13 ± 1.39	27.03 ± 0.98
14	30.52 ± 0.48	26.11 ± 0.25	5.64 ± 0.31	5.83 ± 0.45	48.10 ± 0.78	26.91 ± 2.37

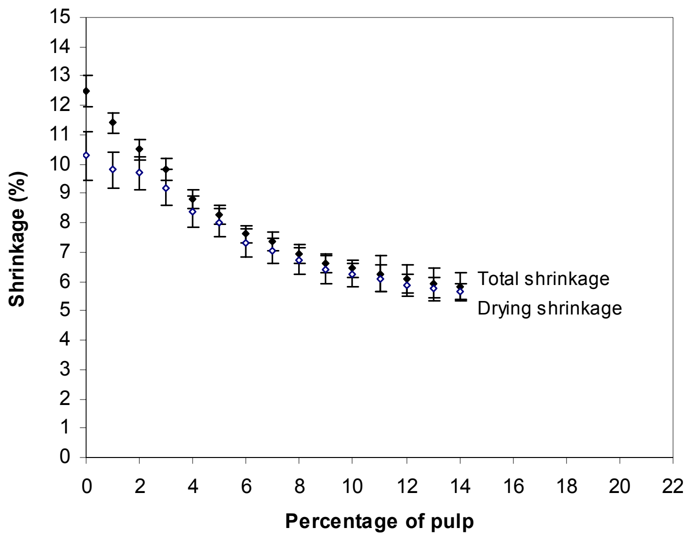
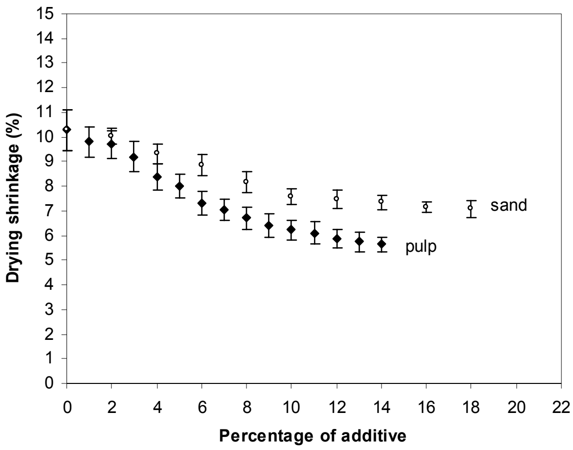
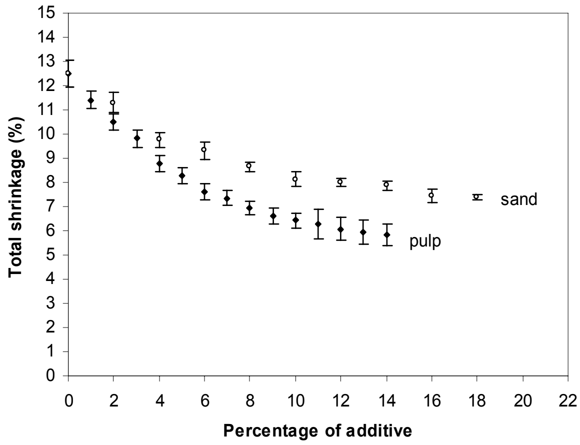


Figure 6 Influence of pulp content on the shrinkage of the pulp-clay body.



(a)



(b)

Figure 7 Comparison of linear shrinkage values of the sand-clay and pulp-clay bodies.

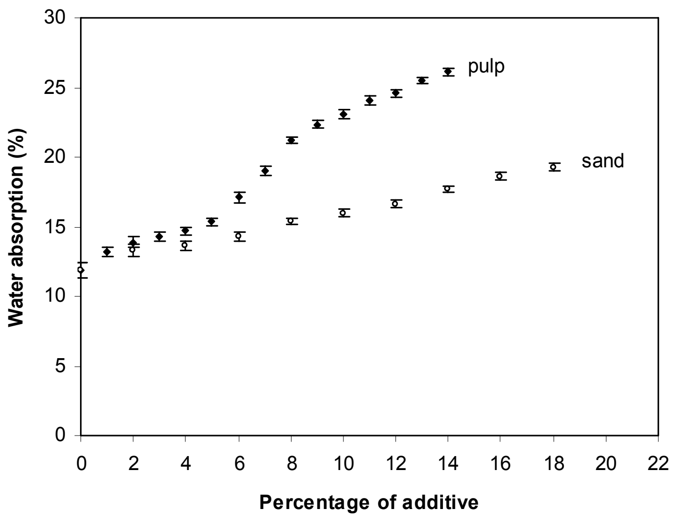


Figure 8 Comparison of water absorption values of the sand-clay and pulp-clay bodies.

The drying and total shrinkage curves (**Figure 6**) decreased with increasing amounts of pulp, which were similar to that obtained with sand-clay bodies but a little less shrinkage (**Figure 7**). Conversely, the water absorption of fired pulp-clay body increased with increasing amounts of pulp and was higher than that of the sand-clay body in all tests (**Figure 8**). When the pulp content was above 5 %, the difference in water absorption of the sand-clay and pulp-clay bodies increased more quickly, i.e. 2.81 % higher at 6 % additive and 8.46 % higher at 14 % additive. These results suggest that an increase in the amount of pulp which is an organic matter had completely been burnt during firing, contributing toward increasing water absorption (porosity).

Two curves for dried *MOR* and fired *MOR* values have been obtained (**Figure 9**). First, the dried *MOR* values increased from a minimum value (18.55 kg_f/cm^2) at 1 % pulp to a maximum value (63.98 kg_f/cm^2) at 6 % pulp, and then decreased and remained almost constant (about

48.1 - 48.95 kg_f/cm^2) above 7 % pulp. Moreover, the dried *MOR* values of pulp-clay bodies were higher than that of sand-clay bodies at all tests (**Figure 10**). The main reason for the above results is that the pulp fibers spread throughout the body behaved like reinforcing components to make the structure of the body stronger.

Second, the fired *MOR* values of the pulp-clay bodies (**Figure 9**) were likewise increased with increasing the pulp content from 1 to 4 %, and the highest value of fired *MOR* was 80.44 kg_f/cm^2 at 4 % pulp. Conversely, at a pulp content ranging between 5 and 14 %, the fired MOR values began to decrease dramatically and became lower than dried MOR values at the same content. The main reason for the above results is that at a pulp content above 4 %, pulp fibers spread throughout the texture of the pulp-clay body were completely burnt during firing, contributing toward increasing porosity of the fired body over the suitable point. Then the fired pulp-clay body is lighter and more fragile. There was no black coring, cracking and bloating on the fired samples. Moreover, the fibrous nature of the pulp did not create any difficulties during mixing and forming steps. These results highlight the importance of pulp addition on the enhancement of the clay body properties in the future.

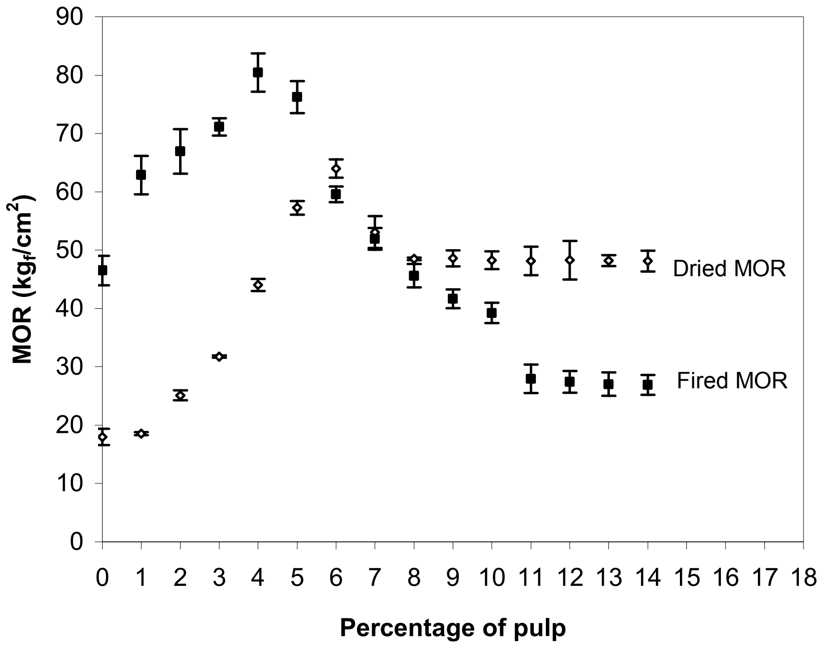


Figure 9 Influence of pulp content on the *MOR* value of the pulp-clay body.

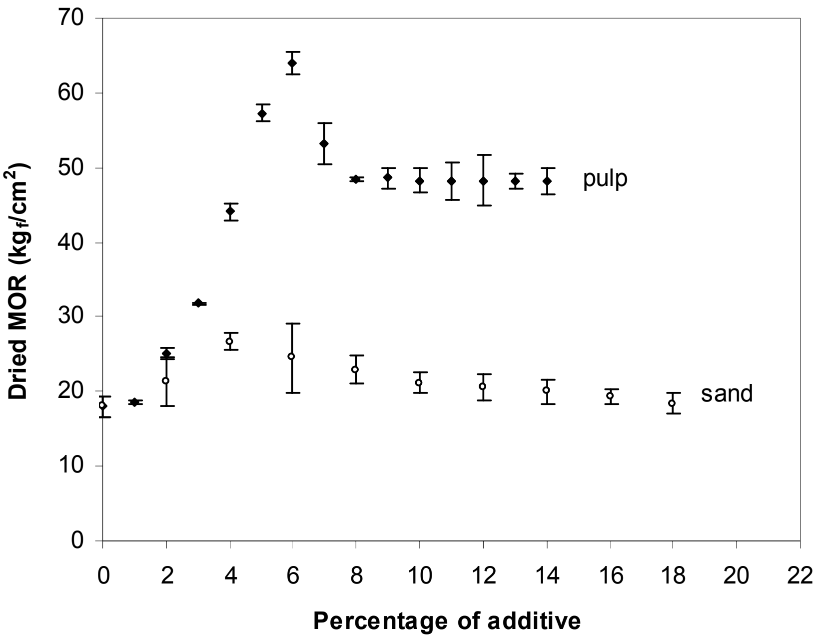


Figure 10 Comparison of dried *MOR* values of the sand-clay and pulp-clay bodies.

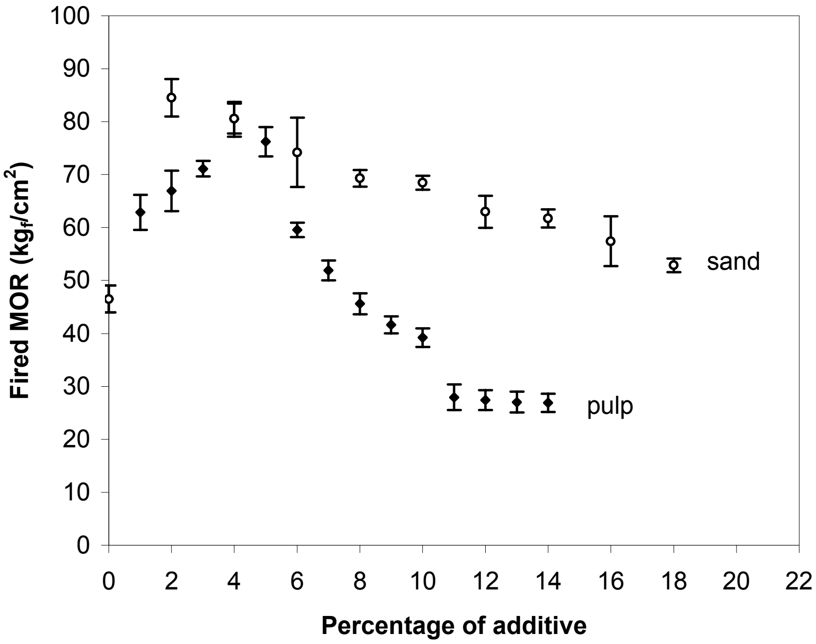


Figure 11 Comparison of fired *MOR* values of the sand-clay and pulp-clay bodies.

The comparison of dried *MOR* values of clay bodies made from each additive is shown in **Figure 10**. The dried *MOR* values of pulp-clay bodies were much higher than that of sand-clay bodies at all tests. It is opposite to the fired *MOR* values (**Figure 11**), that is, the fired *MOR* values of pulp-clay bodies were lower than that of the sand-clay bodies for all tests. It showed that sand could be used for mixing with clay in wider ranges than pulp.

Conclusions

The conclusions based on the experimental results of the effects of the various contents of each additive, such as sand and Bulrush pulp, on the physical properties of the clay bodies have been obtained. For each additive type, the weight ratio of each additive to the clay affected the properties of dried and fired clay body such as shrinkage, water absorption and also strength. It is found that higher sand or pulp content led to higher water absorption but lower shrinkage of the clay body. At the sand content ranging between 2 and 14 % or the pulp content ranging between 1 and 5 %, the fired *MOR* values of clay bodies were enhanced above that of the local pottery clay body (60.14 kg_f/cm^2). The maximum fired *MOR* value of the sand-clay body (84.51 kg_f/cm^2, at 2 % sand) was slightly higher than that of the pulp-clay body (80.44 kg_f/cm^2 at 4 % pulp). The studies developed in the present work show that it is possible to use the pulp of green Bulrush (Scirpus grossus L.f.) which contains non-wood organic matter or sand (size < 178 μm) as an additive by blending with clay (size < 125 μm) to produce a good quality, smooth clay body, highlighting its potential for decorating pottery. This work has highlighted the need for further studies to improve the properties of local pottery clay body, corresponding to a change in texture.

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