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Fabrication of Eco-Green Brick by Using of Vetiver Grass as Feldspar Replacement

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Abstract. Vetiver grass is a widespread plant in Thailand. It has been used in several applications such as land erosion prevention, toxic pollutants removal, and environmental remediation. The chemical analysis provided that it mainly contained of >50% of potassium and ~20 wt% silicon. Since, the main element is potassium, then it is likely to be used as feldspar replacement in ceramic processing. The thermal analysis of vetiver grass also revealed that the vetiver grass can act as fluxing agents to form a glassy phase at low temperatures (600°C). The effect of vetiver percentage in ceramic processing on some physical and mechanical properties of ceramics were examined including, firing shrinkage, density, porosity, and bending stress. The results showed that with increasing the ratio of vetiver grass the density of sample decreased from 1.7 g/cm^3 (without vetiver grass) to 1.1 g/cm^3 (30 wt% of vetiver grass) at 600°C of firing temperature. The explanation was that during the firing process vetiver grass can generate CO_2 from hydrocarbon decomposition, this CO_2 created pores inside the sample, then the density was decreased and pore volume also increased. Meanwhile, the bending stress decreased from 3.6 MPa (without vetiver grass) to 0.5 MPa (30 wt% of vetiver grass) at 600°C of firing temperature. In summary, the results proved that the vetiver grass is a good candidate to be feldspar replacement in ceramic processing. In the other words, it can be one option for promoting environmental sustainability in term of waste and mining reductions.

Introduction

At the present day, the use of construction materials has been increased rapidly. This leads to increase of use of natural resources. Brick is one of the most common construction materials. In general, brick is made of clay and feldspar. The latter acts as fluxing agents to form a glassy phase at low temperatures. In addition, it also improves the durability and strength of the brick. In the meantime, Thai's government encourage farmer in the remote area to grow up vetiver grass due to its advantages such as, preventing land erosion, and embankment stabilization [1, 2]. Besides, the recent literature review showed that the vetiver grass can be used in environmental remediation applications such removal of polycyclic aromatic hydrocarbons (PAHs) [3], persistent organic pollutants (PoPs) [4].

The previous by the authors [5] revealed the chemical analysis of vetiver grass, it showed that potassium (K) and silicon (Si) are the main elements. This data suggest that it has main elements similar to feldspar. Then, this work presented the possibility of use of vetiver grass as feldspar in ceramic processing.

Methodology

The fresh vetiver grass was corrected from the crop field in Phitsanulok Provice, Thailand. In order to remove the water, vetiver grass was dried at 120°C for 12 h in oven. Afterwards, it was cut and blend for 30 min. The chemical analysis of vetiver grass was done by X-Ray fluorescence (XRF).

Samples were prepared by mixing of red clay (local supply) with vetiver grass at seven different weight ratios, as shown in the Table 1. The red clay was dried at 120°C for 12 h, followed by ball milling for 24 h. The red clay and vetiver grass were mixed with 20% of water, subsequently pressing to form the bar with 10x2x1 cm of diameter. Then, the samples were calcined in the muffle furnace at 400°, 600°, and 800°C for 12 hr with 5°C/min of heating rate, followed by natural cooling. The density of samples was examined using Archimedes technique. The bending stress was evaluated using 3-point bending method.

Table 1. The weight ration of clay and vetiver grass

Sample	Percentage of red clay (wt%)	Percentage of vetiver grass (wt%)
1	100	0
2	95	5
3	90	10
4	85	15
5	80	20
6	75	25
7	70	30

Results and Discussion

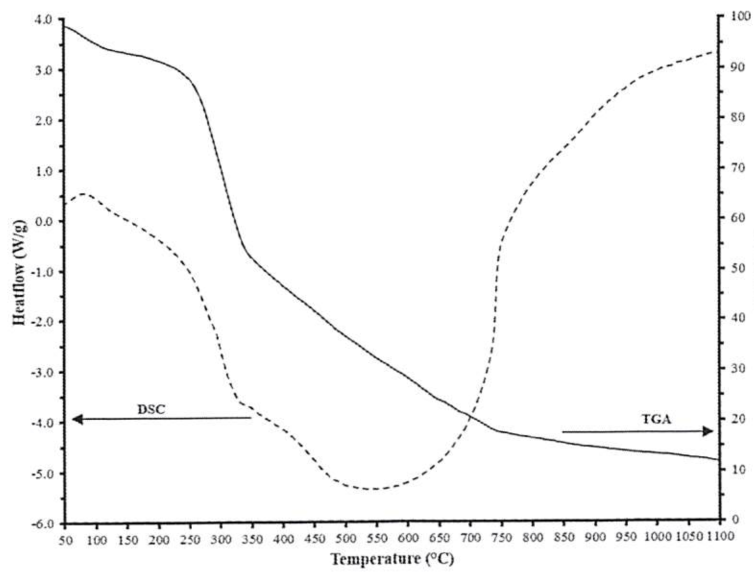

Figure 1. Thermal analysis of vetiver grass

The chemical analysis shows that the vetiver grass mainly consists of potassium (57 wt%), silicon (20 wt%), calcium (9 wt%), chorine (7 wt%), sulphur (3 wt%), phosphorus (2 wt%) and iron (1.5 wt%). This data confirm that the main element is potassium, then it is possible to be used as feldspar replacement. the DSC/TGA curves of dried vetiver grass are shown in Fig. 1. It suggests that there is weight loss of vetiver grass at temperature ~100°C, it can siad that there was the removal of

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physically adsorbed water. Besides, there is other main weight loss over the rage 500°C to 600°C, this can refer to the dehydroxylation process of the remaining minerals [6, 7]. The exothermic peak of DSC analysis is shown at ~600°C, this peak suggests the flux forming of the vetiver grass. Therefore, It can be implied that the vetiver grass start melting to form the crystalline phase at ~600°C. This data also confirm that vetiver grass is very suitable to be used in ceramic processing.

Fig. 2 shows the effect vetiver grass percentage and firing temperature on firing shrinkage. It can be seen that the percentage of vetiver grass can effect on the firing shrinkage. The increasing of vetiver grass percentage and firing temperature result to increase of the firing shrinkage. With increasing the percentage of vetiver grass, it can be said that the volume of carbon and fibre in ceramic body before firing also increased. Then, after firing process carbon and fibre were decomposed from the ceramic body, resulted to the shrinkage of samples. As the same reason, with increasing firing temperature, it can also enhance the decomposition rate of carbon and fibre as well. It has to be noted that there is not much different on shrinkage of the sample firing at 600°C and 800°C. This suggests that the sample is pretty stable at 600°C of firing temperature.

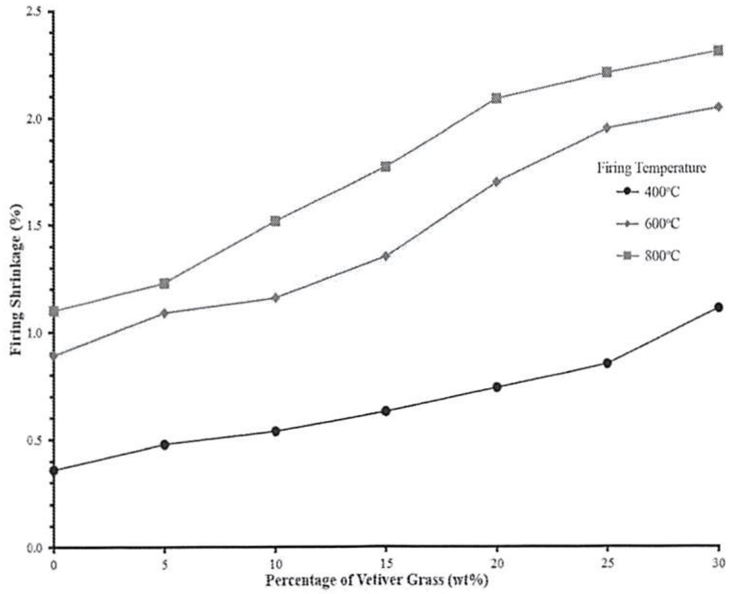

Figure 2. Firing shrinkage of samples

The density of ceramic body decreased significantly with increasing the ratio of vetiver grass, as shown in Fig. 3. It is important to be noted that the firing temperature does not has effect on the density of the sample. The explanation of decreasing of density is that the loss of organic compound from the vetiver grass. Since, the TGA data suggest that the organic compound started decomposed at ~300°C, then it decomposed into CO_2 and H_2O. This phenomenon can create the pore in the ceramic body. The supporting information is also shown in the percentage of pore in the ceramic body, as shown in Fig. 4. It clearly indicates that the pore volume increased with increasing the ratio of vetiver grass.

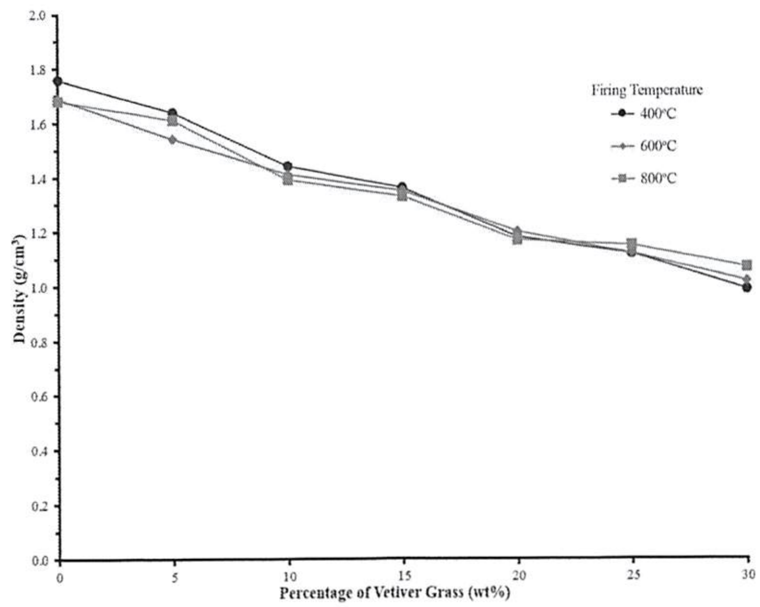

Figure 3. The density of sample

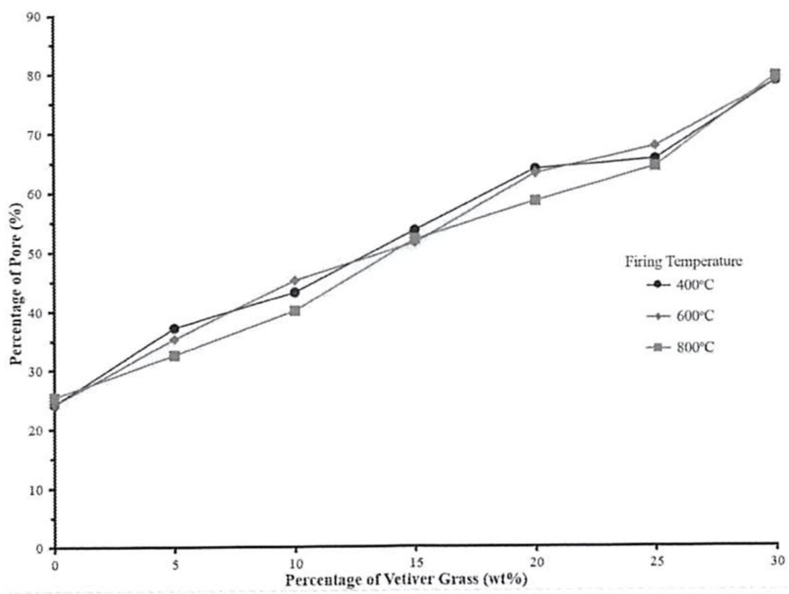

Figure 4. The percentage of pore of sample

Fig. 5 shows the bending stress of the sample. The data shown that the bending stress significantly decreased with increasing the ratio of vetiver grass. Since, the pore volume increased with increasing the ratio of vetiver grass, this is the key reason of decreasing in bending stress. In addition, the firing temperature also effects on the bending stress, at high firing temperature, the sample had higher bending stress compared to low firing temperature.

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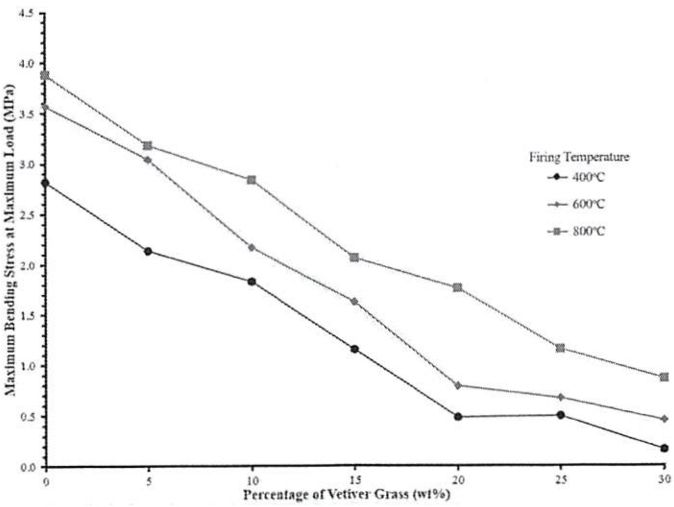

Figure 5. Bending stress of the sample

Summary

The present work have succeeded in using vetiver grass as feldspar replacement in ceramic processing. The results suggest that the sample of using vetiver grass can be form and stable at low temperature (~600°C). The firing shrinkage of ceramic body was also found to be 1 – 2%. In the meantime, the density decreased significantly with increasing the ratio of vetiver grass. While, the percentage of pore increased. However, the bending stress data shown with increasing the ratio of vetiver grass the bending stress decreased significantly. Therefore, it can be concluded that the vetiver grass is possible to use as feldspar replacement because it can reduce the firing temperature to ~600°C, which is lower than normal brick firing temperature (~800°C). However, it has to be noted that the stress of sample also decreased. Then, the further investigation on vetiver grass ratio is needed in order to improve the quality of ceramics.

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References

[1] S.O. Oshunsanya: Catena Vol. 104 (2013), p. 120

[2] N.O.Z. Abaga, S. Dousset, S. Mbengue, and C. Munier-Lamy: Chemosphere Vol. 113 (2014), p. 42

[3] K.C. Makris, K.M. Shakya, R. Datta, D. Sarkar, and D. Pachanoor: Environ. Pollut. Vol. 146 (2007), p. 1

[4] M. Ye, M. Sun, Z. Liu, N. Ni, Y. Chen, C. Gu, F.O. Kengara, H. Li, and X. Jiang: J. Environ. Manage. Vol. 141 (2014), p. 161

[5] S.T.T. Le, N. Yuangpho, T. Threrujirapapong, W. Khanitchaidecha, and A. Nakaruk: J. Aust. Ceram. Soc. Vol. 51 (2015), p. 40

[6] S.Kr. Das and K. Dana: Thermochim. Acta Vol. 406 (2003), p. 199

[7] L. Vaculíková and E. Plevová: Acta Geodyn. Geomater. Vol. 138 (2005), p. 167