CHAPTER 7

CONCLUSION

In this study, the effects of charcoal additive on physical and thermal insulation properties of fired test briquettes are examined. The experiments can be divided into 3 parts: 1. preparation and characterization of Hang Dong clay and charcoal, 2. tests on physical and mechanical properties of test briquettes after being fired at various temperatures using Hang Dong clay briquettes as reference and comparing Hang Dong clay mixed with 0, 2.5, 5.0, 7.5 and 10% by weight of charcoal particles and with three different sizes of charcoal particles: size 1 (2-3 mm.), size 2 (1-2 mm.) and size 3 (less than 0.5 mm.), and 3. examination on the thermal insulation property of fired test briquettes.

The major chemical components of Hang Dong clay consist of SiO_2, Al_2O_3 and Fe_2O_3 and also other chemical components such as TiO_2, CaO, and K_2O. The mineral components of Hang Dong clay are kaolinite, quartz, feldspar and muscovite. The charcoal used in this research is mostly carbon present. The distribution of particle sizes of Hang Dong clay is in the range of 27.2 - 43.0 micron. For charcoal additive, it is a highly porous residue of microcrystalline graphite. The charcoal additive used in this study is retrieved from local area so it is processed from local woods in the northern part of Thailand.

The characteristics and analysis of physical and mechanical properties of charcoal added to clay content for the production of test briquettes are reported. The main goal of the addition of charcoal in clay body is to produce lightweight and more porous fired test briquettes. An increase in the content of charcoal addition leads to an increase in the fired shrinkage, water absorption and apparent porosity. While the value of bulk density and compressive strength of specimen varied with the amount of charcoal addition. The more percentage of charcoal is added to clay body and the higher temperature is used in firing, the higher the compressive strength and less water absorption of the fired test briquettes become. This can be explained that during the burning out of charcoal additive in the body, the porosity occurs and the pores are open and continuous. Thermal expansion coefficients are most likely due to the different amounts of charcoal mixed in the fired test briquettes. As a result, the thermal conductivity values vary with the porosity. The amount of charcoal addition significantly influences the effective thermal conductivity of fired test briquettes. The comparison physical and mechanical properties of other clay bricks to fired test briquettes as shown in Table 7.1.

Table 7.1 Comparison properties of clay bricks to ones of commercial clay bricks.

Property of clay bricks	**Compressive strength (kg/cm^2)**	**Water absorption (%)**	**Thermal conductivity (W/m K)**
* Commercial insulation brick	30-80	-	0.13
* Clay brick-Related works	15-40	-	1.15
* Insulation brick (K BLOCK^{TM} CLC Technology)	30-80	-	0.14
** Hang Dong clay mixed with various charcoal 0-10%, size 3 (less than 0.5 mm) fired at 950 ^{o}C	152.66-78.59	17.18-33.21	0.270-0.216
*** Clay brick-TISI	35	25	-

*Data from K BLOCKTM CLC Technology Co., Ltd

** Test Briquettes (In this research)

*** Thai Industrial Standards Institute (TISI)

The effects of charcoal additive on the physical and mechanical properties of fired test briquettes were examined. The charcoal addition of sizes 1-3 was mixed in the range of 0, 2.5, 5, 7.5 and 10% by weight of Hang Dong clay. After firing at the temperatures 900-1100 ^{o}C, the results confirmed the better physical and mechanical properties of the fired test briquettes with 2.5 -10 % charcoal addition of size 3 fired at 950 °C than those of the reference, namely higher apparent porosity due to higher percentage of water absorption 18.27-33.21 % compared to fired clay bricks standardized by Thai Industrial Standards Institute; TISI77-2531 whose water absorption was 25%. The compressive strength of fired test briquettes was 78.59-143.45 kg/cm^2 whereas that of the counterpart was 35 kg/cm^2. Then the fired test briquettes were examined for their thermal properties

The thermal properties of briquettes

Thermal expansion coefficients of briquettes (COE)

Thermal expansion analysis was performed on fired test briquettes mixed with charcoal 0%, 2.5%, 5.0%, 7.5% and 10% (size 3) by weight and fired at 950 °C. The results indicated that their Thermal expansion coefficients increased 8.8, 6.4, 8.9, 9.3 and 9.8 $\times 10^{-6}$ $^{o}C^{-1}$ respectively.

Thermal insulation properties of briquettes (*k*)

The thermal conductivity analysis was performed on fired test briquettes mixed with charcoal 0%, 2.5%, 5.0%, 7.5% and 10% (size 3) by weight and fired at 950 °C.

The results showed that higher percentages of charcoal induced low thermal conductivity to the specimens. From the results, it could be explained that thermal conductivity decreased with a decrease in density and increased with an increase in fired briquettes porosity. It was shown that the thermal conductivity was directly proportional to the density of the fired test briquettes. An understanding of conduction process indicated that the determining factor was porosity which was related to density. As a result, the thermal conductivity was 0.270 (0%), 0.262 (2.5%), 0.252 (5.0%), 0.238 (7.5%) and 0.216 (10%) respectively.

The results of this study can be speculated that 950 ^{o}C which was the most appropriate firing temperature for test briquettes should also be the most appropriate firing temperature for manufacturing Hang Dong clay bricks with charcoal addition for construction materials because bricks are more durable, porous and stronger than current commercial bricks. Thus, charcoal could be used as a pore former addition in clay body. Conclusively, the results revealed that charcoal could be regarded as a potential addition to raw materials used in the manufacturing of lightweight fired clay bricks.