EFFECTS OF MICROSTRUCTURE ON MECHANICAL STRENGTH OF SELECTED CLAYS FROM UGANDA

BY

OBWOYA KINYERA SAM
M.Sc. (Reading University, UK), DASE(University of Bristol, UK),
BSc/Dip Ed (MUK)

A Thesis submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy of Makerere University.

PHYSICS DEPARTMENT
FACULTY OF SCIENCE
MAKERERE UNIVERSITY

April 2004.

DECLARATION

I declare that, except where specifically acknowledged, this thesis is my own work. It is being submitted for the degree of Doctor of Philosophy of Makerere University. It has not been submitted for any degree or examination at any other University.

Obwoya Kinyera Sam

(Name of candidate)

(Signature)

.....14th.....day of April 2004.

APPROVAL

This is to certify that the following study of **Obwoya Kinyera Sam** has been carried out under the following title of:

EFFECTS OF MICROSTRUCTURE ON MECHANICAL STRENGTH OF SELECTED CLAYS FROM UGANDA.

Supervisor's signature: .....

Professor Yusto Kaahwa, Ph.D.
Physics Department,
Makerere University,
P.O Box 7062,
Kampala

Supervisor's signature: .....

Professor Eldad. J.K. B. Banda, Ph.D.
Physics Department,
Makerere University,
P.O Box 7062,
Kampala

DEDICATION

I dedicate this work to my beloved wife Perry; children: Julius, Jimmy and Angella whose prayers and encouragement gave me high motivation and inspiration to undertake this research to its completion.

ACKNOWLEDGEMENTS

I am very grateful to the following for their contributions towards this research:

- First and foremost to my supervisors: Prof. Yusto Kaahwa (Makerere University) and Prof. Eldad Banda (Makerere University) for their passionate and invaluable support during the research.
- Physics Department, Makerere University, for its financial assistance towards the research.
- Mr Okello Alfonce for his technical assistance during measurements of fracture loads of the specimens using Monsanto tensometer at the Department of Mechanical Engineering, Faculty of Technology, Makerere University.
- Mrs Perry Obwoya for contributing most of the finances towards the research.
- Mr. Okumu John, of Uganda Bureau of Standards for some useful discussions that I had with him during analysis of the data and for availing me with some of the technical data.
- Dr. John Legge of Kyambogo University, and Mr. George Braybrook of the Department of Earth & Atmospheric Sciences, University of Alberta, Canada, for their generosity in meeting the cost of producing the scanning electron microscope micrographs used in this research.
- Finally I wish to thank Kyambogo University, for providing part of my tuition fees and research funds, and for granting me study leave in order to undertake the course at Makerere University.

ABSTRACT

This thesis presents results of a study of the dependence of modulus of rupture (MOR), Young's modulus, *(E)*, and flexural rigidity,*(D)*, of sintered clay specimens on microstructure, average particle size and production variables. The production variables considered were sintering time, sintering temperature, and compaction pressure.

The study shows that the MOR, Young's modulus and flexural rigidity of the clay product increase as compaction pressure, sintering temperature and sintering time are increased, but decrease as the particle size increases for all the processing conditions. The microstructure of clay specimens of higher strength are such that, the pores are well rounded and fewer in number. The grain boundaries are also thin and well defined with glassy phase being dominant as compared to liquid and pore phases. Higher strength of the clay specimens is also associated with formation of mullite which forms needle-shaped crystals with an interlocking network that gives high stability at elevated temperatures.

The variation between MOR and sintering time, *t*, can be described by a relation of the form

$$MOR = \alpha t^2 + \beta t + \vartheta$$

where α, β and ϑ are constants with some of their mean values for samples compacted at 49.584MPa and sintered at 1200^{0}C are: $\alpha = -0.37 \pm 0.16 MPas^{-2}$, $\beta = 4.93 \pm 0.87 MPas^{-1}$ and $\vartheta = 21.05 \pm 7.26 MPa$