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INVESTIGATION OF FOUNDRY PROPERTIES OF IKERE-EKITI CLAY DEPOSIT

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ABSTRACT

Green compression strength of Ikere-Ekiti clay was studied to determine its suitability for foundry operations.The effects of clay content,tempering water and starch on the green compression of the moulding sand were measured using standard methods of American Foundrymen's Society(AFS).The results obtained showed that the green compression strengths increased with increasing tempering water and clay contents.The optimum conditions were also determined and these are 3.0% tempering water and 6.0% bentonite clay and 5.5% tempering water and 13.0% Ikere-Ekiti clay.The corresponding green compression strengths were 138kNm and 52kNm for bentonite and Ikere-Ekiti clays respectively.These optimum conditions were used in measuring the effect of starch on sand-clay mixture.An enhancement of the binding ability of Ikere-Ekiti clay and strength of the mould was observed.The findings also showed that Ikere-Ekiti can safely be used as suitable replacement for bentonite in foundry operations.

KEYWORDS:substitute,binder,bentonite,green strength

INTRODUCTION

The addition of binders to moulding sands in foundry operations has for long been a subject of intensive study.This is because binders are known to enhance various moulding properties of sands employed in sand casting operations(Davis and Oelman,1985;Rochier and Allais ,1970).Such properties include permeability,strength,plasticitycollapsibilityand refractoriness.Binders can thus be described as bonding materials in either liquid or solid form whose main function is to produce cohesion between refractory grains of moulding sand in the green or dried state(Beeley,1982).

Generally,the most widely used binding agents are clay-based.This is because they can be recycled in closed systems and their binding characteristics regenerated by the addition of water.Clays are hydrated sheet structure which take the general form of minute plates in approximate particle size 0.01 - 1μm in breadth(Beeley,1982).Details in respect of origin and physical characteristics of clay minerals can be found in literatures(Jain,1979 and Rhodes,1979).

The most extensively used binder in foundry establishments is bentonite.Bentonite clay is in high demand as it is also used in other industries such as oil,paint and paper mills to mention just a few.However,bentonite is largely

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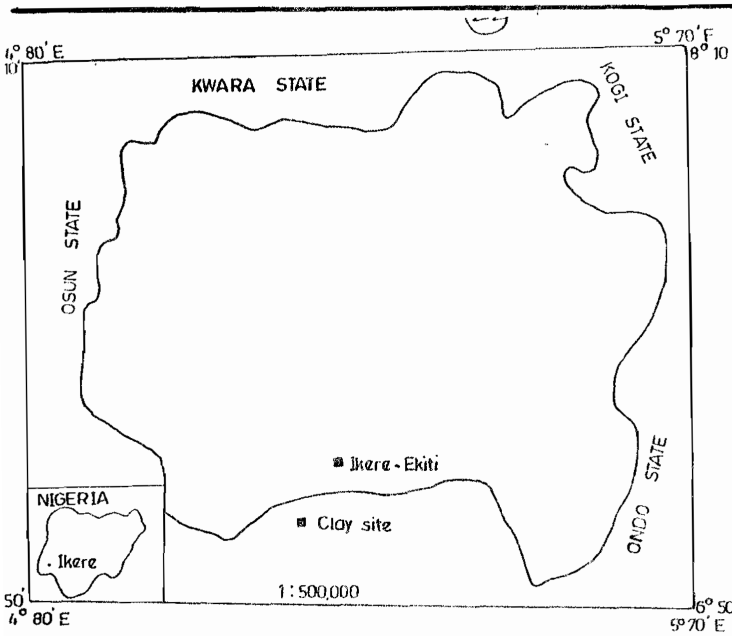

Fig 1 :Map of Ekiti State showing location of clay.

imported at a prohibitive costs resulting in foreign exchange depletion.

There has been a number of investigations on the properties of moulding sand with various additives(Balogun et al,1980;Balogun and Adepoju,1983;Loto and Akeju,1994;Ibitoye and Afonja,1997a,1997b and Omotoyinbo et al,1997).In most cases investigated,the moulding properties were enhanced by the addition of the binders.

Some local potter's clays were found adaptable for foundry use.In particular,they are suitable for green mould casting of ferrous and non-ferrous alloys when used to bond silica base sand(Loto et al,1994;Ibitoye and Afonja,1997a,1997b,Omotoyinbo et al,1997).Also addition of starch has been shown to be effective binders of moulding sand(Balogun and Adepoju,1983;Ibitoye and Afonja,1996).In this study,the use of Ikere-Ekiti local clay was investigated as a substitute to imported bentonite clay.

Table 1.Physical Properties of Silica Base Sand,Bentonite and Ikere-Ekiti Clays.

Property	Silica Base Sand	Bentonite Clay	Ikere-Ekiti Clay
Average Finess Number(AFS)	45.42	93.28	72.89
Moisture Content(%)	1.6	10.5	19.36
Plasticity	-	62.12	26.03
Clay Content(%)	1.12	100	100
Sintering Point(°C)	1450	1050	1550
Loss on Ignition(%)	0.1	10.1	7.01

Table 2:Basic Chemical Composition of Silica Base Sand,Bentonite and Ikere-Ekiti.(wt.%)

Oxide	Ikere-Ekiti	Bentonite	Silica Base Sand
SiO_2	47.38	60.76	98.9
Al_2O_3	31.46	21.87	0.19
MgO	0.001	3.03	0.02
CaO	0.0237	1.38	0.05
Fe_2O_3	9.87	5.02	0.06
Na_2O	0.001	1.82	0.008
TiO_2	1.138	-	-
K_2O	0.2982	-	-
Loss on Ignition(LOI)	11.06	-	-

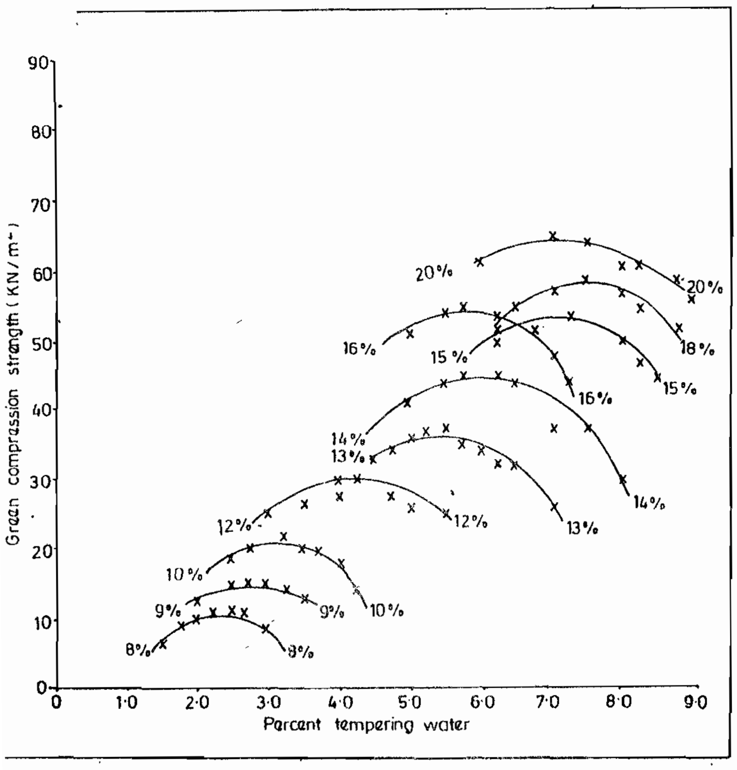

Fig 2: Influence of Ikere-Ekiti clay and tempering water on green strength of base sand.

MATERIALS AND METHODS

The silica sand as well as the imported *bentonite clay were from* Delta Steel Co.Ltd,Aladja-Warri.The local clay was obtained from a deposit in Ikere-Ekiti located in Ekiti State,Nigeria(Figure 1).Both the local clay and silica sand were first washed to remove some deleterious particles,and then dried.The local clay was crushed and milled to fine powder.

The silica base sand,local and bentonite clays were graded through a 45 micron sieve.Their chemical compositions were determined using wet chemical techniques while their physical properties were also measured.The results obtained are given in Tables 1 and 2.

Washed,dried and graded silica base sand was thoroughly mixed in a sand mixer with graded binder of different percentages ranging from 2% to 20% and tempering water also of different percentages ranging from 1% to 9%. *In each case of the binders used,fifty* grammes(50g) of mixed samples was put in a specimen tube,rammed three times and then removed carefully.Green compression test was carried out on the samples using the methods of the American Foundrymen's Society(1963).The test was repeated three times on similar test samples and average value determined.The results obtained are plotted in Figure 2 and 3.To determine the optimum green compression strength,the peak points on Figures 2 and 3 were obtained and plotted against the corresponding water contents.This is shown in Figure 4,from which the optimum green compression and tempering water content were determined.By using these optimum conditions,the effect of variation of starch on the green compression strength of clay -water - sand mixture was examined by progressively increasing its content in the mixture.The results obtained for both bentonite and Ikere-Ekiti clays are shown in Figure 5.

RESULTS AND DISCUSSION

EFFECT OF CLAY AND TEMPERING WATER ON GREEN STRENGTH OF MOULDING SAND

The strength of a moulding sand is to a large extent determined by the amount of binders and water added to it.Figures 2 and 3 show the

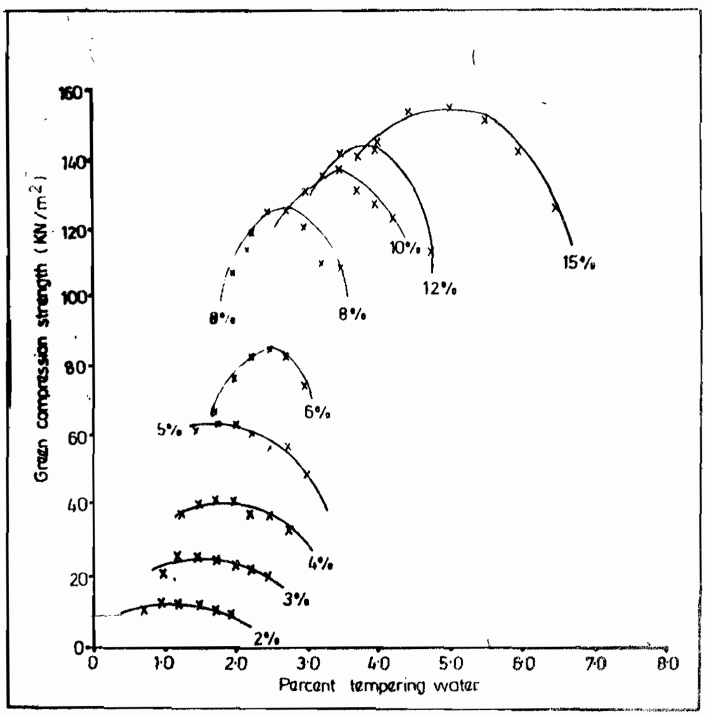

Fig 3: Influence of bentonite clay and tempering water of green strength of base sand.

effect of Ikere-Ekiti clay,bentonite clay and tempering water on the green strength of silica base sand respectively.The green compression strength increases with increasing clay and water content reaching an optimum value,followed by a gradual decrease.The decrease in strength can be attributed to the fact that the optimum tempering water content has been exceeded,thus causing the clay-sand-water to be sticky like mud and thereby resulting in reduced green strength.Furthermore,it can be seen from the Figure 2,that Ikere-Ekiti clay displayed a characteristically low bonding properties when compared to bentonite(Figure 3).This is particularly not surprising,judging from the measured plasticity of the clay(Table 1) which is low compared to that of bentonite clay.

OPTIMUM CLAY AND WATER ADDITION DETERMINATION

The green compression strengths of the test specimens with different clay and water contents are shown in Figures 2 and 3.Figure 4 is a plot of peak points on Figures 2 and 3 against the corresponding water contents.Two zones of differing increases in green compression strength with increases in tempering water are observed.In the first zone,the increase is very rapid and sharp.This is because the moulding mixture is sufficiently plastic causing the particles of the moulding sand to bind together very well.However,increase in green compression strength with water observed in the second zone can be related to the increasing inter-particle distance,causing plasticity of the moulding mixture to reduce.This eventually transforms to gradual increase in green compression strength with water.The optimum green compression strength occurred at the point where there was a change from sharp/rapid increase to the gradual increase in the green compression strength.Thus,the optimum conditions determined were 3.0% tempering water and 6.0% bentonite clay additions as well as 5.5% tempering water and 13.0% Ikere-Ekiti clay.The corresponding green compression strengths were 138kNm^{-2} and

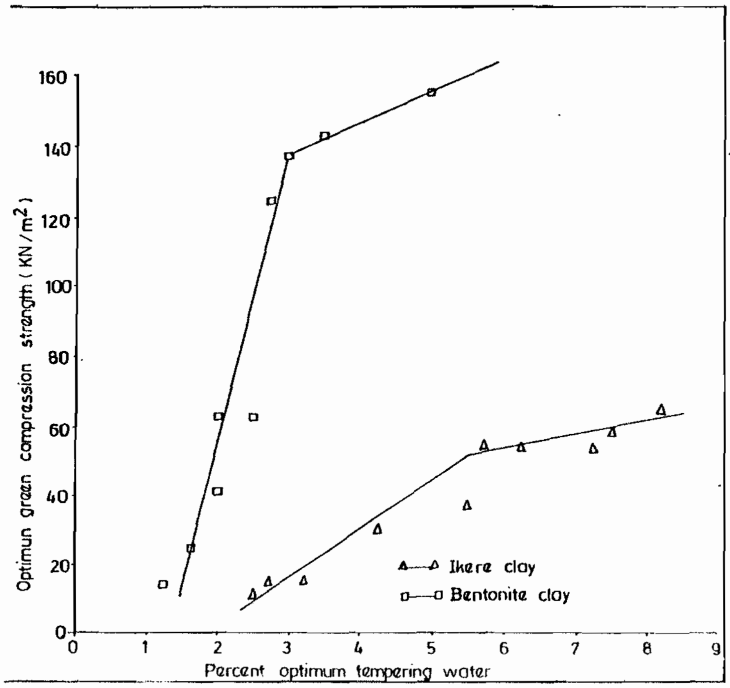

Fig 4 : Variation of optimum green compression strength with optimum tempering water.

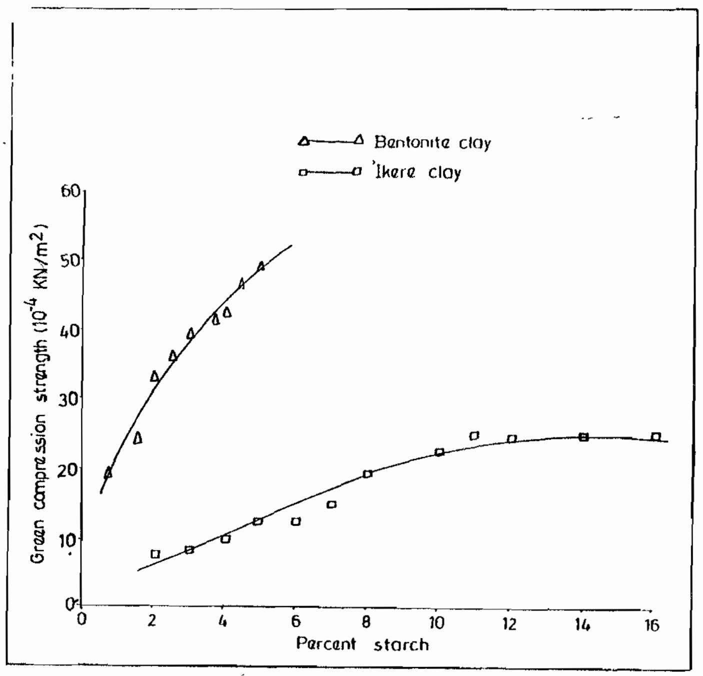

Fig 5 : Effect of variation of starch on green compression strength of clay-water-sand mixture.

52kNm^{-2} for bentonite and Ikere-Ekiti clays respectively.

The value of 52kNm^{-2} obtained for Ikere-Ekiti clay in this study compares favourably with 34 -65kNm^{-2} given as standard by American Foundrymen's Society(1963) on clay bonded moulding sands. Although, the value of 138kNm^{-2} for bentonite is far higher than that obtained for Ikere-Ekiti, in the light of the standard given by AFS(1963), Ikere-Ekiti could safely be used as suitable replacement for foundry operations.

EFFECT OF VARIATION OF STARCH ON GREEN STRENGTH OF CLAY-WATER-SAND MIXTURE

Figure 5 is a plot of green compression strength against the clay-water-sand mixture using the optimum conditions as determined from Figure 4. From the plot, it can be seen that the green strength increasaed steadily with starch additions for both clays. This is expected because starch is known to develop a gelatinous bond with water. This ability to exhibit strong moisture bond delays the air drying of sand mixtures and contribute to improved bench life of moulding sand. The results obtained are in good agreement with the observed values by Balogun and Adepoju(1983).

CONCLUSION

Investigations have been undertaken to determine the suitability of Ikere-Ekiti clay deposit as substitute for bentonite in foundry operations. It was found that the green strength of the silica base sand increased with increase in Ikere-Ekiti clay and tempering water contents in the same manner as bentonite clay. The optimum green compression strength obtained for Ikere-Ekiti clay bonded moulding sand was found to be within the acceptable limit, an indication that Ikere-Ekiti can safely be used as replacement for bentonite in foundry operations.

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