ISSN 2250-3153

Computer Programe for the Determination of Optimum Compressive Strength of SDA-Clay Bricks

[1]Dr. D.O Onwuka, [2]Chijioke Chiemela, [2]Ibearugbulam O. H., [3]Obilonu A. N, [4]Adinna B.O

[1]Civil Engineering Department Federal University of Technology Owerri Imo State Nigeria
[2]Civil Engineering Department Federal Polytechnic Neked Owerri Imo State Nigeria.
[3]Agricultural Engineering Department Federal Polytechnic Nekede Owerri Imos State
[4]Civil Engineering Department Nnamdi Azikiwe University Awka Anambra State Nigeria

Abstract- Often times, admixtures such as sawdust ash (SDA) are added to raw mixes of burnt bricks in order to modify the properties or reduce the cost of the final product. This article present computer programs based on Simplex and Regression Theories, for the determination of the optimum percentage of saw dust ash to be added to clay in order to produce burnt bricks of optimum compressive strength. Bricks of optimum mix would in its finished state, satisfy at minimum cost, the required performance determined by its application. Besides, the compressive strength of SDA-clay bricks obtainable from a specified mix proportions of its constituents and vice verse. Comparison of the results determined by computer programs based in Scheffe's and Regression Theories, showed that there is complete agreement between them. The two computer results, also agreed with the experimental results.

Index Terms- Computer Programs, Optimum Compressive Strength, Clay, Sawdust ash (SDA), Bricks, Simplex Theory and Regression Theory.

I. Introduction

Clay bricks are masonry units widely used for centuries as building components all over the world. As a matter of fact, bricks are the oldest manufactured building materials, some of which are estimated to be about 6000 years old (Ibstock, 2005). Their properties vary according to the purpose they are intended to serve. The high compressive strength of burnt clay bricks has been exploited for millennium to build structures ranging from high-storey to massive public buildings, big bridges and viaducts (Ignis, 2008).

Sawdust ashes and other pozzolanic materials have been individually or collectively used as admixtures to modify the properties or reduced the cost of bricks and the other building materials. However, it is difficult, time consuming as well as expensive to determine the optimal percentage of Sawdust ash to be added to be added to in order to produce burnt bricks of optimal compressive strength at minimum cost. Computer programs based on Simplex Theory (Scheffe's, 1958) and Regression Theory (Osadebe, 2003), were adopted in this work for the determination of the optimal mixtures of SDA-clay burnt bricks. The programs can be used quickly to determine optimum bricks having a specified mix proportions, and vice versa.

II. THEORITICAL BACKGROUND

Two computer programs were developed using response functions based on the Simplex and Regression theories.

III. SIMPLEX THEORY

Simplex theory (Scheffe, 1958) is the basis of the first response function used in the development of the first computer program for the determination of the optimum compressive strength of the SDA-clay bricks. The theory is applicable only when the response (i.e. property of a mixture) sought, is a function of the mixture components. In this theory, a polynomial function (i.e.Eqn.( )) is used to represent the response of a pseudo-components.

$$F = b_0 + \sum b_i X_i + \sum b_{ij} X_i X_j \text{-------------------} 1$$

Where: b_i and b_j are constants

X_i and X_j are pseudo components

i and j are subscripts representing points on the simplex lattice and they lie within the region $0 \le i \le j \le 3$

For the SDA-clay bricks with three components, the final response function F, derived from Eqn.(1), is given as follows (Chijoke, 2011):

$$F_{(x)} = 28.32X_1(2X_1 - 1) + 18.03X_2(2X_2 - 1) + 14.35X_3(2X_3 - 1)$$
$$+98.68X_1X_2 + 80.28X_1X_3 + 70.48X_2X_3 \text{-------------} 2$$

The final response function given by Equ.(2) is the basis of the first computer program for the optimum compressive strength of SDA-clay burnt bricks.

IV. REGRESSION THEORY

The second computer program, is based on the response function derived from Regression theory (Osadebe,2003). Here the response function $F_{(x)}$, is given as a function of its predictors, Z_i, as follows:

$$F_{(z)} = F_{(x)}{}^{(0)} + \sum \partial F/\partial Z_i (Z_i - Z_i{}^{(0)})$$

$$+\tfrac{1}{2}!/\sum\sum \partial^2 F\left(Z^{(0)}\right)/\partial Z_i \partial Z_j \left(Z^{(0)}\right)\left(Z_i - Z_i^{(0)}\right)\left(Z_j - Z_j^{(0)}\right)$$

$$+\tfrac{1}{2}!/\sum\sum \partial^2 F\left(Z^{(0)}\right)/\partial Z_i{}^2 \left(Z^{(0)}\right)\left(Z_i - Z_i^{(0)}\right)^2 + - - - - - \quad (3)$$

Where $1 \le i \le 3,\ 1 \le i \le 3, 1 \le j \le 3$ and $1 \le i \le 3$ respectively.

The response function, $F_{(x)}$, is assumed to be continuous and differentiable with respect to its predictors, $Z_{(i)}$. By making use of Taylor series and expanding Eqn.(3) in the neighbourhood of a chosen point, $Z = Z_1{}^{(0)}, Z_2{}^{(0)}, Z_3{}^{(0)}, Z_4{}^{(0)}$, and $Z_5{}^{(0)}$, Eqn(4) was obtained:

$$F_{(z)} = 2027767Z_1 + 885121.7Z_2 + 1431628Z_3 + 231203.6Z_1Z_2 - 27119950Z_1Z_3$$
$$-22325282Z_2Z_3 - - - - - -(4)$$

Where Z_1, Z_2 and Z_3 are the ratio of the actual component portion to the total quantity of SAD-clay mixture.

$$\begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \\ Y_4 \\ Y_5 \\ Y_6 \end{bmatrix} = \begin{pmatrix} Z_1^1 & Z_2^1 & Z_3^1 \\ Z_1^2 & Z_2^2 & Z_3^2 \\ Z_1^3 & Z_2^3 & Z_3^3 \\ Z_1^4 & Z_2^4 & Z_3^4 \\ Z_1^5 & Z_2^5 & Z_3^5 \\ Z_1^6 & Z_2^6 & Z_3^6 \end{pmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_{12} \\ \alpha_{13} \\ \alpha_{23} \end{bmatrix} - - - - - - - - - - - - - - (7)$$

Where

$$[\alpha]^T = [\alpha_1, \alpha_2, \alpha_3, \alpha_{12}, \alpha_{13}, \alpha_{23}] - - - - - - - - - - - - - - (8)$$
$$\left[Y^{(n)}\right]^T = [Y^1, Y^2, Y^3, Y^{12}, Y^{13}, Y^{23},] - - - - - - - - - - - - - - (9)$$
$$\left[Z_i^{(K)}\right] = [Z_1^K, Z_2^K, Z_3^K, Z_4^K, Z_5^K, Z_6^K] - - - - - - - - - - - - - - (10)$$

Where $1 \le n \le 6$ and $1 \le k \le 3$

The elements of the $Z^{(n)}$ matrix were derived from the matrix of actual portion i.e $\left[S^{(n)}\right]$, while the elements of $Y^{(n)}$ matrix were obtained from laboratory test. Therefore, the elements of the matrix of constant coefficient can be determined from the following equation.

$$[\alpha] = \left[Z^{(n)}\right]^{-1}\left[Y^{(n)}\right] - - - - - - - - - - - - - - - - - -(11)$$

Eqn(4) is the final regression response function for the development of computer program for the determination of the optimum compressive strength of SDA-clay burnt bricks.

V. REGRESSION MATRIX

The response function, which is dependent on the proportion of mixture components, is given by

$$Y^{(n)} = \sum \alpha_i Z_i{}^{(n)} + \sum \alpha_{ij} Z_i{}^{(n)} Z_j{}^{(n)} - - - - - - - - - - - - - -(5)$$

Where $1 \le i \le j \le 3$ and $n = 1,2,3$

The above equation can be given in matrix form as follows:

$$\left[Y^{(n)}\right] = \left[Z^{(n)}\right][\alpha] - (6)$$

Where $\left[Y^{(n)}\right] =$ matrix of resonse function at the 'nth' point of observation.

$\left[Z^{(n)}\right] =$ matrix of predictors or fractional portion
$[\alpha] =$ matrix of constant coefficient

Expanding Eqn(6) yields:

VI. COMPUTER PROGRAM

Interactive computer programs coded in Visual Basic 6.0 language were developed for the execution of the formulated response functions. The first program based on Simplex response function is given in appendix ( ), while the second program based on the Regression response function is given in Appendix ( ).

Each of the programs is prepared in two segments. The output of the first segment is a set of mix proportion of bricks components obtainable from an output of a desired compressive strength. And the output of the second part is the compressive strength of bricks obtainable from a given input of mix proportions of bricks components. Also, optimum compressive strengths are printed out. The results of the executed programs are given in Table 1 and 2 respectively.

Table 1: Mix Proportions from the computer program based on Simplex Theory, corresponding to a desired compressive strength of 26.02KN/m^2.

Compressive Strength (KN/m^2)	Clay (Kg)	SDA (Kg)	Water (Kg)
26.03	0.08	0.29	0.71
26.02	0.05	0.28	0.72
26.02	0.06	0.29	0.72
26.02	0.07	0.29	0.71

Table 2: Mix Proportions from the computer program based on Regression Theory, corresponding to a desired compressive strength of 26.02KN/m^2.

Compressive Strength (KN/m^2)	Clay (Kg)	SDA (Kg)	Water (Kg)
26.03	0.08	0.29	0.71
26.02	0.05	0.28	0.72
26.02	0.06	0.29	0.72
26.02	0.07	0.29	0.71

Compressive strength output corresponding to a given mix proportion:
Output of Simplex Function program
Input the value of clay 0.04
Input the value of SDA 0.28
Input the value of water 0.72
Strength F, of 30KN/m^2, clay 0.04, SDA 0.28 , water 0.72

Output of Regression Function program
Input the value of clay 0.04
Input the value of SDA 0.28
Input the value of water 0.72
Strength F, of 30KN/m^2, clay 0.04, SDA 0.28, water 0.72

VII. DISCUSSION OF RESULTS

The compressive strength results from the two computer programs based on the Simplex and Regression functions are in agreement with the laboratory results as well as with each other. The optimum compressive strength of burnt bricks obtained from simplex function program, is. But, the optimum compressive strength obtainable from the regression function program has no upper bound.

VIII. CONCLUTION

Each of the two programs developed, can be easily and quickly used to determine various combination of bricks components that can yield burnt bricks of a desired compressive strength. Besides, the programs can be used to determine the compressive strength of bricks produce from a given mix proportion of its components. Another value that can be obtained from the program is the optimum compressive strength. The use of the program saves cost.

REFERENCES

[1] Chijioke Chiemela (2010), Mathematical Models for the Optimisation of the Compressive Strength of Saw Dust Ash-Clay Bricks, M.Eng Thesis Submitted to the Department of Civil Engineering, Federal University of Technology, Owerri, Nigeria.

[2] Ducman, V and Keeper, T (2001), The Influence of Different Waste Additives to Clay – product Mixture. Original Scientific Article, MTAEC9, 41(6), p 289.

[3] Elinwa, A.U (2006), Effect of Addition of Sawdust Ash to Clay bricks, Civil Engineering and Environmental System, Vol. 23, No 4, 263-270.

[4] Ibstock (2005) ‘’ Technical information Sheet 16’’

[5] Osadebe, N.N (2003) ‘’ Generalised Mathematical Modelling of Compressive Strength of Normal Concrete of as a Multi-variant function of the Properties of its Constituent Components’’.

[6] Scheffe, H. "Experiments with Mixtures" Royal Statistical Society Journals Ser. B Vol. 20, Pp 344-360 (1958).

AUTHORS

First Author – Dr. D.O Onwuka, Civil Engineering Department Federal University of Technology Owerri Imo State Nigeria
Second Author – Chijioke Chiemela, Civil Engineering Department Federal Polytechnic Neked Owerri Imo State Nigeria.
Third Author – Ibearugbulam O. H, Civil Engineering Department Federal Polytechnic Neked Owerri Imo State Nigeria.
Fourth Author – Obilonu A. N, Agricultural Engineering Department Federal Polytechnic Nekede Owerri Imos State
Fifth Author – Adinna B.O, Civil Engineering Department Nnamdi Azikiwe University Awka Anambra State Nigeria