FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

Book of Proceedings

1ST BIENNIAL ENGINEERING CONFERENCE

Theme:

DECAY IN INFRASTRUCTURE - A CHALLENGE TO SCIENCE AND ENGINEERING RESEARCH IN REALISING VISION 20-2020

Date: 26th - 28th June, 2008 | Time: 10:00am

Venue: Federal University of Technology, Main Campus, Gidan Kwano, Minna, Niger State, Nigeria.

PROCEEDINGS OF THE 1ST BIENNIAL ENGINEERING CONFERENCE (BEC' 08)

Held at the School of Engineering and Engineering Technology of the Federal University of Technology, Minna Main Campus

on

26th – 28th June 2008

THEME: DECAY IN INFRASTRUCTURE – A CHALLENGE TO SCIENCE AND ENGINEERING RESEARCH IN REALISING VISION 20 – 2020

Members of the Local Organizing Committee

Dr. M. O. Edoga	Chairman	Chemical Eng. Dept.
Mr. A. Mukhtar	Secretary	Chemical Eng. Dept.
Dr. E. N. Onwuka	Member	Elect/Comp. Eng. Dept
Dr. J. Tsado	Member	Elect/Comp. Eng. Dept
Dr. J. O. Abu	Member	Agric Eng. Dept
Dr. V. I. Ogwuagwu	Member	Mechanical Eng. Dept
Mr. O. J. Okegbile	Member	Mechanical Eng. Dept
Dr. O. Chukwu	Member	Agric Eng. Dept.
Dr. S. M. Auta	Member	Civil Eng. Dept.
Dr. B. A. Alabadan	Member	Agric Eng. Dept.
Mr. A. A. Aboje	Member	Chemical Eng. Dept.
Mr. P. Idah	Publicity Chairperson	Agric Eng. Dept.
Engr. J. I. Aguwa	Member	Civil Eng. Dept.
Mrs. W. Yahya	Protocol Chairperson	Chemical Eng. Dept.
Engr. F. Atume	Member	Registrar COREN

Co-opted Members

Engr. J. O. Okafor	Technical Secretary	Chemical Eng. Dept.
Mr. C. Chukwudozie	Member	Chemical Eng. Dept.
Mr. U. Musa	Member	Chemical Eng. Dept.
Engr. L. I. Onyeji	Member	Chemical Eng. Dept.
Mr. J. Ochoge	Member	Chemical Eng. Dept.
Elder M. A. Olutoye	Member	Chemical Eng. Dept.

TABLE OF CONTENTS

PAPERS

SESSION GA1: AGRICULTURE AND FOOD SECURITY, ENERGY

SESSION GB1: RESEARCH EVALUATION

Session GC1: Collaborative Research

Session GA2: Transportation Infrastructure and Materials

Session GB2: Water and Waste Management

Session GC2: Information and Communication Technology (ICT), Process / Quality Control, Analysis and Safety in Engineering System

*QUANTITATIVE ANALYSIS OF THE CHEMICAL COMPOSITIONS OF SELECTED CEMENT BRANDS IN NIGERIA

by

***MUIBAT DIEKOLA YAHYA**

Department of Chemical Engineering, Federal University of Technology Minna, Niger State, Nigeria

Email: <mdoyejobi@yahoo.com>

ABSTRACT

This work was carried out to evaluate the quality of Cement produced by the Nigeria Cement industries using Atomic Absorption Spectrophotometer (AAS). Five brands of cement samples were analysed.

The percentage (%) composition of Na_2O, K_2O, Fe_2O_3, Al_2O_3 and MgO are within the acceptable range of British Standard (BS) and America Society for Testing Materials (ASTM), The percentage composition of Silica was below standard specification for Dangote, Sokoto, Burham, and Benue cement with respective composition of 18.02%, 15.0%, 19.07% and 14.53%. Ashaka cement alone has a specification close to expected standard. The CaO content agrees well British Standard for all cement types with Dangote having the lowest of 51.67%, Ashaka 60.00%, Burham 56.17 and Benue Cement 55.90%.The results obtained for the five cement brands met 85.98% specification requirements and thus can be recommended for structures with low loading capacities.

INTRODUCTION

Cement is a mixture of compound consisting mainly of silicate; and aluminate of calcium formed out of calcium oxide, silica, aluminum oxide and iron oxide.(Taylor, 1990) Performance characteristic of Cement are influenced by their major composition lime (CaO), silica (SiO_2), alumina (Al_2O_3), iron or ferrite (Fe_2O_3)) and minor composition (Na_2O, K_2O, MgO). ASTM classification of cements as Types I through V are based partly on composition, with Cement optimized for different application. For example, the rapid strength development of Type III Cements is as result of large percentage of CaO with their relatively large mass fraction of alite. In contrast, the decreased mass fraction of alite and aluminate produces Low Heat Type IV Cement. The ability to accurately determine cement composition should lead to a better understanding of its effects on performance and aid in the prediction of structures and concrete material properties (Struzman, 1996). However, to maximize benefit in construction industries, every cement products must meet up with all the required standard composition and properties. Series of standard analysis and test such as X-ray diffraction analysis, ICP spectrometry analysis, microscopy method of flame photometer are among few to be mentioned .It is difficult to analyze cement using the Titrimetric/Gravimetric method because major compounds such as CaO, SiO_2, Fe_2O_3, Al_2O_3, SO_3 are being produced at the same time and the process is time consuming. So, a modification of the process is indeed necessary, but is attended with some trials and error and has risks. However, Atomic Absorption Spectrophotometer (AAS) technique has made rapid progress in recent years. The advantages of AAS are good detection limits, controllable matrix and chemical effects, analytical specification/ relative low cost, simplicity in instrumental handling and excellent accuracy, precision and sensitivity (Iyaka, 2006).

The aims of this work are:

i) To investigate the composition of compounds in different brands of cement, namely Dangote, Burham, Sokoto, Ashaka and Benue Cement

ii) To check if the properties of the above named brand of cement conforms to specification requirement.

METHODOLOGY

Five different Brands of Cement namely Dangote, Sokoto, Benue, Burham and Ashaka Cement where collected from their various production areas which have different climatic conditions.

DETERMINATION OF MAJOR CONSTITUENTS OF PORTLAND CEMENT

The procedures used in the chemical analysis of portland cement are described in this group of tests. For routine samples, the Atomic Absorption method is used as described in ASTM (ASTM Designation C 114).

A. APPARATUS

1. Unless otherwise indicated, all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society.
2. Atomic Absorption Spectrophotometer -(AAS) - The Perkin-Elmer A Analyst 100

PROCEDURE

Before testing, samples were passed through an 850-mm sieve in order to mix the samples. The lumps were broken and foreign materials removed. The cement was stored in air tight moisture proof containers to prevent aeration or absorption of moisture prior to test.

As given in National Institute of Standards and Technology (NIST) Standards:

Series of 5 standard cement samples were selected namely Ashaka, Benue, Sokoto, Dangote, and Burham Cement.

Preparation of Standards:

0.250g of each sample was weighed into a 100ml beaker and was dispersed with 20ml of distilled water and 4ml of concentrated HCl. Lumps were broken with glass stirring rod and was removed from the beaker. The samples were covered with a water glass and digested on a low hot plate for 15 min at approximately 75°C. During digestion, samples were stirred continuously and filtered through a medium texture filter paper into a 200ml volumetric flask. Samples were washed thoroughly with hot HCl acid (1:99) and rinsed severally in hot distilled water. The samples were cooled to room temperature and then diluted to a volume of 200ml.

Preparation of Samples

0.125g of cement was weighed into a 100ml beaker and dispersed with 10ml of distilled water and 2ml of concentrated hydrochloric acid. The samples were digested and prepared exactly as described as above. The final filtrate was diluted and made to the mark 100ml.

RESULTS AND DISCUSSION OF RESULTS:

Table 1.1: Result of chemical analysis of test sample

% COMPOSITION OF THE BRANDS					
Oxide	*Dangote*	*Sokoto*	*Ashaka*	*Burham*	*Benue*
SiO_2	18.02	15.0	20.65	19.07	14.53
FeO_3	10.5	0.84	2.20	3.15	0.715
CaO	51.67	54.5	60.00	56.17	55.9
Al_2O_3	1.25	3.20	3.83	5.30	3.12
MgO	1.45	1.84	0.75	0.74	1.45
SO_3	1.40	0.17	1.70	1.14	0.33

Table 1.2: Standard Specification of ASTM and Federal Specification Board

	Type I	*Type II*	*Type III*	*Type IV*	*Type V*
C_3S	45	44	53	28	38
C_2S	27	31	19	49	43
C_3A	11	5	11	4	4
C_4AF	8	13	9	12	9
$CaSO_4$	3.1	2.8	4.0	3.2	2.7
MgO	2.9	2.5	2.0	1.8	19
CaO_f	0.5	0.4	0.7	0.2	0.5

TABLE 1.3: CALCULATED MINERAL PERCENTAGE COMPOSITION OF PORTLAND CEMENT

SAMPLES	C_3S	C_2S	C_3A	C_4AF	TOTAL SUM
ASHAKA	22.55	46.41	12.51	6.08	87.55
BENUE	20.58	41.83	6.36	7.62	76.36
BURHAM	22.91	42.94	12.51	6.08	84.44
DANGOTE	33.33	26.47	14.33	4.77	78.90
SOKOTO	21.40	41.98	6.60	7.92	77.90

DISCUSSION OF RESULTS.

The cement samples shall be individually discussed.

ASHAKA CEMENT

From Table 1.1 the CaO of Ashaka cement agrees well with Type IV of ASTM Portland cement and was slightly in conformity with Type I. This corresponded to the Low Heat Portland Cement of British Standard and Ordinary Portland cement respectively. The percentage content of SiO_2, Al_2O_3, Fe_2O_3 and MgO were all in conformity with Type I. Although MgO was quite low, the value corresponded well with Ordinary Cement of BS. The percentage content of SO_3 is of the same magnitude with Type I and Type II though slightly high in comparison to other cement. Ashaka has the highest C_2S as compared to the other cement. . Cements high in C_2S will hydrate much more slowly, leading to a denser ultimate structure and a higher long-term strength. The relative ratio of C_3S to C_2S, and the overall fineness of cements, has been steadily increasing over the past few decades. Indeed, Pomeroy (1989) notes that early strengths achievable today in concrete could not have been achieved in the past except at very low water-to-cement ratios (w/c's), which would have rendered concretes unworkable .However, the CaO differ totally from Type I but corresponded with Type IV Low Heat of BS. These variations are all within the acceptable limit (BS & ASTM). It can be deduced that Ashaka is more of Type I Ordinary Cement and can be used for general concrete construction.

BENUE CEMENT

Benue cement has 14.53% SiO_2, 0.715%Fe_2O_3, 55.9% CaO, 3.12%Al_2O_3, and 1.45%MgO. The CaO of Benue cement is low but slightly in conformity with Type V of ASTM Portland Cement. This corresponded to Sulfate resistance Portland cement of British standard. The percentage of SiO_2, Fe_2O_3, Al_2O_3 and MgO are also slightly in conformity with Type V of ASTM Portland cement and slightly in conformity with sulphate resistance to Portland cement of British standard. The Benue Cement recorded the lowest % content of SiO_2 and aluminate. Set Retarder and water Reducers are used to improve the compressive strength of concrete (ASTM C 150 AND A ASHTO M85)

SOKOTO CEMENT

Sokoto cement has 0.84%Fe_2O_3, 3.20%Al_2O_3, 0.17%Na_2O, 54.5% CaO, and 15.0%SiO_2 and 1.84%Mgo. The Al_2O_3 of Sokoto Cement merges well with Type II of ASTM Portland cement but slightly in conformity with Type I, this corresponded to the Ordinary Portland Cement of British standard. The CaO, SiO_2 and MgO of Sokoto Cement is below the British Standard and Type I through V of ASTM Standard. This was attributed to less early strength but developed higher later strength and longer setting time.

BURHAM CEMENT

On table 1.1, the percentage values of SiO_2, Al_2O_3 and Fe_2O_3 fell within the range of Type I Portland cement. The MgO, though out of range of ASTM, still merges well with BS of Ordinary Cement.On the other hand, the percentage values recommended for CaO, SO_3 and CaO all fell within Type IV of Portland cement. The C_3S and C_2S contents tally well with Type IV low heat Portland cement, Based on the high silica content, Burham cement has a higher C_3A content and this enhances the initial strength gain. C_3A hydrates very rapidly and will influence early bonding characteristics. Abnormal hydration of C_3A and poor control of this hydration by sulfate can lead to such problems as flash set, false set, slump loss, and cement-admixture incompatibility (Previte 1977; Whiting 1981; Meyer and Perenchio 1979).

Sequel to this, it can be said that Burham cement, lies within the region of Type I Portland cement. It can be used for general concrete structures.

DANGOTE CEMENT

Dangote cement has so many varying properties when compared with all the other cement types. It recorded the lowest percentage of composition of CaO and also the highest percentage of Fe_2O_3. The SiO_2 percentage value was in accordance with the Ordinary Cement of BS .The Al_2O_3 of about one percent composition corresponded slightly with Type IV of ASTM. The MgO and SiO_2 values are of Type I and its CaO and SO_3 percentage composition are of Type IV. Its mineralogical composition, its C_3S and C_3A corresponded to Type I while its C2S and C_4AF are Type IV and Type V respectively. The low value of C_4AF was as a result of the substitution of Ferric oxide for Alumina and thus an increase in C_3A and a reduction of C_4AF. This was ascertained as given in Kind formular, (Voljencki,V.; 1986). Dangote has the highest C_3S when compared to other cements. Cements high in C_3S (especially those that are finely ground) will hydrate more rapidly and lead to higher early strength. However, the hydration products formed will, in effect, make it more difficult for hydration to proceed at later stages, leading to an ultimate strength lower than desired in some cases. This ability to achieve desired strengths at a higher workability (and hence a higher w/c) may account for many durability problems, as it is now established that higher w/c invariably leads to higher permeability in the concrete (Ruettgers, Vidal, and Wing 1935; Whiting, 1988).

CONCLUSION

From the analyses, it was observed that the two brands, Sokoto and Benue Portland cement produced in the country are defective.The Fe_2O_3 content in both cement is less than 3% and MnO is practically absent in the raw material used. This eliminates their influence on the clinker formation mechanism of alite, belite and calcium alumino ferrite solid solutions (Odigure, 1997).

Consequently, the poor performance of these cement is connected with poor sintering condition especially inability to obtain the required sintering temperature and cooling regime (Bensted, J. 1979). This has encouraged the formation of predominantly poor hydrating C_2S, belite solutions. It is recommended that the locally produced cement be used particularly for structures with low loading capacity.

The imported cements were not uniform in their chemical properties. The Dangote Portland cement has relatively high Fe_2O_3 content. It is impossible to sinter such cement in a normal rotary kiln. Consequently, microscopic analysis needs to be performed to ascertain the class of cement. This may belong to a slag Portland cement. The Burham brand has a chemical composition of 'a normal Portland cement. Both cements can be used for structures with high loading capacity.

REFERENCES

ASTM Designation: C 114. Portland Cement Association, Research Department Bulletin 214, 'Analysis of Portland Cement by Atomic Absorption.'

Bensted, J. (1979). Blue Circle Industries Limited, Research Division, Green Wither, UK Iyaka Y.A. (2006)., Atomic Absorption Spectrophotometer Determination of Heavy Metals in Soil.

Meyer, L. M., and W. F. Perenchio. (1979). Theory of concrete slump loss as related to use of chemical admixtures. Concrete International. Design and Construction 1 (1):36-43

Odigure, J. O.; (1997). Cement and Concrete Research 21 1641 – 1648

Pomeroy, D. (1989). Concrete durability: From basic research to practical reality. ACI special publication. Concrete durability SP- 100: 111-31.

Previte, R. (1977). Concrete slump loss. ACI Journal Proceedings 74 (8):361-67.

Ruettgers, A., E. N. Vidal, and S. P. Wing. (1935). An investigation of the permeability of mass concrete with particular reference to Boulder Dam. ACI Journal Proceedings 31:382-416.

Standard specification for portland cement (AASHTO M 85-89).(1986). AASHTO standard specification for transportation materials. Part I, Specifications, 14th edition.

Standard specification for portland cement (ASTM C 150-86). (1990). Annual book of ASTM standards 4.02:89 - 93.

Strutzman P.E., Guide for X-ray Diffrraction Analysis of Portland Cement and Clinker

Taylor, W.F.W (1990), Cement Chemistry Academic Press Limited, London.

Taylor, W. F. W., ed. (1964). The chemistry of cements. 2nd volume. London: Academic Press.

Voljencki,V.; (1986).Mineral Binding Materials, fourth edition, Stroiizdat, Moscow

Whiting, D. (1981). Evaluation of super-water reducers for highway application. FHWA/RD 80/132 (March). Washington: FHWA.