Open Access Library Journal
2021, Volume 8, e6966
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Chemical Analysis of the Parameters Determining the Quality of a Case of Cement from Cement Sold on the Mbuji-Mayi Markets

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How to cite this paper: Pierre, K.M.J., Alexis, N.K., Christophe, K.L. and Paul, C.M. (2021) Chemical Analysis of the Parameters Determining the Quality of a Case of Cement from Cement Sold on the Mbuji-Mayi Markets. *Open Access Library Journal*, **8**: e6966.
https://doi.org/10.4236/oalib.1106966

Received: November 7, 2020
Accepted: March 12, 2021
Published: March 15, 2021

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Abstract

This study aims to assess the quality of cement used in civil engineering. We have used the following approaches and techniques for data analysis: calcination conydexiométrie gravimetric and photometric. The results show that as regards the content of SO_3, MgO, Cao and alkali oxide, the cements are within the limits of the standards required by the Congolese Control Office (OCC). In view of these results, the conclusion is that the cements used in Mbujimayi can be effectively put to several uses that do not require special cements.

Subject Areas

Analytical Chemistry

Keywords

Chemistry, Chemical Analysis, Determination of Parameters, Cement, Mbuji-Mayi

1. Introduction

Unfortunately the province of Kasai Oriental does not produce cement despite its multiple projects on Katanda and Bakodile limestone. Thus it is obliged to import cement from other provinces and from outside of the country. In the markets of the town of Mbuji-Mayi, one can find cement from the following cement factories:

- Lukala cement

- Lubudi cement
- Cement in Chilanga
- Kalemie cement
- Es Pagnole cement plant

These cements used in several construction sites in the city of Mbuji-Mayi are sometimes the subject of piracy, by some ill-intentioned sellers by adding either sand, or ashes from the calcination, thus distorting the parameters of the firewood d 'a good cement. This sensitive denatured cement can negatively influence the construction works, thanks to which, we proposed to study six parameters which determine the quality of a good cement by the standards of the Congolese Control Office (acronym OCC), which are those of the American company A.STM: US Society for Testing of Materials. The objective we are pursuing by studying these different parameters is to determine whether the cement sold on the Mbuji-Mayi market is of good quality. For the parameters to be studied the standards set at the following limits, one can never go beyond ser:

- 0.85% ± 0.15% insoluble residue
- 4.00% ± 0.25% of fire losses
- 2.00% ± 0.10% sulfur trioxide
- 5.00% ± 0.40% magnesium oxide

To these values, we added the limits of certain parameters that we could not bypass according to Wilfred (2005); they are: 57% to 70% for calcium oxide, 1% for alkaline oxides, in this case sodium and potassium oxide [1]. We must note that the quality of a good cement depends on four previous settings. For this study, we used quantitative analysis techniques such as: gravimetry; the flame of complexiometry and photometry.

Since our study is about cement, it is good to talk briefly about this building material.

2. Cement

2.1. Definition

Cement can be defined in different ways: as a binder or a thermodynamically unstable and more soluble body system which, in the presence of water, gives a saturated solution, which will crystallize spontaneously causing setting and forming a more stable system; or powder of an alternative binder resulting from the firing at high temperature (1400˚C to 1500˚C) of a carefully measured mixture of clay and limestone [2].

2.2. Types of Cements and Their Behavior

There are several types of cement which can be grouped into two categories:

2.2.1. Aerial Cement

1) Cement of anhydrite

It is prepared from natural gypsum at a temperature of 600˚C to 700˚C as a mixture with catalyzed curing: CaO; (N_a^+, Cu^{2+}, Fe^{2+})SO_4; fired dolomite, alkaline slag [3] is a slow-setting cement that comes on after thirty minutes and ends after twenty-four hours. It is used for masonry mortars,

2) Antacid cement

It is a cement which contains within it calcium carbonate and clay injected with a liquid glass there are also certain anti-acid substances such as quartz, sodium fluorine silicate (Na_2SiF_6) with 0.5% linseed oil and 2% ceresite is a normal, hydrophobic, chemical resistant hardening cement is used in the insulation of chemical refractories in acid absorption towers as well as in chemical industry premises.

2.2.2. Hydraulic Cement

1) Roman cement

They are pure dolomitic marls and boiled with 25% clay impurities, 15% of mineral additives and 5% natural gypsum ($CaSO_4 \cdot 2HO_2$) is a slow-setting cement and low resistance Its hydraulic modulus varies between 1.1 to 1.7 Its setting begins after 15 minutes and ends after 24 hours. It is used for plaster and masonry, inferior concrete and for wall stones and small blocks [3] [4].

2) Portland cement pozzolamic

It is a clinker pulverized with hydraulic substances varying from 20% to 50% mixed with various industrial siliceous wastes and volcanic ash. It is a sedimentary which contains 30% diatomite and tripoli and has a slow. During its hardening, it undergoes two processes; hydration of mineral clinker and the interaction of active mineral admixture with calcium hydroxide to resist water and is used for the construction of works underwater and in circles with high temperature variation.

3) Slag cement

It is a cement for granulated blast furnace slag (cast iron waste) It has spontaneous hardening under water and higher resistance to water, humidity and frost It is used in hydraulic constructions in humid environment as well as in constructions subject to frost and humidity and drying.

4) Aluminous cement

It is a mixture of bauxite and baked lime with a preponderance of low alkalinity calcium aluminate and 2% mineral additives. It is a fast hardening cement (30 minutes and ends after 12 hours) and good physical properties—mechanical. It is used for restoration works of dams, pavements, foundations, buffering of oil and gas probes, as well as lining of mine shafts, tunnels.

5) Portland cement

It is a cement composed of approximately 75% calcium carbonate and 25% clay and a little gypsum after clinkerization. This cement produces hard, air-stable and frost-resistant cement products. It is used in several areas depending on their varieties.

6) The expansive elements

This is aluminous cement containing calcium aluminate and a high alkalinity of about 30% natural gypsum. Volume increases when cured in humid conditions and without suffering shrinkage. It is used for the restoration of damaged concrete constructions as well as for the hydraulic insulation of tunnels and mine shafts also in underground constructions.

3. Experimental Study

3.1. Chemical Analysis of Samples

In our study, our attention is focused on the quantitative determination in different types of cement, can the parameters confer the harmful properties related to their use in the building according to the American standard (ASTM) such as the OCC the currently using. The physical-chemical laboratory of the Higher Pedagogical Institute of Mbuji-Mayi and that of Biopharco served as a research framework.

3.2. Sampling

To begin our study, we have for years no preference, the specimens collected are samples taken from our various markets in the city of Mbuji-Mayi; in the province of Kasai Oriental. For this purpose, we collected four types of cement from *any* city: white cement from Spain, Chilanga cement from Zambia, Lukala cement and cement in Lubudi; which constitute our sample.

We did not find in the Kalemie cement market and the Likasi cement plant. Our sample was taken in a single day in August of the year 2019.

3.3. Prepare and Processing of the Sample

After harvest, our samples were weighed and then broken up into cement solutions according to the following procedure [5]:

- weigh two grams of sample in a 250 cc beaker,
- mix with 20 cc of distilled water while stirring,
- add 20 cc Hcl 1.19 density and 37%,
- heat gently for 10 to 15 minutes,
- dilute the solution with 35 ml of distilled water,
- allow to digest for 15 minutes at a temperature just below the boiling point,
- filter through filter paper (medium temperature: slow filtration),
- wash two to three times with lukewarm distilled water each time the filter paper turns yellow,
- the filtrate (stock solution) obtained is used for the determination of the parameters and the residue for the determination of the insolubles.

3.4. Materials and Devices

Throughout our analyses, we used the following different materials and devices:

- Volumetric flasks of 500 and 250 ml
- pipette (±0.05 ml) 10 ml and 25 ml
- Digital MLA variable volume micropipette (50 and 200 ml)

- -Γ*ραδυατεδ* feet 50 ml and 250 ml
- porcelain crucibles
- plastic capsules
- beakers of 200 and 400 ml
- a crystallizer
- ft nces
- a squeeze bottle
- a desiccator
- Ashless medium texture quantitative filter papers
- a precision electronic analytical balance of the baxtran type (±0.001)
- a CG818 pH meter
- a VULCAN type muffle furnace
- a Prolabo type oven
- a magnetic stirrer + magnetic bar
- a Ciba Corning 410 type flame photometer (0 to 100 ppm)

3.5. Reagents

During our operations, for our analyses, we used the following reagents:

- Concentrated hydrochloric acid (1.19; 37%),
- 10% barium chloride,
- potassium cyanide,
- chloride with ammonium hydroxide,
- EDTA 0.01 M,
- distilled water,
- potassium hydroxide,
- the NET,
- the solution of Patton and Raeder 1%,
- the buffer solution at pH 10 NH_3 and NH_4Cl,
- the standard solution (mixed) based on sodium (2989.6 ppm) and potassium (207 3p pm).

3.6. Techniques and Methods Used for Laboratory

To arrive at the results of our research, we used the following techniques and methods: the calcination furnace, the filter paper filter, gravimetry, complexiometry and flame photometry.

The results of our study are presented in Table 1.

Table 1 presents the results of our analyses carried out on the four cement samples according to their origins; compared to the values set by OCC standards. Reading shows us the following:

- for insoluble contents and losses on ignition, the cements sold in Mbuji-Mayi do not meet OCC/ASTM standards,
- for sulphite, calcium oxide, magnesium oxide and alkali oxides, the parameters analysed are in accordance with the OCC standards and the values set by

Table 1. Results of four cement samples.

Type of cement + origin	Insoluble matter content (%)	Fire loss (%)	SO_3 content (%)	CaO content (%)	MgO content (%)	Na_2O and K_2O content (%)
Lukala cement (Bas Congo)	3.75 ± 0.001	4.16 ± 0.001	1.14 ± 0.001	63.91 ± 0.001	0.84 ± 0.001	0.33 ± 0.001
Standard	0.85 ± 0.15	4.00 ± 0.25	2.00 ± 0.10	63.5 ± 6.5	5.00 ± 0.40	1
Lubudi cement (Katanga)	5.79	9.47	2.13	58.82	1.01	0.23
Standard	0.85 ± 0.15	4.00 ± 0.25	2.00 ± 0.10	63.5 ± 6.5	5.00 ± 0.40	1
Chilanga cement (Zambia)	4.86	7.31	1.39	61.59	1.57	0.74
Standard	0.85 ± 0.15	4.00 ± 0.25	2.00 ± 0.10	63.5 ± 6.5	5.00 ± 0.40	1
White cement (Spain)	4.39	4.79	1.18	68.67	1.31	0.27
Standard	0.85 ± 0.1 5	4.00 ± 0.25	2.00 ± 0.10	63.5 ± 6.5	5.00 ± 0.40	1

the literature according to A-Komar and therefore WILFRED W. Scott cements are consumables.

4. Interpretation of Results

After our analyzes on four cement samples taken from soils in Mbuji Mayi, and comparing them to the table above, our samples individually did not fully meet the values set by the ASTN WILFRED *i.e.* standard in the book entitled "Standard method of chemical analysis" used by the OCC, which states that a cement is declared compliant if it meets the following conditions:

- insoluble residues: 0.85% ± 0.15%
- $\pi\alpha\rho$ your fire: 4.00% ± 0.25%
- $\sigma\upsilon\lambda\phi\upsilon\rho$ dioxide: 2.00% ± 0.10%
- Magnesium oxide: 5.00% ± 0.40%.

We added the limits of two parameters that could not be bypassed according to WILFRED, they are calcium oxide: 63.5% ± 6.5%. And all the sodium and potassium oxide does not exceed 1% content according to Komar. The cement produces Spanish, white cement apart from the fire losses and insoluble residues whose content slightly exceeds the limits or 4.79 and 1.31 for 4.00 and 0.85 set by the OCC/ASTM, other parameters, the excess of which can influence the quality of the cement, are within the limits of sulfur trioxide, magnesium oxide, and alkali oxides. According to OCC/ASTM, other parameters of which their exc Sc little wind influence the quality of the cement, also fall within the limits. I is sulfur trioxide, magnesium oxide and alkali oxides. Thus according to OCC/ASTM, the product does not comply. But the literature tells us that the existence of insoluble matter shows the presence of heavy metals such as lead, uranium or its derivatives, etc.... which, therefore, can be radioactive and have harmful effects on the human body later on. that is, their content exceeds the authorized threshold.

As for the losses on fire, we will say that it can be a question of poor packaging of products that could have captured humidity or a possible infiltration of foreign bodies after machining, just as we can think of an orchestrated mafia by sellers.

Lukala cement showed almost the same behavior as white cement, its insoluble substance content is 3.75 to 0.85 determined by OCC/ASTM which disqualifies it, but all radical parameters are good that is to say meet the standards, so according to KOMAR it is a cement that has no unhealthy effects such as causing the expansion or swelling of the hardened cement or even delaying the setting or on the contrary it is—that is to say cause sudden sets of the cement paste.

Lubudi cement can undergo the same according to ASTM standards, due to the excessive values of insoluble matter; the losses on ignition give respectively 5.79 and 9.47 for 0.85% and 4.00% and sulfur trioxide, which slightly exceeds the limit set is 2.13 to 2.00 according to the standards. As this cement is a Portland clinker cement, its results are within a range of 0 to 5% MgO and 0 to 1% for alkaline oxides and between 1.5 and 3.5 for SO_3. According to KOMAR, their higher content reduces the quality of the cement. Magnesium oxide fired at a temperature of about 1500˚C and subjected to the action of water, slowly moves away causing the appearance of cracks in the mortar or in already hardened concrete, this is why its content should not exceed 5%. The presence of alkaline oxides in amounts greater than 1% can destroy hardened concrete. A high content of SO_3 from gypsum or coal ash causes the following phenomena:

- the variation in the volume of the cement during its hardening,
- if the hardening takes place in air, the evaporation of the water leads to a decrease in volume and conversely, the hardening takes place under water, the opposite phenomenon is observed, to know its swelling.

A particularly dangerous phenomenon is the shrinkage (decrease in volume) which can lead to cracking of the hardened concrete, thus, the cement of Lubudi in view of its results described in the table above is a compliant product for construction.

Chilanga cement fulfills the same conditions as other cements, that is to say; it can be, according to the standards of the American society for testing materials that the OCC considers, said poorer therefore not compliant, but this cement has no adverse effects in construction especially the last four parameters which affect the mechanical quality of the cement are within acceptable limits (see table).

The levels of calcium oxides, substances predominant in cement, always accompanied by magnesium, meet the weight requirements according to our analysis and also as reported by A and IP KOMAR MOUKHELENON in their books which indicate that calcium oxide is found in cement in proportions varying between 62% and 67%, or 57% to 70% according to WILFRED W SCOTT (63.5% on average).

Taking into account these interpretations according to the OCC/ASTM standards, we confirmed that the four cements studied are of good quality despite the two parameters (insoluble residues and loss on ignition) give results which differ significantly in percentage; these differences are insignificant if we consider at the outset all the parameters of our study. They may suggest the presence of certain heavy metals, either humidity or a case of adulteration, but this does not affect the mechanical quality of the cements studied and the population can use it.

5. Conclusions

Our study consisted of studying the key parameters that determine the quality of a target cement. We have six parameters which are the content of insoluble residues in heat loss, sulfur oxide to magnesium oxide, calcium oxide and alkali oxides.

Our samples were taken from the markets of Mbuji-Mayi during the period of August 2019 and we were able to collect 4 types of cement from the following cement: Lukala cement, Lubudi cement, Chilanga cement and the Spanish cement factory.

We subjected these cements to analyze which gave us the following results as indicated in the table above. All these four types of cement with regard to the content of SO_3, MgO, CaO and alkali oxides are within the limits of the required standards. But with regard to the insoluble matter content, the results found strongly deviate from the standards set by the OCC; this can be explained by the presence of certain heavy metals that some researchers will be able to study later. The white cement and that of Lukala present a value which deviates slightly from the fixed standards. And the Lukala cement is within the tolerated limits of 4.16 ± 0.001, 4.00 ± 0.25 required by the OCC/A STM while the Lubudi cement and that of Chilanga do not deviate very significantly.

In view of all these results, we can conclude that the cements can be used with more or less a certain efficiency for several uses which do not require special cements.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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