

## Construction Material Considerations: Preference and Utilization of Cement in Ghana

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### Abstract

Multiple factors are often considered by professionals in the building industry in the preference and utilization of cement. Cement is a binder that sets and hardens independently and can bind other materials together through chemical hydration. It is used in concrete and mortar for different construction activities such as industrial, commercial, residential, recreational and civil works. Different types and brands of cement have been used for various purposes in Ghana since 1999. This study seeks to identify the brands of cement preferred by professionals in the construction industry and investigate factors that influence their selection and preference for the various brands of cement in Ghana. This is an exploratory study employing purposive sampling technique to obtain data from selected institutions with professionals in the construction industry. The study revealed that, Ordinary Portland Cement (OPC) produced by the Ghana Cement Company (GHACEM) is widely used and accepted as compared to the other brands on the Ghanaian market and further recommend improvement in the production capacity of other brands of cement.

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**Keywords:** cement, brand, preference, construction industry, utilization

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### INTRODUCTION

Cement is a binder that sets and hardens independently and can bind other materials together through chemical hydration. It is used in concrete and mortar for different constructional activities such as industrial, commercial, residential, recreational and civil buildings. The preference for cement and other building materials is crucial, can be complex and influenced and determined by numerous preconditions (Trusty, 2003; Rahman et al., 2008; Wastiels and Wouters, 2008; Flórez et al., 2009). Different types and brands of cement are used for these constructional activities. Selection of cement as a building material plays a key role in achieving a successful project completion and is performed both at an early stage of the design process and at the working plan by the design team (Franzoni, 2011). Aciu and Manea, (2014) described a method for the choice of the optimal material from a group of materials, taking into calculation the following impact criteria and categories: depletion of natural resources, environmental degradation, toxic substance emissions due to the energy consumed during the production, execution, exploitation and demolition processes, as well as the possibility of reusing waste.

Huni, (2015) outlines some factors affecting preference and utilization of building materials such as cement including cost, aesthetics, durability, supplier, availability, performance and maintenance. Further studies group factors that affect the choice building materials into extraction and manufacturing; sourcing; construction and installation; waste

disposal, recycle and reuse; performance Branz, (2018).

Cement has become a very important international commodity because of increased infrastructural development world-wide. By the year 2010, the construction sector in Ghana was the single largest consumer of cement with the building construction industry accounting for about 95% of its usage. Two major sectors are identified within the building construction industry, namely residential which accounts for about 75% of cement consumption and industrial development comprising of offices, schools, factories and commercial structures which consume about 20% of all cement produced and imported into the country. The remaining 5% of the current productions were consumed by the road sector (Antwi –Barfi 2001). Hewlett, (2003:45) spell out classes of cement including 32.5, 32.5R, 42.5, 42.5R, 52.5 and 52.5R. There are however, three (3) types of cement produced and/or used in Ghana. These are Class 42-5N Portland cement, Class 42-5 Portland Limestone cement and Class 32-5R Portland cement.

Ghana Cement (GHACEM) was the sole producer of cement in Ghana until 2002 when a new company called Diamond cement begun manufacturing and more companies have been established recently, including the Dangote cement factory in Ho, Savannah cement factory in Buipe and the Fortress cement company in Accra. The Building and Road Research Institute of the Council for Scientific and Industrial Research, Ghana (CSIR-BRRI) has

developed clay Pozzolana that can partly replace cement for construction. The dominant form of cement used worldwide is Portland cement, with approximately 4 billion tons produced in 2014 (USGS, 2015). In spite of the installed capacities of about 7.4 million tons of cement per annum, far above the current consumption of only 5 million tons per annum, Ghana imports about 1 million tons (Trade Ghana, 2016). Cement, as mentioned earlier, is used for all types of construction, ranging from high strength concrete units like columns, beams to very low strength mixes such as mortars and plasters. Also, it is used for foundations (substructure) and superstructure.

A study by McDonald in 1995 showed that about 43% of the total number of cement used in every construction goes into the substructure concrete works with the remaining 57% spread among the superstructure components. Specifically, plastering uses about 32% while the mounding of blocks take up about 13% with concrete and block works making up 8% and 4% respectively. The increase in demand for housing and infrastructure has resulted in different brands of cement on the Ghanaian market leaving practitioners with the problem of choice. The aim of this paper is therefore to identify brands of cement and factors affecting its preference and utilization by professionals in the construction industry in Ghana.

### **Early Uses of Cement**

Cement is a binding substance used for construction that sets, hardens and adheres to other materials binding the cement (Naidu & Pandey, 2014; Mason & Lea, (2018); Saini et al., 2018). In other words, it is a powdery substance made by calcining lime and clay, mixed with water to form mortar or mixed with sand, gravel, and water to make concrete. McFadyen, (2006) defines cement as a crystalline compound of calcium silicates and other calcium compounds having hydraulic properties. Perhaps the earliest known occurrence of cement is from about twelve million years ago, a deposit of cement was formed after an occurrence of oil shale located adjacent to a bed of limestone burned due to natural causes. These ancient deposits were investigated in the 1960s and 1970s (History of concrete, 2012). The oldest use of cement dates to the thousands of years old Egyptians used natural cement made by combining limestone and gypsum for the construction of their massive and highly impressive pyramids. The fact that the Egyptian pyramids proudly stood the test of time over such a long period of human history is a testimony to the strength of cement. The Greeks and Romans made the first hydraulic cement by adding crushed volcanic ash to lime which was later called 'pozzolanic' cement, named after the village of Pozzuoli near Vesuvius in Italy (Shetty, 2005; Blezard, 2004). Later in the Roman era, the concept

of cement where they used a combination of slaked lime with pozzolana, a volcanic ash which made impressive structures (Jklakshmi, 2015). Lime (calcium oxide) was used in Crete by the ancient Greeks. There is evidence that the Minoans of Crete used crushed potshards as an artificial pozzolan for hydraulic cement (Blezard, 2004). Although any preservation of this knowledge in literacy sources from the Middle Ages is unknown, medieval masons and some military engineers maintained an active tradition of using hydraulic cement in structures such as canals, fortresses, harbors, and shipbuilding facilities (Sergio, 2009). Louis Vicat devised a method of combining chalk and clay into an intimate mixture and burning this, produced an "artificial cement" in 1817 considered the "principal forerunner" of Portland cement. In Russia, Egor Cheliev created a new binder by mixing lime and clay (Blezard, 2004). In the US, the long curing time of at least a month for Rosendale cement made it unpopular after World war one in the construction industry and construction firms turned to the use of Portland cement after its invention in 1824 by Joseph Aspin from England (Kosmatka et al, 2002).

### **History of Cement Production in Ghana**

Cement production in Ghana begun with the establishment of GHACEM in Tema by the Government of Ghana in collaboration with a Norwegian company, on August 30, 1967 (Ghacem, 2018). Ghacem enjoyed a monopoly of cement production until it was privatized in 1999, when another firm (Diamond) started operation alongside with importation of cement about the same time, and later established a manufacturing plant in 2002. The national agenda to export cement means that domestic market size should not necessarily constrain the number of cement firms that can viably operate within a country (Ellis and Singh, 2010). Prices of cement remained stable until it doubled in 2007 causing great concern in the building industry. Although there had been some electricity load shedding which contributed to the price increases, in the view of many analysts, the price hikes had continued beyond the load shedding period (2012-2016). The dominant cement company attributed the increase in prices to the higher prices associated with imported raw materials (Ellis and Singh, 2010). Even the presence of another domestic producer did not act as a sufficiently strong competitive restraint in terms of price reduction. After Wacem, producers of Diamond Cement broke the monopoly enjoyed by Ghacem in 1999, other firms were established to increase competition in the cement production including Green view International Limited, which operates in Tema Community 2; Savanna Cement at Buipe in the Northern Region and Fortress International, which imports bagged cement. In addition is Dangote Cement Ghana Limited which started operations in Ghana on February 10, 2010, as

a cement bagging plant importing bulk cement from outside Economic Community of West African States until 2018 when they begun construction of a new plant in Takoradi for full production. Using local materials to produce cement by CSIR-BRRI took a giant step with the construction of a production plant in 2012 at Gomoa Mpumem in the central region to produce pozzolana cement using clay. In December 2016, Cements Afrique (CIMAF) inaugurated a production plant in Tema to augment cement supplies in Ghana (Boadu and Ocloo, 2016). Competition in the cement industry and the high demand has led to a new the construction of a new plant in Tema in March, 2018 by CBI Ghana to produce and supply premium cement under the brand name “Supacem” (GNA, 2018).

**METHODOLOGY**

The exploratory research design, which seeks to obtain an understanding of the existing situations, was employed for study (Agyedu et al, 1999:46). The research basically involves construction experts from purposively identified and selected institutions with

in-depth knowledge about the construction industry. Institutions such as the Kwame Nkrumah University of Science and Technology’s and Kumasi Technical University Development Offices, the Civil Engineering, Building Technology and Architectural Departments of the KNUST, CSIR-BRRI, AESL and Real Estate Developers within the Kumasi Metropolis. These institutions were selected based on purposive sampling as the professionals in these institutions use cement regularly in their specification and works. Questionnaires were then administered to the following professionals based on their numbers in the various institutions. The sample size was derived after a preliminary survey was undertaken to identify all the selected construction professionals in each of the institutions as listed in Table 1. Upon the count, a sample frame was obtained and a 100 percent survey was undertaken. In all a total of 80 questionnaires were administered. Table 1 gives a description of the professionals that were sampled from the various institutions.

Table 1: Data Sources and Sample Sizes

<i>Institutions</i>	<i>Professionals</i>	<i>Number Sampled</i>
CSIR-BRRI	Quantity Surveyors	7
	Architects	6
	Structural Engineers	3
KNUST Development Office	Quantity Surveyors	6
	Architects	9
	Structural Engineers	1
Kumasi Technical University Development Office	Quantity Surveyors	3
	Architects	1
	Structural Engineers	1
AESL	Quantity Surveyors	7
	Architects	10
	Structural Engineers	3
Civil Engineering Department- KNUST	Structural Engineers	3
	Architects	9
	Quantity Surveyors	6
Department of Architecture - KNUST	Quantity Surveyors	2
	Architects	2
	Structural Engineers	1
Department of Building Technology- KNUST		
Kumasi Technical University		
Total		80

Source: Field Survey, 2018

The data was systematically analyzed and harmonized using both quantitative and qualitative methods. In presenting cement usage at various level of the construction process, three major categories were used. These were concrete works, block works and rendering/mortar works. This was to prevent repetition and monotony in the research report. Categorization is detailed as - Concrete Works: Foundation; Oversight concrete; Floor Screed; Suspended Floor; Beams and Columns and Drains. For Block Work, the following were considered; blocking work and curbs. Rendering/Mortar consisted of rendering, landscaping and aprons. The categorization is as a result of similarities in mixture proportions and cement used at the various parts of the building process. For instance, amount of cement usage in every cubic meter of mixture for concrete

works is assumed the same. Hence, the categorization is to summarize and combine all forms of repetition from the survey. The study however, had a limitation of some respondents not too familiar with the new brands of cement especially “fortress” and “savanna”. Moreover, it took several visits to and from the respondents in order to obtain the questionnaires for the study.

**RESULTS AND DISCUSSIONS**

**Characteristics of Respondents**

The study focused on the three main professionals within the building construction industries and these were architects, quantity surveyors and civil engineers. These professionals were considered because they form the project team within the building industry that deals directly with the quantity and type of cement to be used. Among these

professionals, 48% of the respondents were architects, 31% were quantity surveyors while the remaining 21% were civil engineers. Majority of the respondents (41.4%) have had between five to nine years working experience, with 27.6% of them having less than four experiences within the building industry. Those within the category of 10 to 14 years of working experience constituted 20.7% of the respondents. Only about 10% of respondents had 15 to 19 years of working experiences. About 69% of the respondents were members of various professional bodies, such as the Ghana Institute of Architects, Ghana Institution of Surveyors and the Ghana Institution of Engineers.

**Awareness of Brands of Cement Available on the Markets**

The main brands of cement used for construction in the country are GHACEM Cement, Dangote, Fortress, Diamond and Savannah. In assessing the usage of cement therefore, the study focused on these five brands. Pozzolana, a locally produced cement additive was also considered given the surge in its popularity over the past few years. The study revealed a high knowledge from all the respondents about GHACEM. Figure 1 shows that Diamond Cement was the second most popular brand of cement among construction professionals within the metropolis as 96.6% of the respondents were aware of its existence, with 86.2% of the respondents being aware of the existence of the main locally produced cement additive, Pozzolana. Dangote, Fortress and Savanna Cements recorded 58.6%, 41.4% and 24.1% respectively with regard to their popularity with respondents.

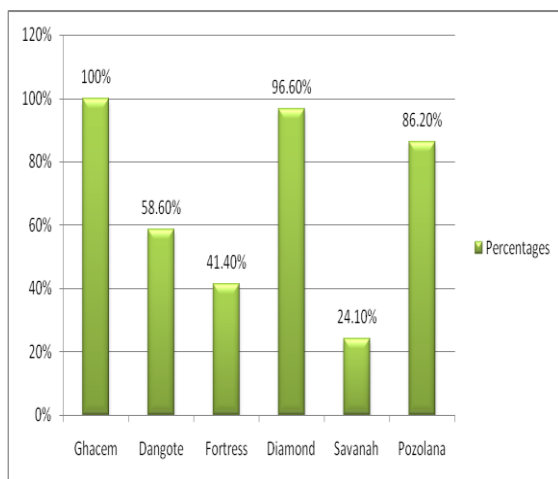


Figure 1: The Awareness of Brands Cement. Source: Field Survey, 2018

**General Factors Influencing the Choice of Brand of Cement**

It is important to identify the factors that affect the choice of brands of cement as these factors would help to give an idea as to why professionals in the industry would prefer a particular brand at certain

stages of construction. The study identified four main factors that affect the choice of a particular brand of cement used for construction by the professionals in the building industry. The major factor was the availability of a particular brand of cement as this influenced the choice of 55.2% of the professionals interviewed. Availability falls under sourcing as stated by Branz, (2018) and it involves transportation to site. It was therefore not surprising to notice that Ghacem brand of cement was the preferred choice by majority of the respondents. Other factors influencing the choice of a particular brand of cement include the quality of the brand i.e. performance, the nature of work to be done i.e. construction and installation as well as the prevailing price of a particular brand of cement i.e. Cost (Huni, 2015; Branz, 2018). The study realized that for 20.7% of the respondents, their choice was influenced by the quality of a particular brand of cement (See Figure 2). These professionals revealed that they prefer brands with good bonding, setting and hardening properties. The nature/type of constructional works to be done and the prevailing price of brands of cement also affect the preference of cement as 13.8% and 10.3% of the respondents respectively affirmed to this as shown in Figure 2.

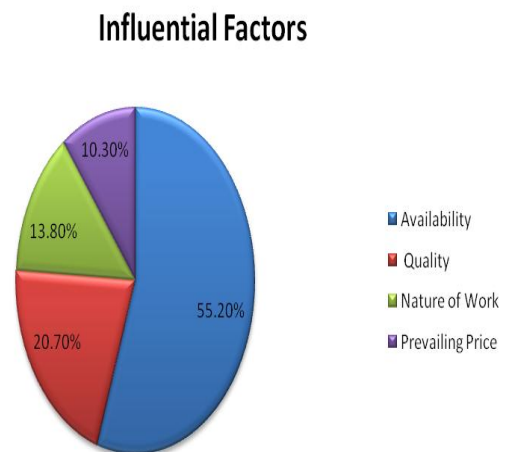


Figure 2: Factors Influencing the Preference of Cement. Source: Field Survey, 2018

**Cement Usage**

The amount of cement used at any level of the building process determines the strength and durability of the stage of construction. The strength however depends on the right mixture with other materials like fine, coarse aggregate and water. The usage and preference of cement type at the various stages in the construction process is discussed below:

**Concrete Works**

Concrete work is very important as the entire strength of a building largely depends on it. The strength of concrete determines how a building is able to withstanding pressure and natural disasters like flood, storms, earth quakes, etc. From the study, 44% of professional workers in the building industry use only

Ghacem cement for their concrete work whilst 24.1% combine Ghacem Cement with Diamond cement. A further 20.6% prefers Dangote cement for concrete work whilst 10.3% would like a mixture of Pozzolana and Ghacem cement (or any Portland cement).

Reasons for the choice of cement for concrete works varies from one professional to the other. This ranges from sourcing i.e. availability on the market to its performance i.e. setting time and hardening (drying) properties. The reasons for preference of particular brands of cement are as shown Figure 3. It shows that the major reason for cement utilization for concrete works is its availability on the market which represents about 29.4% of the respondents. Out of these professionals, 17% use Ghacem while Pozzolana had 1% from the 29.5%.

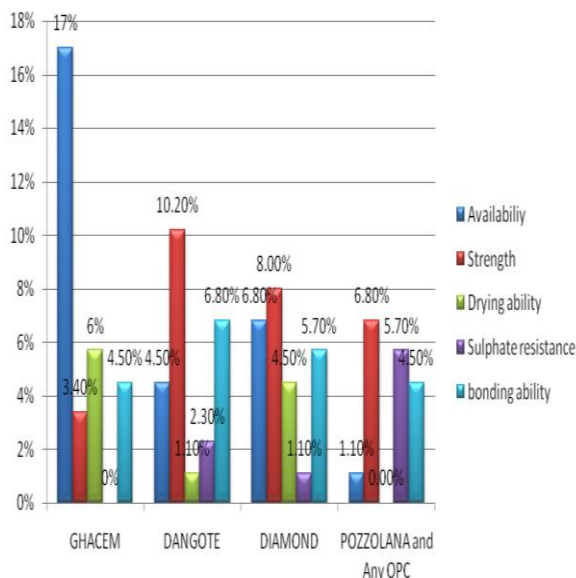


Figure 3. Reasons for Choices/Usage for Concrete Works. Source: Field Survey, 2018

However, 28.4% of professionals interviewed will choose a particular type of cement for concrete work based on its strength. The study suggests that 10% of professional prefer the Dangote cement to Ghacem cement (3.4%). In effect, cement users prefer Dangote for concrete works mainly because of its perceived strength. Pozzolana is mainly preferred based on its strength and sulfate resistance. Overall, 11.4% of professionals base their choice on the setting time and hardening ability of the brand of cement, 21.6% of preference is based on the bonding ability of cement while 9.1% based on little or no sulfur attack on the concrete work.

**Block Work**

The strength of blocks for walls is important as blocks which lack the necessary strength can cause defects such as cracks, dampness and sometimes collapse of buildings. Ghacem cement dominate usage with a percentage of 58.6, while 21.3% prefer Diamond cement. Also, 11.4% uses a mixture of

pozzolana and any OPC with 9.3% preferring Dangote or Diamond. Again the major reason for the utilization of a brand of cement is its availability on the market which accounted for 46.4%, 18.2% based on the strength capabilities of the brand of cement. Figure 4 shows reasons for usage of particular brands for block works.

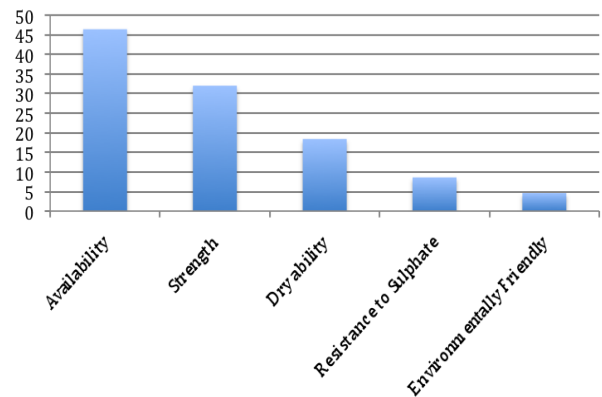


Figure 4. Reasons for Brand Used. Source: Field Survey, 2018

The above shows that availability of the brand is the major factor driving preference and utilization with environmental friendliness being the least driving factor. The reasons are grouped by cement brand in Figure 5.

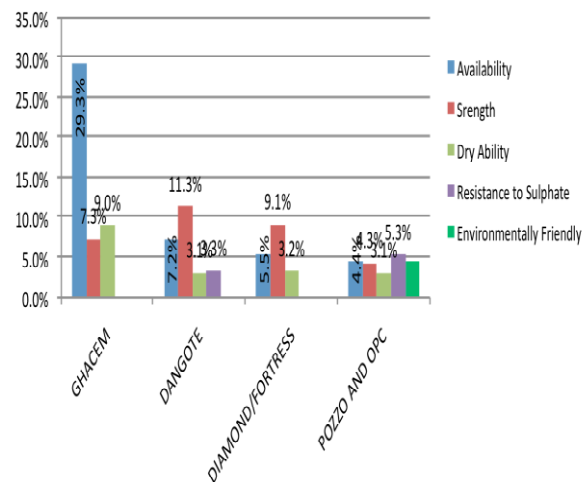


Figure 5: Reasons for Choices/Usage for block works. Source: Field Survey, 2017

The above shows that aside availability, professionals demand GHACEM based on its setting time (dry ability).

**Mortar for Rendering**

Rendering is also important in the building process. It is the cover for the interior and exterior parts of the building. The strength, compactness and aesthetical beauty of rendering works cannot be underestimated. According to the survey, a cement sand mix ratio of 1:4 is for both rendering and mortar works. On the

brands of cement used, the Ghacem brand had a usage percentage of 58.2, Diamond cement was used by 21.2% of the respondents whereas the usage of Dangote and Pozzolana with other OPC constituted 9.3% and 10.9% respectively.

Figure 5 shows the relationship between brands of cement and reasons for usage. From the Figure 6, 31.4% of professionals would prefer cement that finds itself on the shelves. It further shows that Ghacem brand benefited from such professionals as 28.3% utilized Ghacem brand because it was available on the market. Also, 23.6% of professionals utilize cement due to its setting time for construction. Again Ghacem with the introduction of the super rapid cement had the largest share with 17.2%, with Diamond or Fortress having 4.5% of such professionals. On Strength, Diamond or Fortress brands had 10.2% the highest share of the 27.9% of professionals who rely on the strength for their preference for cement.

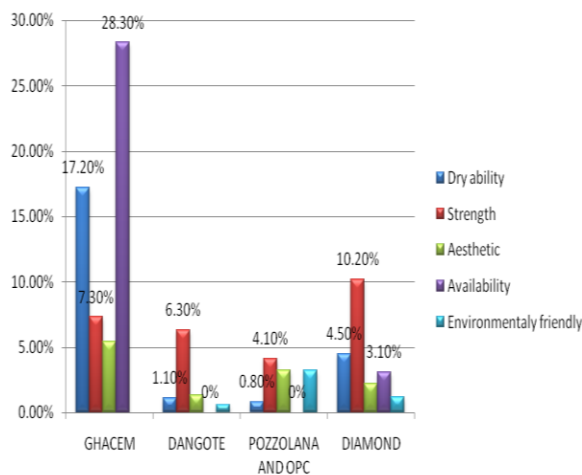


Figure 6: Reasons for utilizing Cement for rendering and mortar works Source: Field Survey, 2018

## KEY FINDINGS

### Influential factors to the choice of cement

Ghacem, Diamond, Dangote, and Pozzolana (a cement additive) were the main brands of cement used by the professionals in the building industry within the Kumasi metropolis. The main factors that affect the preference of cement as identified by the study were availability of the brand of cement, quality of the brand, nature of the work to be done and the prevailing price of particular brands of cement at the market. The availability of brands of cement was seen to be the most single factor that influence the choice of professionals in the building industry as more than half (55.2%) of the respondents preferred using GHACEM since it is the brand that is mostly readily available in the market.

## Cement Utilization

### Ghacem

Ghacem was the most preferred brand of cement for all the various stages of building that were considered in the study, that is, concrete works, block work, rendering and mortar works. The study revealed that as many as 44% of the professionals' sampled use Ghacem for their concrete works. Another 24.1 and 10.3% of them also combine Ghacem with Diamond and Ghacem with Pozzolana respectively. The major reason for the utilization of Ghacem for concrete works as identified by the study was its availability as compared to the other brands. Another main reason for the utilization and preference of this brand of cement for concrete works had to do with its drying ability, as 5.7% of the total 11.3% whose choice for a particular brand of cement were influenced by the its drying ability go in for Ghacem. Interestingly, with regards to strength as an influential factor for the choice of cement for concrete works, Ghacem recorded the least with 3.4% out of the total 28.4%. This therefore means that when the production capacity of the other brands of cement are increased, and hence made readily available at the market, they would enjoy higher patronage. More than half (58.6%) of the professionals sampled prefer to use Ghacem for the block works in construction, with the issue of availability being the main reason for this choice. Out of the total of 44.6% of respondents whose choice were influenced by availability, 29.3% of them were those who go in for Ghacem for their block works.

The drying ability of ghacem was also another influential factor that affects the choice of the brand for block work. When it comes to plastering and mortar works, Ghacem was still seen as the most patronized brand of cement as 58.2% of professionals preferred this brand. The availability factor still remained as the main reason why the professionals interviewed prefer to use Ghacem for their plastering and mortar works. Other significant reasons for the usage of ghacem of plastering and mortar as identified by the study was its drying ability as 17.2% out the 58.2% who prefer to use ghacem for this section of construction confirmed to this. The strength and aesthetic nature of Ghacem were also the some of the reasons given for the choice of this brand for plastering and mortar works.

### Dangote

With regards to concrete works, 20.6% of the respondents prefer to use Dangote cement. Cement users prefer Dangote for concrete works mainly because of its strength as most of the respondents (10.2% of the 28.4%) whose choice of brand of cement were influenced by its strength went for Dangote. It could, however, be inferred that professionals who do not compromise on the strength of cement are likely to go in for Dangote rather than

Ghacem. The bonding ability of Dangote was also another main influential factor for its usage for concrete works by the respondents who prefer to use this brand of cement. Like the concrete works, the main reason that influenced the choice of Dangote for block work was its strength. The study revealed that 11.3% (which represented the highest proportion) out of the 32% of the professionals whose choice were based on strength of brands goes in for Dangote for the block works. Other reasons included its availability and resistance to sulphate. Usage of Dangote for rendering and mortar constituted 9.3% of the professionals. The strength of Dangote was seen as the main factor that influences the choice of the professionals with 6.3% response rate. The aesthetic nature of the brand for rendering and mortar and the drying ability of Dangote were among the other reasons why the respondents preferred this brand.

**Diamond**

Diamond cement was the second most preferred choice for concrete works with a usage of 26.1% of the respondents with another 24.1% of them combining Diamond and Ghacem for this stage of the construction process. Among other reasons, the strength of Diamond and its availability were the major factor that influenced its choice by their consumers in the building industry who were sampled. Out of the 28.4% of respondents whose choice were based on strength 8% of them preferred Diamond. Diamond was therefore seen as the second most preferred choice based on strength. Other factors that affected the choice of diamond cement for concrete works included its bonding and drying abilities. The strength of Diamond cement was also a major reason that influenced its choice for block works, as most professionals who do not comprise on strength would prefer Diamond for block work to Ghacem or Pozzolana and other OPC. The study revealed that 21.2% of the respondents prefer to use Diamond for rendering and mortar block works. Diamond usage for plastering and mortar had 10.2%, which was the highest share of the 27.9% of professionals who rely on the strength of cement. Its availability, drying abilities and aesthetic nature were also some of the influential factors for this choice of cement at this stage.

**Pozzolana and any OPC**

Ghacem was identified by the study to be the most preferred OPC that the respondents would like to mix with Pozzolana for concrete works as 10.3% of them prefer this mixture/combination. The ultimate reason for the combination of pozzolana with other OPC for concrete works was its ability to resist sulphate in the soil as 6.8% out of the 9.1% of professionals whose choice were influenced by the ability of the brand to resist sulphate prefer mixing pozzolana and other OPC. Only about one percent of the professionals used pozzolana for concrete because of its

availability. To increase the consumption of pozzolana therefore means that the production capacity as well as the distributive networks of the brands needs to be enhanced so as to increase the stock of the brand in the market. With regards to block works, the issue of sulphate resistance was seen to be the main reason why some professionals prefer to use a mixture of pozzolana and other OPC. Obtaining pozzolana was still seen to be a major limitation for the usage of the product for block work as availability of the product was an influential factor for only 4.4% out of the 46.4% of the professionals whose choice were based on availability. When it comes to rendering and mortar works, 10.9% of the professionals prefer to combine pozzolana with other OPC. The aesthetic nature of the products (mixture of pozzolana and OPC) on plastering was seen to be the major reason that influenced this choice. Table 4 indicates brands of cement and reason for its preference and utilization.

Table 4 Brands of cement and reasons for its preference and utilization

CONSTRUCTION STAGE	BRAND USED	MAJOR REASON FOR USAGE
Concrete Works	Ghacem	Availability and Drying Ability
	Dangote	Strength and Bonding Ability
	Diamond	Strength and Availability
	Pozzolana and OPC	Sulphate resistance
Block Work	Ghacem	Availability and Drying Ability
	Dangote	Strength and Availability
	Diamond	Strength
	Pozzolana and OPC	Sulphate resistance
Rendering and Mortar	Ghacem	Availability and Drying Ability
	Dangote	Strength and Aesthetic Nature
	Diamond	Strength and Availability
	Pozzolana and OPC	Aesthetic nature

Source: Field Survey, 2018

**CONCLUSION**

Cement plays an important role in the development of every economy especially in countries like Ghana which is trying to catch up with other middle income countries such as Malaysia, Brazil, and China. Cement production and usage has a lot of multiplier effects on the development of every economy such as creation of jobs, construction of commercial, residential, educational and industrial buildings. It is also more beneficial when the local content in the production and usage is very high because every income that is usually earned is spent within the economy. As cement production and usage in Ghana increases, the prices of the product also keeps on increasing day in and day out. This is because most

of the materials that is used in the production such as clinker and gypsum is imported from Europe and other parts of the world. Though, over the past decade, about four new cement brands have been introduced into the Ghanaian economy, most of these cement are produced with imported materials and therefore making it difficult for these new cement companies to expand and for that matter increase production to compete with the already established company like Ghacem. The study revealed that, the Ordinary Portland Cement that is produced by the Ghana Cement Company (GHACEM) is widely used and accepted by the professionals in the construction industry because this particular brand is available in all parts of the country and at any time of the year. These professionals claim that the other brands of cement are not readily available on the market hence limiting the choices. In this regard, production of new binding materials like cement and other additives such as local clay Pozzolana should be enhanced to accelerate housing and infrastructure provision for sustainable national development. There is therefore the need to continue researching and developing new ways of producing binders and additives such as cement and Pozzolana which are relatively cheaper and very good when it comes to quality.

### RECOMMENDATIONS

The production capacity of the other brands of cement used in the country should be increased so as to improve availability of the products to users. Government policies should be geared towards the creation of an enabling environment that would enhance existing cement companies' production capacities as well as attracting other investors, both local and foreign to invest in cement production in the country. Policies like tax holidays for specific periods of time and free zones should be improved by the government and other stakeholders to enhance the performance of cement production companies and attract others to invest in cement production in the country.

Improving the production capacity of cement would increase supply and thereby helping to reduce the periodic shortage of cement in the country. There is the need for regular organization of sensitization programs for both professionals and non-professionals) in the building industry who use cement to ensure effective and efficient usage of the product. Research institutions such as the Building and Road Research Institute (BRRI) with support from other governmental and non-governmental organizations in the building industry should organize regular public forums on the appropriate brand of cement to be used at the various stages in building construction. Such forums should also include sensitization on the correct mixing ratio of cement on various stages of construction. Other cost efficient approaches on the usage of cement such as the

combination of Pozzolana (a cement additive) with other brands of cement should also be properly propagated so as to help reduce the cost that would be incurred from the patronization of cement. This would also lead to the reduction on the overall cost of construction. Effective supervision and monitoring by the professionals at construction sites: One major technical challenge that was identified by the study with regards to cement utilization had to do with the issue of difficulty of some artisans to use and mix the right proportion of cement for various types of work. Curbing this situation would require an effective supervision of these artisans by the various professionals at the construction sites to instruct and direct them on the appropriate approach to use.

Various research institutions in the building industry such as the Building and Road Research Institute (BRRI), Faculty of Architecture, School of Engineering, KNUST among others should be well resourced to undertake more and comprehensive research on cement and other related products to enhance its usage in the construction industry. It was for instance, through research that the cement additive, Pozzolana was developed, hence when these institutions are well resourced and given the maximum support by the government, similar and even more effective products would also be developed. The production of clinker, the major binding component in cement, for instance remains one of the major problems faced by the nation as the state spends huge amount in importing this product. Resourcing these institutions well could lead to the production of this product or alternative ones that would help to save the state from spending huge amount of foreign exchange to import this product. Cement production companies should extend their distribution networks by establishing more centers across the country. This would help reduce distances of access to the product and thereby reducing the transportation cost which in most cases, affect the overall cost of the product.

One major way of educating the consumer on cement utilization is by communicating with the labels. Clear and well detailed labels can alert consumers on capabilities, efficient usage and weakness, which is paramount in choosing a brand of cement for construction work. Hence brands should include vital information on their labels.

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