THE ROLE OF JAGGERY AS A RETARDER IN CONCRETE FOR AFFORDABLE HOUSING DELIVERY IN NIGERIA

[1]Abdulkarim Abdulmumin Manga and Musa Aminu Alhaji
Waziri Umaru Federal Polytechnic, Birnin Kebbi
abdulkarimmanga@yahoo.com

ABSTRACT

Hot weather characterized by high ambient temperature and low relative humidity causes rapid cement paste and difficulties during concrete. Admixtures that retard rapid cement paste settings are necessary to prevent fresh concrete from the adverse effects of hot weather. However, in Nigeria the retarding admixtures are imported and also expensive. Jaggery as locally sourced admixture is another substitute that has been established to be a retarder, but its effects vary with cement's chemical composition. Therefore, this study assessed the role of Jaggery as a retarder on the properties of concretes made with Dangote, Ashaka, Bua, Sokoto and Elephant brands of Portland cement produced in Nigeria. It also looks at the concept of Housing delivery in Nigeria. Cement paste was prepared using 0.06%, 0.1% and 0% as control. Setting time tests were performed at two different temperatures; at normal laboratory temperature of 27^{o}C and simulated hot ambient temperature of 43^{o}C (similar to Sokoto, Birnin Kebbi, and Maiduguri, etc.). The results showed that the initial setting times of the control pastes made with Ashaka, Bua, Dangote, Elephant and Sokoto cements at 43^{o}C was reduced by 51.85%, 38%, 45.94%, 24.73% and 40% respectively when compared with the control pastes at normal laboratory temperature of 27^{o}C. The reduction effects were eliminated by the addition of 0.1% and 0.06% of Jaggery in all the cement brands at 43^{o}C. Thus, significant increase in initial setting times was recorded. Similar trends were observed for the final setting time in all the brands of cement. The results revealed that the 0.1% addition of sugar proved to be optimum dosage for the cement pastes made with Ashaka, Dangote, Elephant and Sokoto cements. On the other hand, 0.1% as the optimum dosage. The research concluded that the use of Jaggery as a retarding admixture in cement paste made with the brands of cement enhanced the setting properties of concretes when an optimum dosage is used. It is recommended that, Jaggery can be used as retarder when concreting in hot dry weather regions in Nigeria.

Keywords: Cement brands, Hot weather, Jaggery, Setting time, Housing, Delivery

INTRODUCTION

Housing means shelter but to others it means more as it serves as one of the best indicators of a person's standard of living and his or her place in the society (Nubi, 2008). In addition to serving as a shelter, housing is also a produced commodity, consumer good, assurance for families, means used for reproducing social relations, and an investment tool protecting money's value against inflation (Amao & Ilesanmi, 2013).

Considering the health, welfare and productivity of man, housing plays a significant role. Housing is a spatial and material symbol, a microcosmic reflection of social and cultural expectation. It reflects the cultural, social and economic values of a society and is the best physical and historical evidences. Housing is not just shelter it involves every other facility that

could bring about the comfortability of mankind. Housing quality is determined by the proximity of essential facilities, services and human daily activities. However, Salau (1990) describes housing as total residential environment, including physical structure, all necessary services, facilities, and apparatus for man's general health and social well-being. Cost of building materials the cost of building construction influences the housing inadequacy among the lower income earners in Nigeria.

Concrete is a heterogeneous material which consists of a chosen mixture of binding materials such as lime or cement, well graded fine and coarse aggregates, water and admixtures to produce concrete with special properties (Duggal, 2008). Khan (2006) opines that concrete is the most widely used construction material globally and has gained a unique place in the construction industry. The most important characteristics of fresh and hardened concrete are workability, setting time, rate of strength development, ultimate strength, durability and impermeability of the concrete. The desired properties of fresh and hardened concrete can often be economically achieved by properly mixing the ingredients, placing, and compacting. However, there are instances where the properties above may be adversely affected during the concrete production due to hot weather effect (Khan, 2006).

Furthermore, Okereke (2003) noted that extreme North East and North Western parts of Nigeria such as Maiduguri, Yola, Sokoto, Birnin kebbi etc. are categorized as hot dry regions with temperature which ranges between 35 to 43^{o}C with the low relative humidity of 40%. According to Ali *et al.* (2000) in hot dry zones, the climatic conditions are often harsh, characterized by high ambient temperature and low relative humidity. Thus, it is more difficult to control the water content of concrete mixes which is the most important factor in concrete making. It follows that hot weather generally introduces undesirable properties on concrete, such as loss of slump, accelerated set, increased water demand, and strength reduction. These undesirable properties cause concreting problems and may lead to low durability (Ali *et al.*, 2000). But, Rana (2014) opines that to offset the negative effects of hot weather on the cement paste of concrete certain admixtures that delay the setting of cement paste and modify concrete workability are helpful in hot weather concreting. Hence, retarder admixtures are used to slow down the reaction between cement and water by affecting the growth of the hydration products and reducing the rate of water penetration to the cement particles (Myrdal, 2007).

Alsadey (2013) defined retarding admixture as a type of chemical admixture that delays the initial reaction rate between cement and water and, hence, retards the setting time of concrete and lengthens the setting time and workability retention. It is particularly important for concreting in hot weather. A retarding admixture holds back the hydration process, leaving more water for workability and allowing sufficient time for the concrete to be placed, compacted and finished. Also, it stops the rapid set shown by tricalcium which causes false set of the cement paste (Abalaka, 2011b).

Jaggery made from sugarcane – sucrose is a very efficient retarder admixture capable of delaying or prolonging the setting of cement paste in concrete (Gupta and Gupta, 2004). The use of sugar as a retarder admixture also slows down hydration's chemical process, so that concrete may remain in plastic state and workable for longer period (Suryawanshi*et al.*, 2014). The mechanism of function of Jaggery as a retarding admixture is that its retardation arises from the adsorption of sugar molecules on to the surfaces of growing particles of hydrating products (calcium silicate hydrate). Hence, the hydration process slows down (Khan and Ullah,

2004). Due to the slow in hydration process the cement paste remains in plastic state for a longer time.

Moreover, Greesan*et al.* (2014) states another mechanism of precipitation theory that the Jaggery increases calcium, aluminium, and iron concentrations in concrete. Jaggery's sugar molecules combine with these metals to form insoluble chemical complexes that coat the cement grains. Several key chemical processes that harden the concrete are then impeded. Hydration process is slow down and therefore; the concrete takes longer to set. For this reason, Jaggery is known as one of the best retarder (Greesan*et al.*, 2014).

Abalaka (2011) noted that the sugar content of 0.06% by weight of cement can improve compressive strength of concrete by 3.62% compared with control at 28 days and delay initial setting time by 1.556 hours (94 minutes). No adverse effect on concrete and cement paste has been observed at this sugar concentration level for the age of 28days curing period. Also, Rana (2014) found that 0.1% of sugar by weight of cement delays both the setting times and shows around 4% increase in compressive strength, but above 0.13% by weight of cement accelerated the setting time cement paste. Shetty (2009) opines that when Jaggery is added to concrete mix in a careful controlled manner (about 0.05% to 0.1% by weight of cement), the mix's setting time will be delayed by about 4hours. However, Shetty (2009) asserted that the exact effects of Jaggery as a retarding agent on concrete mix depend on the chemical composition of cement.

Furthermore, research conducted by Khan and Baradan (2002) in Pakistan on three different types of cement under the same curing condition (namely; PKC/A42.5 cement, PKC/B32.5 cement and PC 42.5 cement), the findings revealed that 0.8% Jaggery (sugar) content acted as an optimum sugar content for retarding the setting of PKC/A42.5 cement, 0.1% for PKC/B32.5 cement and 0.2% for PC42.5 cement. This means the retardation effects of Jaggery in concrete depends on the brand of OPC used. Hence, this research work assessed the effects of Jaggery as a retarder on the properties of cement pastes made with selected brands of Portland cement in Nigeria.

THE CONCEPT OF HOUSING AND HOUSING DELIVERY SITUATION IN NIGERIA

In Nigeria, the housing delivery system is a combination of various inter-linkage components such as land, infrastructures, building materials, building regulations policies end more importantly the finance component (Ebie, 2003). Therefore, the new housing reforms created financial mechanisms and institutions that will make available to the private sector (developers) funds for the production of mass houses, and allow purchasers (mortgagors) to have easy access to borrowed money through the Primary Mortgage Institutions (Ebie, 2004).

Research has shown that 75% of urban housing is situated in slum conditions (UNDN, 2005 In Amao & Ilesanmi, 2013). Indeed, the housing quality is poor and clearly an affront to human dignity (Agbola and Olatubara, 2003). As part of effort to increasing qualitative, affordable housing for the country's masses, the Federal Government in 2004, pledged to adequately fund research about the manufacture and the use of local materials in the sector (Amao & Ilesanmi, 2013).

Housing delivery is a high contentious and politicized issue that is of great concern to administrators, scholars and the public in Nigeria (Sule, 2006). In housing delivery, institutions

have been identified as an important component in the formulation, implementation and monitoring of housing policies and programmes (UNCHS, 1996).

MATERIALS AND METHOD

Materials

The materials used for this study include: The selected Portland cement used in this research were Ashaka, Bua, Dangote, Elephant and Sokoto cement brands which conformed with ASTM C150 (2005). They were obtained from accredited dealers in Kaduna metropolis, Nigeria. The Jaggery (sucrose) used as a retarding admixture in this experimental study was made in Gwandu Local Government, Kebbi State. Clean tap water was used for the experimental works. The water quality conformed to the specification of BS EN 1008-2 (2002), which specified water use to be free from odour, color, taste, and impurities.

Preparation of Samples of Cement Paste

A samples of neat cement pastes made with the five cement brands were prepared for the setting times test according to BS EN 196- 3 (1987) standard. These samples were taken as control samples i.e. 0% addition of Jaggery. Then successive samples of cement pastes containing different dosages of 0.06% and 0.1% addition of Jaggery by weight of cement were also prepared and tested for the five brands of Portland cements used in this research. The tests were performed at two different temperatures at the normal laboratory room temperature of 27^{o}C and an oven temperature of 43^{o}C−approximate maximum ambient temperature for Sokoto, Birnin Kebbi, Maiduguri and Yola etc.

RESULTS

In this subsection, the initial and final setting time tests weres carried at two different temperatures; at normal laboratory temperature of 27^{o}C and an oven temperature of 43^{o}C− approximate maximum ambient temperature for Sokoto, Birnin Kebbi, Maiduguri and Yola are presented and discussed.

Setting times

The test results for initial and final setting times of various cement pastes made with cement brands at two different temperatures are shown in Table 1. The result revealed that both the initial and final setting times increased continuously with increased percentage additions of sugar by weight of cement at all the temperatures. Apart from Bua cement that showed decrease in setting time as the percentage addition of Jaggery increases. The control pastes' initial setting times at 27oC for Ashaka, Bua, Dangote, Elephant and Sokoto cements were recorded as 108minutes, 100minutes, 111minutes 93minutes and 125minutes respectively. Generally, at 43^{o}C the control pastes recorded a decrease in the initial setting times by 51.8%, 38%, 45.94%, 24.73% and 40% for Ashaka, Bua, Dangote, Elephant and Sokoto cements respectively when compared with the control pastes at 27^{o}C. This effect could be attributed to the fact that higher temperature increases the internal temperature of hydration of the cement paste, thereby increasing the rate of chemical reaction, which accelerates the setting time of the cement paste (Hassan, 2010).

To overcome this effect of rapid decrease in setting times, 0.06% and 0.1% of Jaggery by weight of cement were added to all the cement brands subjected to setting time test at 43ºC. At 0.1%, four cement brands recorded the higher percentage increase in initial setting times more than at 0.06% addition of Jaggery. The percentages increase recorded were 196%, 175%, 100% and 124% for Ashaka, Dangote, Elephant and Sokoto cements. In comparison, Bua cement recorded a decrease in initial setting time of 49%, but recorded an increase of 88% at 0.06% addition of Jaggery. Also, it can be observed that there was an increase in the final setting times in all the brands of cement as the percentage addition of Jaggery increases with Sokoto cement recorded the higher increase of 108% and Bua cement recorded lower increase of 80% when compared with the control pastes.

Table 1: Comparison of the setting times of cement brands with percentage addition of jaggery at two different temperatures

Setting time	Cement Brands	27ºC			43ºC		
		0%	0.06%	0.1%	0%	0.06	0.1%
Initial setting (Minutes)	Ashaka cement	108	210	290	52	130	154
	Bua cement	100	254	147	62	188	51
	Dangote cement	111	270	320	60	75	165
	Elephant cement	93	367	425	70	117	140
	Sokoto cement	125	370	440	75	150	168
Final setting (Minutes)	Ashaka cement	189	345	500	100	195	247
	Bua cement	180	377	198	110	261	150
	Dangote cement	201	363	465	123	180	225
	Elephant cement	167	494	560	102	217	245
	Sokoto cement	218	515	575	125	230	270

Source: Experimental work (2019)

DISCUSSION

The increased in the setting times in all the cement brands could be as a result of retarded hydration due to the presence of sugar. Sugar increases the concentrations of calcium, aluminium and iron in concrete. The Jaggery which contained sugar molecules combine with these metals to form insoluble chemical complexes that coat the cement grains. Another reason for the setting time's extension is adsorption of sucrose molecules which acts as thin layer over the cement particles. Furthermore, Bua cement brand that showed a decrease in setting times as the percentage addition of sugar increases, this phenomenon could be the low content of tricalcium aluminate C3A compared to the other brands of cement. This observation concurs with an earlier finding by Myrdal (2007).

The cement price used in construction is exorbitantly high, which defeats the good intention of improving access to decent housing accommodation for the teeming urban residents. This also undermines the essence of building for the low-income people at the center and should fairly be represented and served. Government's bold initiative to build these satellite towns and the show of commitment should not be derailed by the prohibitive cost of

the houses by which most low-income people would hardly afford it. In Nigeria, governments have made several efforts to improve housing delivery. These efforts include introducing public-private partnership in housing; provision of licenses to primary mortgage institutions in the year 2000; and private real estate developers from 2000 to date; reviews and strengthening of housing policies. Despite these efforts, there remains a huge gap between the available housing stock and the houses' need. These efforts' failure has had the most negative effects on the medium and low income segments of society. Attempts at providing adequate housing especially for the low-income earners have shown that this category of people has not benefited. Main reason for this is the cost of production of the houses.

CONCLUSION

Based on the outcomes of the effects of Jaggery as a retarder on the cement pastes made with selected brands of Portland cement in Nigeria, it can be concluded that: The addition of Jaggery to the cement pastes made with Dangote, Sokoto, Bua, Elephant and Ashaka cement brands retards the setting times of the cement paste both at the normal laboratory temperature of 27^{o}C and 43^{o}C. The optimum dosage of Jaggery for Ashaka, Dangote, and Sokoto and Elephant cement brands was 0.01%. While for Bua cement brand 0.06% proved to be the optimum dosage. Heat affects the Dangote, Sokoto, Bua and Elephant cement brands' setting time as such retarding admixture should be used in these cement brands when concreting in the hot weather regions.

RECOMMENDATIONS

The research work recommends that the government encourage the use of local building material for construction to reduce building cost and the importation of building materials like retarding admixtures that are very expensive. This would go a long way in reducing housing deficit in Nigeria.

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