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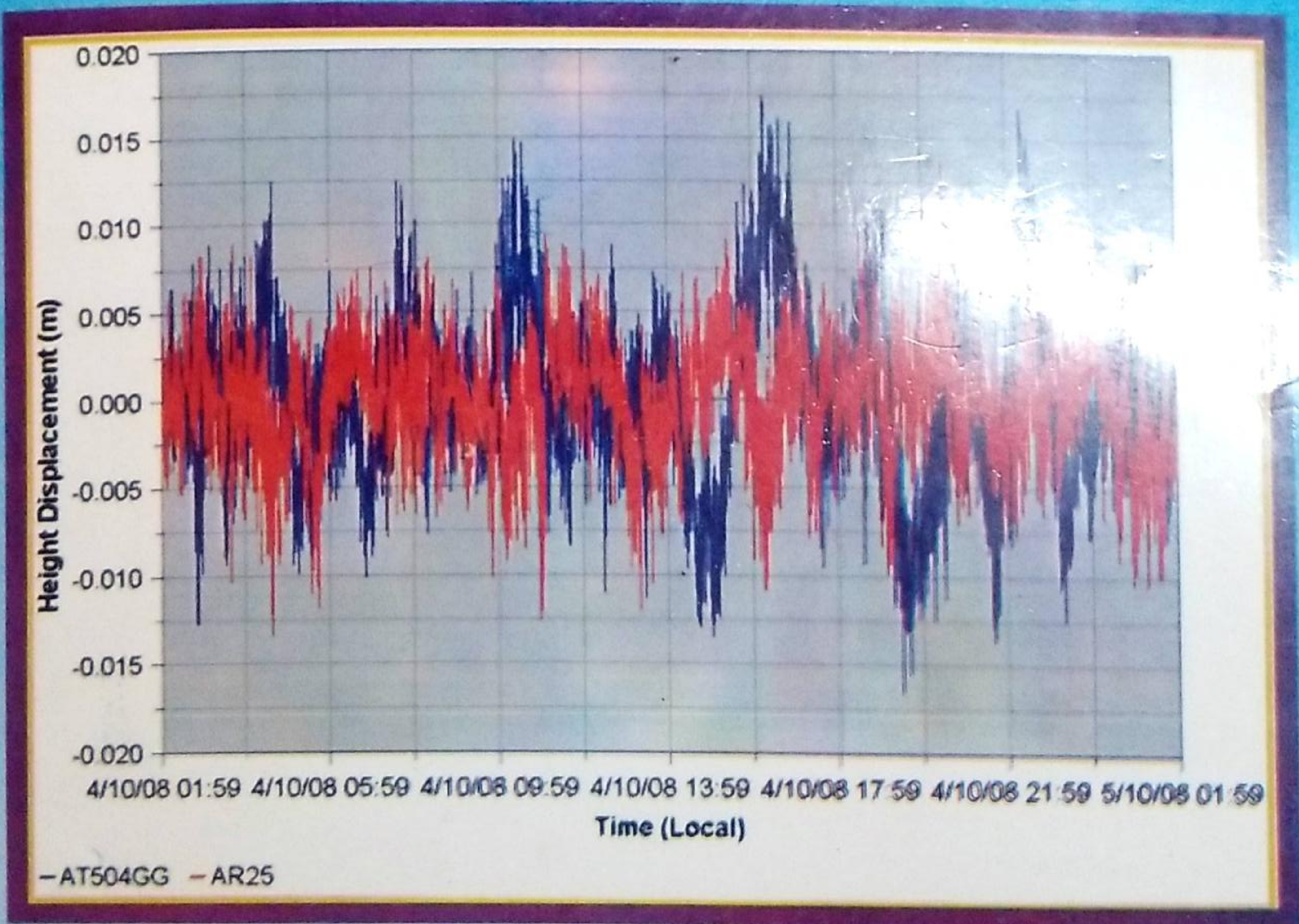

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Strength Characteristics of Laterized Concrete Using Lime – Volcanic Ash Cement

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ABSTRACT
Effect of calcium oxide on volcanic ash laterized concrete was investigated. A total of 60 cubes of 150mm dimensions were cast with volcanic ash (V.A) and calcium oxide (CaO) combination of 90%:10% and 80%:20% respectively while the ordinary Portland cement (OPC) based concrete for 28-day target strength of 25N/mm² served as control. Sand replacement by laterite also varied between 0% and 20% for the laterized specimens. The cubes were cured in water and tested for compressive strength at 7, 14, 21 and 28 days. The result showed that the compressive strength increased as the hydration period increased and that the presence of calcium oxide boosted the strength properties of volcanic ash laterized concrete. The compressive strength of the laterized concrete specimens was higher at the various hydration days for the 20%lat/20%CaO: 80%V.A. sample than the 10%lat/10%CaO: 90%V.A sample. The 28-day strength for 20%lat/20%CaO: 80%V.A sample gave a value of 22.07N/mm² (i.e. 81.74%) as against the 21.53N/mm² (79.74%) gotten for the 10%lat/10%CaO: 90%V.A. sample, while the control mix gave a 28-day strength value of 27.0N/mm² (100%). The volcanic ash – lime cement in the laterized concrete specimens therefore reflects good pozzolanic activity and can be adopted for construction of buildings and rural infrastructure.

KEYWORDS: Volcanic Ash, Laterized Concrete, Calcium Oxide, Compressive Strength, Replacement.

INTRODUCTION

The provision of housing is governed by the need for shelter among other factors and according to *Fitch and Branch (1960)*, the need for shelter must be met by materials that the environment can afford. Such materials must therefore be widely and readily available, appropriate (economically, that is affordable and physically) to the environmental demands, thermally efficient and socially acceptable (*Olusola, 2005*). Besides, the building system derived from such materials must allow participation from the community and thereby improving the cash economy of that community. This is what *Adegoke and Ajayi (2003)* referred to as appropriate technology. Examples of such locally available building materials that fits into these descriptions are cement replacement materials such as rice husk ash, corncob ash, sawdust ash, volcanic ash and conventional sand replacement materials such as erosion sand and laterite, This study focuses on possible replacement of ordinary Portland cement by lime -volcanic ash cement and partial replacement of sand by laterite in concrete production.

Concrete is associated with high strength, hardness, durability, imperviousness and mould ability. It has poor thermal insulation, but has a high thermal capacity (*F.A.O. reports, 2002*) .It is not flammable and has good fire resistance but there is a serious loss of strength at a high temperature. Concrete made with ordinary Portland cement has low resistance to acid and sulphate but high resistance to alkali (*Neville, 1992*). Its compressive strength depends on the proportion of the ingredients i.e. the water-cement ratio and the cement- aggregate ratio. Since the aggregate form the bulk of hardened concrete, its strength will also have some influence; direct tensile strength of concrete is generally low, only about 1/8 to1/4 of the compressive strength and is normally neglected in design calculation especially in design of reinforced concrete (*F.A.O reports, 2002*). Compressive strength is measured by crushing cubes having 150mm dimensions with the cube cured for 28days under standardized temperature and humidity and then crushed in a hydraulic press.

Laterized concrete was defined as concrete in which stable laterite fines replace sand wholly or partially, whole replacement is also referred to as terracrete (*Olusola, 2005*). *Adepegba (1975)* was the first to consider the possibility volcanic glass ...rds, crystals and minerals and other rock ...gment; the density of the particle are as g... in Table 1:

Table 1: Densit... f Individual Ash Particle

Types of pa...icle	Density of particle
Pumice frag...ent	700 – 1200 kg/m^3
Volcanic glass shards	2350 – 2450 kg/m^3
Crystal and ...inerals	2700 – 3300 kg/m^3

Source: *Shiple... and Saran-Wojcicki (1982).*

MATERIALS A...D METHODS

Laterized concre... mixtures with two levels of volcanic ash (V...) – lime combinations and three levels o... laterite replacement also ranging from 0 to 20% (i.e. a total of 4 levels of samples produced in triplicates) were investigated. The control mixture was proportioned for a target concrete strength of 25 N/mm^2 and had a cementitious material content of 292 kg/m^3 fine aggregate content of 680 kg/m^3, a co...se aggregate content of 1158 kg/m^3 and a wa... cementitious materials ratio of 0.65 giving ... free water content of 190 kg/m^3. The ce... and sand replacement by V.A and late...e respectively was thereby computed for b... weight as required.

The volcanic ... used was obtained from Kerang in Ma... Local Government Area of Plateau State i... ...geria as a solid mass. This was ground an... ...eved with a 75μm sieve at the Civil En...ering Laboratory of the Federal Unive... of Technology, Minna. As shown in Tab... ...he total content of Silicon Dioxide (SiO_2) ...minium Oxide (Al_2O_3) and Iron (II) Oxid... (...$_2O_3$) can be said to range between 64% ...orted by *Lar and Tsalha (2005)* and 68% *Hassan (2006)*, which is slightly below the minimum of 70% specified in *ASTM C618*.

Table 3 shows the specific gravity of the V.A sample as 3.04, which is similar to 3.05 as given by *Hassan (2006)*, a value less than that of cement (3.15) as provided by *Neville (2006)*. The fine aggregate used were sand and laterite. The lime used for this study was quick lime (CaO) purchased from the building materials market in Kuta road, Minna. The laterite was obtained from Julius Berger (Nigeria Plc.) burrow pit at Maikunkele, Minna, Niger State, Nigeria. While sand used was river sand, free from deleterious substances (obtained from Bosso area of Minna); the coarse aggregate used was granite obtained from Tri-Acta quarry in Minna with maximum size 19mm (3/4in) specified. Table 3, presents the results of the physical properties of the aggregates. The laterite sample has a specific gravity of 2.54, a bulk density of 1375 kg/m^3, moisture content of 15.79%, a fineness modulus of 2.91, a coefficient of uniformity (C_u) of 8.68 and a coefficient of curvature (C_c) of 1.20. It has a Silica: Sesquioxide ($SiO_2/Al_2O_3+Fe_2O_3$) ratio also simply referred to as Silica Ratio (SR) of 0.97 as shown in Table 4 which presents the result of Chemical Analysis carried out on the laterite sample in the Chemistry laboratory of West African Portland Cement Company (WAPCO) - Shagamu Works Department via an X-ray Fluorescent Analysis using a Total Cement Analyzer model ARL 9900 XP. The S-S ratio is thereby less than 1.33 indicating a true laterite classification as specified by Femor (1981).

Table 2: Chemi... ...nalysis of Kerang's Volcanic Ash Sample

...ements	% Composition by weight	
	KG1	KG2
...O_2	39.64	48.75
...O_3	11.18	16.26
...O_3	12.92	2.13
...O	10.43	11.67
...gO	18.79	4.24

K_2O	1.64	5.71
Na_2O	0.95	3.83
P_2O_5	0.48	0.81
TiO_2	2.52	
MnO	0.08	
SO_3	0.02	
Cr_2O	0.04	
L.O.I		2.71
Total $SiO_2+Al_2O_3+Fe_2O_3$	63.74	67.14

Source: *KG1- Lar and Tsalha (2005)*
KG2- Hassan (2006).

Table 3: Summary of Physical Properties of Constituent Materials

Parameter	V.A	Sand	Laterite	Granite
Specific Gravity	3.04	2.59	2.54	2.64
Bulk Density(kg/m^3)				
Uncompacted	1394	1337	1267	1792
Compacted	1649	1458	1375	1287
% Void	18.29	9.05	7.85	28.18
Moisture Content		3.67	15.79	
Sieve Analysis				
Fineness Modulus		2.41	2.91	
Coefficient of Uniformity		8.00	8.68	1.42
Coefficient of Curvature		1.04	1.23	0.94

The sand on the other hand has a specific gravity of 2.59, a bulk density of 1458 kg/m^3, moisture content of 3.67%, fineness modulus value of 2.41, C_u of uniformity of 8.00 and C_c of 1.57. These results reflect that both the laterite and sand samples are well graded. The granite sample has a specific gravity of 2.64, bulk density of 1287 kg/m^3, C_u of 1.42 and C_c of 0.92, reflecting a uniform sample. All the aggregates conformed to the British Standard Specification *(BS 812- Part 103, 1985)*. The cement used was Dangote Portland cement produced in Obajana factory, Kogi State, Nigeria and conformed to *BS EN 197-Part 1, 2000.*

Table 4: Result of Chemical Analysis of Laterite Sample

Elements	% Composition by weight	Others	Values
SiO_2	40.95	Cl^-	0.00
Al_2O_3	20.38	L.O.I	
Fe_2O_3	21.95	SUM	83.76
CaO	-0.65	LSF	-0.34
MgO	-0.62	SR	0.97
K_2O	0.32	AR	0.93
Na_2O	0.23	C3S	-487.34
P_2O_5	0.03	C2S	-481.23
TiO_2	1.14	C3A	16.92
Mn_2O_3	0.16	C4AF	36.45
SO_3	-0.14	$Al_2O_3+Fe_2O_3$	42.33
Total $SiO_2+Al_2O_3+Fe_2O_3$	83.28		

Source: *Olawuyi (2008)*

Tests to determine slump, density and comprehensive strength were carried out in this study.
For the comprehensive strength tests, 150mm cube specimens were used. A total of 60 specimens were cast and cured in water at room temperature in the laboratory for 7, 14, 21 and 28 days. At the end of each curing period three specimens of each mixture were tested for compressive strength and the average was recorded.

RESULTS AND DISCUSSION

The workability of the concrete specimens decreased as the content of laterite and volcanic ash increased. The compressive strength of the concrete samples increased as the days of hydration increased as reflected in Tables 5 & 6 and as displayed in Figure 1.The 20%lat/20%CaO: 80%VA sample consistently has a higher strength than the 10%lat/10%CaO: 90%VA sample for all the curing days.

Table 5: Summary of Compressive Strength

Curing day's	C25		
	100%OPC	*10%Lat/CaO:90%VA*	*20%Lat/VA:80%VA*
7 day's	10.93	8.21	8.44
14day's	15.69	10.92	11.44
21day's	20.80	13.08	14.06
28day's	27.00	21.53	22.07

Table 6: Percentage of 28-Day Strength

Hydration Period	*100%OPC*	*10%Lat/CaO:90% VA*	*20%Lat/CaO:80%V A*
7 day's	40.48	30.41	31.26
14day's	58.11	40.44	42.37
21day's	77.04	48.44	52.07
28day's	100.00	79.74	81.7

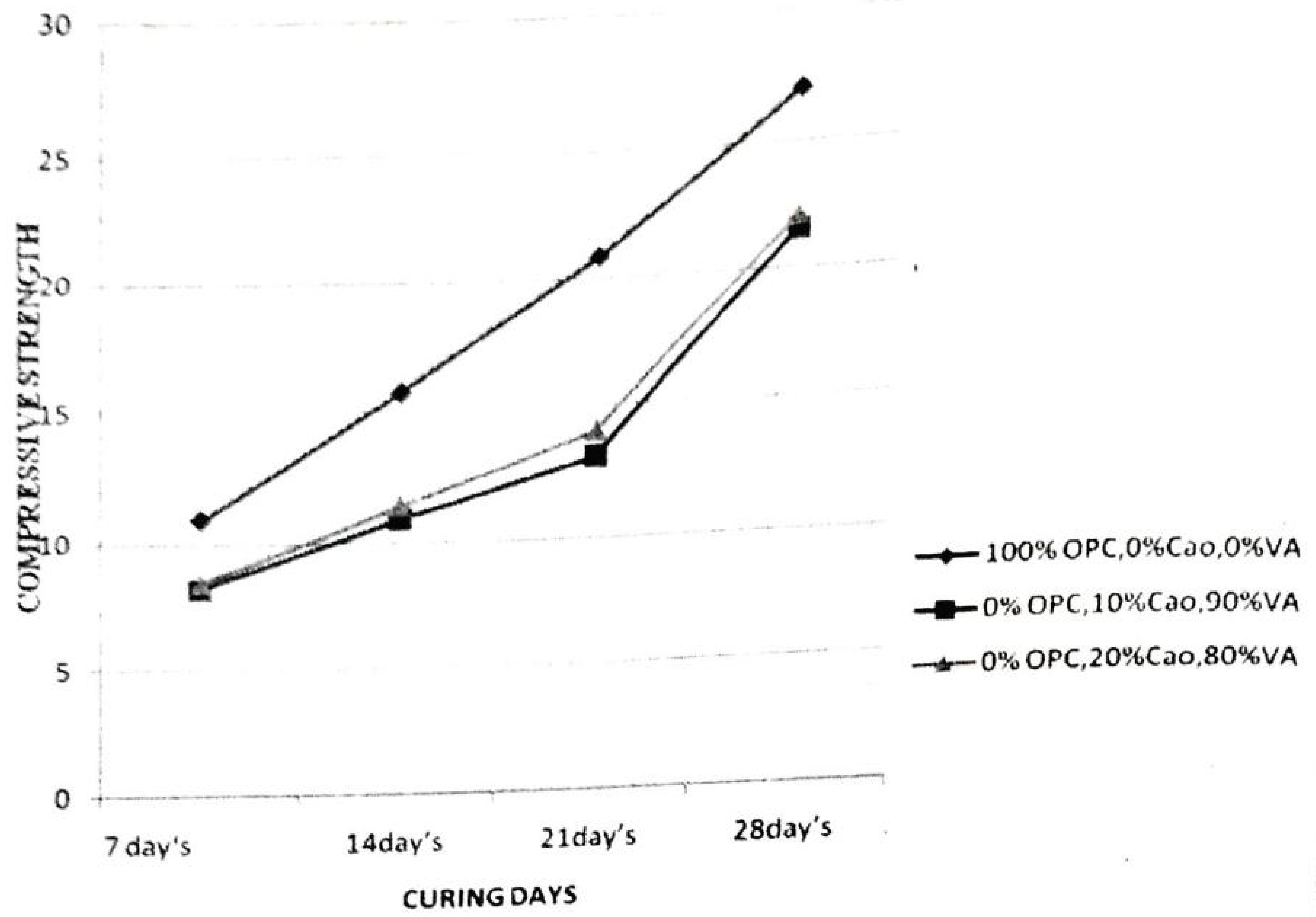

Fig 1:Effect of calcium oxide on performance charateristic of volcanic ash Laterized concrete.

The 28-day strength of the 20%lat/20%CaO: 80%VA sample gave a value of 22.07N/mm2 about 82% of the control sample value of 27N/mm2, while the 10%lat/10%CaO: 90%VA gave a 28-day strength value of 21.53N/mm2 about 80% of the control sample value. This implies that the introduction of the quick lime to the volcanic ash laterized concrete improves the compressive strength of the concrete sample while it can be said that the volcanic ash – lime cement in the laterized concrete shows a good pozzolanic activity having caused the laterized concrete to have gathered a strength value of above 80% from the initial 7-day strength value of about 30%. The development conforms to the requirements of *ASTM C618 08a* and hence can be hoped to have strength similar to the normal concrete (i.e. the control) at later days of hydration such about 60 or 90 days as is experienced for pozzolanas or pozzolanic cement in general.

CONCLUSION

From the studies carried out on the effect of calcium oxide on volcanic ash laterized concrete the followings can be deduced:

(i).The specific gravity of volcanic ash is 3.04 which is close to 3.15 for cement as provided by Neville (2006), while the chemical analysis from previous studies on the volcanic ash sample reveals the total of SiO_2, Al_2O_3 & Fe_2O_3 is around 68% which is just below 70% as required by ASTM C618.

(ii).The setting time was slower compared to conventional ordinary Portland cement concrete.

(iii).Volcanic ash – cement can indeed become a viable alternative to ordinary Portland cement.

(iv).The 20%lat/20%CaO: 80%VA sample gave a good strength value and can be adopted for construction of buildings and infrastructures in the rural areas.

Recommendations

The following are hereby recommended for further studies

(i). An investigation into higher content of quick lime (CaO) possibly up to 40% and effect of varying proportions of VA – Lime cement on varying laterite content on the laterized concrete sample.

(ii). An investigation into effect of CaO on the compressive strength of the volcanic ash laterized concrete at curing age beyond 28-

days as required for pozzolanas to confirm its pozzolanic tendency.

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THE IMPACT OF CONSTRUCTION WASTE ON THE ENVIRONMENT

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ABSTRACT

Ways by which construction sites in Minna, Lagos and Abuja- Nigeria handle the construction waste generated at project sites are improper, and most of these wastes are potential hazards to the community. The paper investigates the construction wastes that are potentially hazardous to the environment. It adopts the use of interviews and site investigations to collate data for analysis. The degree of impact of these wastes was evaluated on the parameters of matrix Impact scale and the checklist of the environmental impact analysis, results and remedies we're presented and recommendation made. The paper highlights the need to enlighten the public and construction companies on the dangers of indiscriminate disposal of construction waste because the waste that are airborne and miscible with water have a far reaching, irreversible impact, and as such require effective means of disposal.

Key words: Impact, environment, construction waste, hazard, Matrix.

INTRODUCTION

Environment as defined by the European union is the combination of elements whose complex interrelationships make up the settings, the surroundings and the condition of life of the individual and of society, as they are or as they are felt, also, Ran and wooden (1980) saw the importance of the environment to man and took their time to study it and they came out with this conclusion about what the Environment is: Environment is the whole complex of physical, social, cultural, economic, and aesthetic factors that affect individuals and communities and ultimately determine their form, Character, relationships and survival. Examples include: air and water quality, erosion control, natural hazards, land use planning, site selection and design, subdivision development, conservation of plant and animal life, urban congestion, overcrowding, displacement and relocation resulting from public or private action or natural disaster, noise pollution, urban design and the quality of the constructed environment, and the impact of the environment on people and the activities.

Waste in the construction industry has been the subject of several research projects around the world in recent years .Some of them have focused on the environmental damage that result from the generation of material waste. Carlos et al (1999). Wyatt (1978) stressed the consequences of high levels of waste in both reducing the future availability of materials and energy.

CONCEPT OF WASTE

According to koskela,(1992) waste is any inefficiency that result in the use of equipment, materials, labour, or capital in large quantities than those considered as necessary in the production of a building .waste includes both the incidence of material losses and the execution of unnecessary work, which general additional cost but do not add value to the product. Therefore, waste should be defined as any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client.

CONSTRUCTION WASTE

The environmental protection department (2007) in Hong Kong concisely states that construction waste is any substance, matter, or thing which is generated as a result of construction, demolition and land clearing (CDL) waste includes all hazardous & non hazardous solid wastes resulting from construction,

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remodeling, alterations, repairs, demolition and land clearing. COWAM (2006). Construction waste is a serious environmental problem in many large cities. A daily average of about 7,030 tonnes of construction and demolition (C&D) wastes were disposed off at landfills in 1998 in Hong Kong, representing about 42 percent of total waste intake at landfills, and most of which can be reclaimed; and in 1999, there were about 7,890 tonnes of C&D wastes disposed daily off at landfills, representing about 44 percent of total waste intake at landfills (Hong Kong Government–Environmental Protection Department, 2006). According to Lu, (1999), construction wastes are made up of about 40 percent of overall solid waste generation in Mainland China. Contrasted to the figures in other advanced countries, for example, C&D debris makes up only about 12 percent of the total waste received at Metro Park East Sanitary Landfill of Iowa State in the United States (Metro Waste Authority, 2000). waste generation in Mainland China is much higher than other countries.

DEFINITIONS AND CLASSIFICATION OF CONSTRUCTION WASTES.

Construction waste varies in size, form, physical, and chemical composition, though waste is not an easy thing to classify. John E.J (1981) adopted the following classification of construction waste.

A. Materials damaged through poor storage, careless handling and poor workmanship
B. Materials missing or deposited in areas which render then unsuitable;
C. Materials damaged but unable within the contract for less important purpose

Wong and Robin (2004) classified construction and demolition waste into inert substances such as sand, brick and concrete, and non-inert substance such as bamboo, plastics, glass, wood and other organic materials. Additionally, waste can also be classified according to its origin, i.e. the stage that the main root causes is related to. Although waste is usually identified during the production stage, it can be originated by processes that precede production, such as materials, manufacturing, training of human resources, design, materials supply and planning. The main classification of waste as proposed by Shingo, (1989) is by the nature of the waste and this helps to understand the different forms of waste, why they occur and how to act in order to avoid them. Below are the various classifications.

Overproduction: related to the production of a quantity greater than required or earlier than necessary. This may cause waste of materials, man-hour or equipment usage. Its usually produces inventories of unfinished products or even their total loss, in case of materials that can deteriorate. An example of this kind of waste is the overproduction of mortar that cannot be used on time.

Transportation: concerned with the internal movement of materials on site .excessive handling, the use of inadequate equipment or bad conditions of pathways can cause this kind of waste. It is usually related to poor layout, and the lack of planning of material flows. Its main consequences are: waste of man hours, waste of energy, waste of space on site, and the possibility of materials waste during transportation.

Processing: related to the nature of the processing (conversion) activity, which could only be avoided by changing the construction technology. For instance, a percentage of mortar is usually wasted when a ceiling is being plastered.

Inventories: related to excessive or unnecessary inventories which lead to materials waste (by deterioration, losses due to inadequate stock conditions on site, robbery, vandalism), and monetary losses due to the capital that is tied up. It might be a result of lack of resources planning or the estimation of quantities.

Movement: concerned with unnecessary or inefficient movements made by workers during their job. This might be caused by inadequate equipment, ineffective work methods, or poor arrangement of the working place.

Production of defective products: it occurs when the final or intermediate product does not fit the quality specifications. This may lead to rework or to the incorporation of unnecessary materials to the building (indirect waste), such as the excessive thickness of plastering. it can be caused by a wide range of reasons: poor design and specification, lack of planning and control, poor qualification of the team work, lack of integration between design and production, etc.

METHODOLOGY

In this study seven construction sites in Minna, Lagos and Abuja were sampled for observation and administration of a well structured questionnaire to the professionals such as architects, builders, quantity surveyors and health officials, The public, and artisan/labour were also interviewed to test for the general awareness level on the impact of construction waste on the environment.

The major focus of the research is to determine the types of construction waste generated and its effect to the environment; level of awareness of public on the impact of construction waste. Data collected was analyzed using the simple matrix method and check list method of the environmental impact analysis (Onyeador & Ikwuegbu, 2005).

RESULT AND DISCUSSION

Table 1 shows the Composition of construction wastes generated in the selected construction sites visited in Minna, Lagos and Abuja (which is in many respects similar, though there are differences in frequencies of occurrence). The wastes comprises of Concrete and Cement , Block Waste, Timber, Tile Waste, Steel And Aluminium, Glass And Plastic waste, and Packaging Material. Concrete and Cement, Block Waste, and Timber are the most prominent (100%) present in the entire site visited while packaging materials waste is the least (23%).

The effects of construction waste and the Environmental Impact Analysis (EIA) check list on the environment can be seen in table 2 and 3. Concrete and its constituents like cement and sand result to dusty conditions which contributes to air pollution and depletion of the Ozone layer especially when most of these wastes are burnt openly, the effect are irreversible and subsequently have a long term effect on the environment. Others on the list have short term, and sometimes negligible effect. construction wastes will result in a range of impacts that are common to most construction sites. Potential impacts include dust and noise, hideouts, the development of informal trading areas, unnecessary destruction of valuable flora and pollution of the soil and water resources.

Data collected revealed that 85% of the professionals that responded to the questionnaire are aware of the impact (effect) of construction waste on the environment, while only 3% were not conscious of the negative implications it has on the environment, a large amount of Artisans and labour (61%) who are directly engaged in the usage of this materials have no idea of the implications of these wastes on the environment. Averagely, the awareness of the general public is not encouraging (27%); the Health workers, sanitary inspectors and Environmental protection agency have a lot to do to keep our environment: Life, property, health, wildlife, air, water, the ozone layer etc save (Figure 1).

Table I: The major types, reasons and frequencies of occurrence of construction waste.

S/N	TYPES OF CONST. WASTE	REASONS FOR WASTE GENERATION	FREQUENCIES (%)
A	Concrete and Cement Waste	flow of plastering, demolished concrete, over-order and template leakage	100
B	Block Waste	transportation damage and cutovers	100
C	Timber Wastes	Cutovers	100
D	Tile Wastes	transportation damage and cutovers	42
E	Steel And Aluminium Wastes	Cut steel bars and aluminium from basement,concrete,and roof activities	87
F	Glass And Plastics	Deformation during transportation and delivery. Obstruction and deformation work, used waste from unstandardized design	56
G	Packaging Material	Packaging from tiles, glass, cement bags, constr. materials.	23

Table 2. Effects of Construction waste on Environment

Type of waste	Air	Water	Soil	Wild life	Vegetation	Health
Concrete and Cement Waste	CC	C	?	CC	C	CC
Block Waste	CC	?	N/A	N/A	CC	N/A
Timber Wastes	N/A	?	?	CC	CC	CC
Tile Wastes	N/A	N/A	N/A	N/A	C	C
Steel & Aluminium Wastes	N/A	N/A	N/A	N/A	C	CC
Glass And Plastic	N/A	N/A	?	N/A	C	CC
Paint and other decorative	CC	CC	N/A	?	CC	?
Packaging Material	?	?	?	?	CC	?

- ***B** Indicates positive impact (benefit), **C** negative impact (cost), **BB** or **CC** a sizeable impact, **N/A** not applicable (where no impact is expected), **?** Question mark (where it is not yet certain whether there will be an impact or not).*

Table 3. The EIA Check List of the Effects of Construction waste

Types	No impact	Positive Impact	Negative Impact	Short Term	Long term	Reversible	Irreversible
Concrete & Cement Waste			✓		✓		✓
Block Waste			✓	✓		✓	
Timber Wastes			✓	✓		✓	
Tile Wastes			✓	✓		✓	
Steel & Aluminum Wastes			✓	✓		✓	
Glass & Plastic			✓	✓		✓	
Paint and other decorative			✓	✓			✓
Packaging Material			✓	✓		✓	

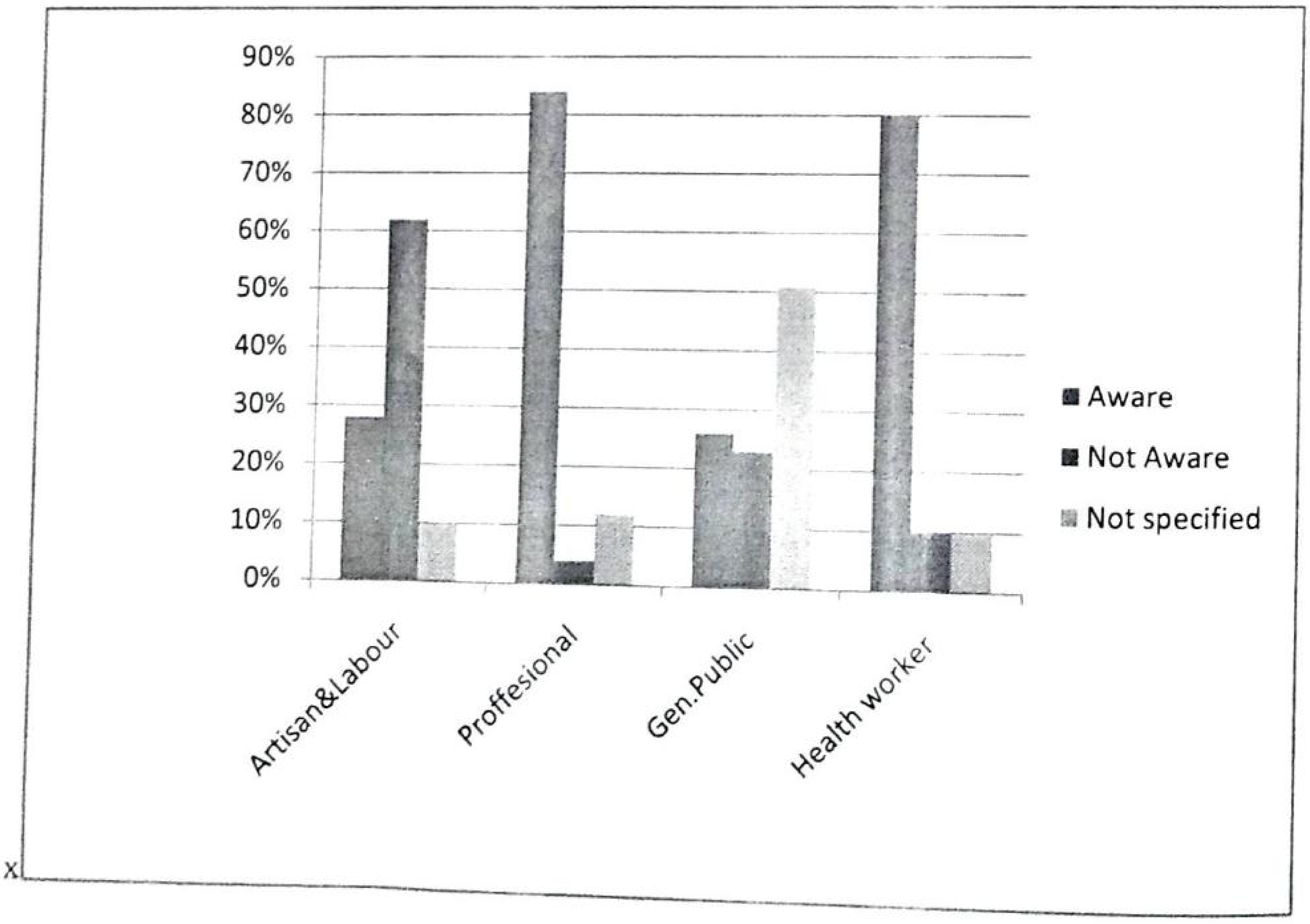

Figure 1. Level of awareness of stakeholders on the impact of construction waste on the environment.

CONCLUSIONS AND RECOMMENDATIONS

From the paper and data presented, the following becomes glaring:

- Existence of man is impossible without his environment and divers activities are carried out daily in our environment, which have gradual destructive effects and leave a residual negative impact on our environment, most of these impacts could be reversible, sometimes non-reversible, long term or short term. Construction and demolition are one of the major human activities done in the environment and when it is not controlled and carefully done, its implication the environment is drastic, not only on human being but also on every other environmental habitats (nature).
- All those involve in construction projects contributes to wastes: designers, material suppliers, site managers, manufacturer, constructor, operatives etc.
- Construction waste is a voluntary waste and it constitutes the most visible and obviously affront to the environment and human (life) health, since it is an act or omission, which alters the nature of land.
- Construction waste is notorious, dangerous and harmful and could be classified as an industrial waste.

In view of the enormity of the effect construction wastes have on the environment, the following recommendations are given so as to keep our environment (nature) for human existence:

- Establishment of an agency responsible for the monitoring and regulation of discharges into the environment in every municipal e.g. Environmental Protection Agency.
- Promulgation/enactment of legislation/regulations for the protection of human health and ecological system from pollution hazards.
- Development of programmes that would advance technology and competence, monitoring and abatement in our educational institutions.
- Mobilization of the community, construction companies, existing regulatory bodies through workshops, seminars, symposiums in the preservation and protection of the environment.
- Development of warning systems that could avert construction waste pollution disasters.
- Evolvement of industrialization policy that places adequate premium on the protection and conservation of the environment and its enforcement.

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