PROTOCOL

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The Provost, College of Medicine,
The University Librarian,
The Dean, Faculty of Engineering,
Deans of Other Faculties,
Members of University Senate,
Heads of Department,
Distinguished Academic and Professional Colleagues,
Distinguished Non-Teaching Colleagues (Administrative and Technical),
Your Lordships (Spiritual and Temporal),
Dear Students,
Gentlemen of the Press (Print and Electronic Media),
Distinguished Guests, Ladies and Gentlemen.

1.0 PREAMBLE

I am immensely grateful to the King of kings and the Lord of lords; the Almighty God - Jehovah who has bestowed upon me His grace and mercy to stand before you all today to deliver this inaugural lecture. With Him alone, ALL things are possible, and without Him, nothing is possible. TO HIM, I DEDICATE THIS LECTURE.

Madam Vice Chancellor, permit me to also dedicate this lecture to my late parents - Pa Nelson Cyril Oviawonyi Ikponmwosa and Madam Victoria Irowa Ikponmwosa. From birth at Mercy Street, Lagos Island Maternity, through living on McCullum and Herbert Macaulay streets in Ebute Metta, the duo made sure that I got educated.

My sincere gratitude and appreciation to Madam Vice Chancellor, Professor Folasade Ogunsola, the 13th and first female Vice Chancellor

of our great University for acceding to my request to deliver this lecture today, 24th January, 2024.

It is indeed a great honour and privilege for me to stand before you all today to deliver **the 396th Inaugural Lecture** of this great Citadel of learning, **the 44th** in the Faculty of Engineering, **the 12th** in the Department of Civil and Environmental Engineering and **the 7th** in the 2023/2024 academic session.

2.0 HOW IT ALL STARTED

I was born on January 24, 1958, into a humble family with six children. The first three are males and the last three are females. I am the third of the boys, now men. My father read up to the then MODERN school level while my mother was not educated. They cherished education and both worked very hard to make sure we all got educated to tertiary level. I started my primary education in the period when we had to go through the infant/standard system of eight (8) years before secondary education. However, in standard four, the system changed to a straight 6-year primary education system. This situation created a big challenge in the family as that led to just a year gap between me and my immediate elder brother, retired Flight Captain Benson Ikponmwosa instead of the usual two/three years gap. My eldest brother, Dr. Alexander Nelson Ikponmwosa was already then at CMS Grammar School, Bariga, Lagos, for his secondary education. I was to be dropped or slowed down from going to secondary school because of the bills to have three children at the same time in college by a local carver (sculptor) and his wife, who only sold provisions (popularly known then as Wosiwosi) in a kiosk, was unthinkable.

My father wanted us all to be in Lagos for our education but seeing the realities on ground, and encouraged by his wife, our mother, agreed to send Benson Ikponmwosa to Edo College in Benin City, and a year later, sent me to Immaculate Conception College (ICC), Benin City but only as a day student to save cost. I had to live with my late grandmother, Madam Oni Tongo, who was there for me throughout my stay in Benin City. God used her to bring out His Glory in me because,

with her help, waking up in the night to wake me up to study for my West Africa School Certificate (WASC) examinations helped me to come out with a cumulative Division One grade result.

Between 1975 and 1978, when I went back to school, I worked at John Holt, Benin City. I also worked at the Federal Audit Department and UBA Plc., both in Lagos. While working, I continued to write entrance examinations to study medicine at many of our universities. All attempts failed, so I settled to be a builder. In 1978, I gained admission into Yaba College of Technology in Yaba, Lagos, to study Building. After the National Diploma Program (ND) and while on the HND program, in 1981, help came my way from Almighty God and I got a Federal Government Scholarship through the Bureau for External Aids to study Civil Engineering in the then Soviet Union.

Although in my youthful days, I wanted to be a Medical Doctor, however, through my journey in life, I became first a builder, then a graduate of Civil Engineering and later a Ph.D. holder, a Doctor of Civil Engineering. Over the years, my passion for Civil/Structural Engineering has grown in leaps. I have found this area of specialisation in human endeavour to be quite interesting and challenging to research.

Madam Vice Chancellor, this is part of the story of my life that shows how Efe Ewaen, the son of a Carver, journeyed as a young Ebute-Metta Lagos boy to earning the title 'Doctor" and now a Professor. The knowledge acquired has been very useful to me in all my professional endeavours as a teacher/lecturer, a researcher and a practising engineer. It has been a reasonably long, challenging but fruitful and fulfilling journey in academics and professional practice which has lasted over forty years. I give thanks to the King of kings, the ancient of days, the 'I am that I am', the Almighty God who has made today a reality in my life. I give my Father in heaven, all glory, all honour and all adorations for he has always been faithful to me. May His name ever remain glorified, Amen.

3.0 INTRODUCTION

The title of my inaugural lecture is **"Concrete, A Friend or A Foe? The Choice is Ours!"** Recent events and accounts recorded of building/infrastructure collapses in Nigeria have left tales of woes, wailing, and sadness in many homes and families. The structures concerned are usually concrete or reinforced concrete. Concrete that is expected to create shelter for man has turned out to be an agent of destruction of lives and properties. In recent years, we have frequently recorded building and/or infrastructural collapses in Nigeria. This is rather unfortunate.

This inaugural lecture will attempt to take us through basic knowledge of concrete to X-ray and carry out a critical appraisal of recent collapses of concrete structures around us when concrete turned out to be our foe instead of our friend. Furthermore, an attempt will be made to proffer solutions aimed at considerably halting the negative trend.

4.0 HISTORY OF EVOLUTION OF CONCRETE

The history of concrete is a fundamental and intrinsic aspect of the history of civilisation. Since time immemorial, channeling creativity, scientific knowledge, and grit – man has created structures to suit his personal and societal needs. Natural cement was first made when the earth first started going through intense geological changes.

With a timeline that dates to 12,000,000 years BC, it is reported that reactions between limestone and oil shale during spontaneous combustion occurred in the region now known as Israel to form a natural deposit of cement compound. During 3000 BC, resourceful and intelligent Egyptians were documented to have used gypsum mortars and mortars of lime for the bonding of stones in constructing the great pyramids. In 800 BC, construction materials historians reported that Greeks and Romans deployed lime mortars and Roman mortars for construction. After 300 BC into the early period of the new age, the Romans developed Pozzolana cement from Pozzuoli, Italy, near Mt. Vesuvius for construction purposes. The material was used to build the Appian Way, Roman baths, the Coliseum, and the Pantheon in Rome.

With years passing by, the production of cementing material (binder) continued to be improved. Between 1793 and 1796, researchers developed different variants of hydraulic lime, which hardened under water. By 1824, Joseph Aspdin of England invented Portland cement, a result of finely ground chalk with finely divided clay, heated in a lime kiln until carbon dioxide (CO_2) was completely removed. The clinker was then ground into fine powder to form cement. To date, this product of 1824, now a global brand, is the main binder used for concrete production. Portland cement's first application as an engineering material is reported to have occurred in 1828 when it was used to 'fill a breach in the Thames Tunnel' by Engr. I. K. Brunel. The beginning of the era of Portland Cements in modern composition is believed to have started in 1860. [2] [3]

From then on, the science of Portland cement grew and the development of cement and concrete products continued to yield good results that encouraged researchers and users. It is reported that by 1891, George Bartholomew constructed the first concrete street in the USA in Bellefontaine, Ohio. By 1903, the first concrete high rise was built in Cincinnati, OH; and this was closely followed by the construction of cheap, cozy concrete houses in Union, NJ, USA in 1908. Between 1908 and 1975, the first concrete dams, Hoover Dam, Grand Coulee Dam, concrete domed sports structure, and assembly hall at the University of Illinois at Urbana-Champaign were constructed. It is believed that the first concrete street and some of the above-mentioned structures still exist today! These are all instances when concrete displayed traces of friendship to mankind. These show the flexibility in usage, the moldability in usage and the versatility and durability that are derivable from the use of concrete. [2] [3] [4]

Madam Vice Chancellor, the modern history of concrete in Nigeria can be linked to when indigenous cement factories commenced operations in the country.

Cement production in Nigeria commenced with the NIGERCEM cement industry which was established in 1954 at Nkalagu in present-day Ebonyi State during the twilight years of the colonial period. It was a collaboration between the Nigerian and British governments. NIGERCEM was one of the earliest attempts by the young Nigerian government to introduce the Import substitution Industrialization (ISI) strategy. Prior to this time, all the cement used in Nigeria was imported.

The West African Portland Cement Company was later established at Ewekoro, Ogun state in 1960. As demand increased with growing economic prosperity following the oil boom, there was an incentive for more manufacturers to come into the cement/concrete production sphere. Accordingly, Benue Cement Company Plc was set up in 1980. In 2006, the Dangote Group commissioned their first factory – the Obajana Cement Plant. Since then, several other cement plants have come into being (Mojekwu *et. al*., [5].

During the colonial period, cement grade imported and used in construction was majorly 32.5 Grade. With the entrance of indigenous manufacturers into the business, until recently, they were all configured to produce 32.5 Grade general purpose cement. Today, they all have the capacity to produce 42.5 and 52.5 Grade products in Nigeria.

This being the case, it means that we should not be recording infrastructural collapses as we have them happening now. During the period of colonial rule and the early period of our independence as a nation, most construction works were executed on 32.5 Grade Ordinary Portland Cement (OPC); houses and bridges were not collapsing the way they are now!! What are those things that we are doing wrongly? What are the things we are not doing? Production of CONCRETE, as a construction material, has been improved over time, all over the world. We now have higher strength-yielding cement grades (42.5 and 52.5), yet we continue to record disasters in the construction industry. This is an indication that there are societal challenges that we all need to address to put a stop to this trend.

5.0 RECENT REPORTS ON BUILDING COLLAPSES

Madam Vice Chancellor, during the National Dialogue on Collapsed Buildings held on November 25, 2010, and powered by LAFARGE [6], many paper presenters came up with different opinions on the challenges and reasons responsible for building collapses in the country.

The Building Collapse Prevention Guild (BCPG) noted at the event that the tragedies that collapsed buildings bring on the people have become worrisome. More worrisome and frustrating is the helplessness of the people toward what could be done to stem the tide. It was opined that while social and economic demands have resulted in an increased quest for the construction of new infrastructure generally, this has also led promoters of such developments to defy regulations and professionalism in putting up such structures in a bid to cut costs and make more profits. Furthermore, BCPG representatives posited at the gathering that government policies and supervision have been grossly inadequate to face the challenges of controlling activities on construction sites.

Furthermore, it was noted at the event that there is unhealthy competition among professional bodies in the built environment. The struggle for superiority has negatively affected the quality of discharge of the responsibilities of professionals in the built environment to society, as over 90% of collapsed structures are in urban cities and towns.

May I humbly note and submit here that the issue of building collapses is a shame to Nigeria and to all Nigerian professionals in the industry. **Apart from non-compliance with the regulation culture that we have developed over the years, there is also the issue of poor knowledge of materials being deployed in construction; especially CONCRETE.**

Oyenuga [7] posited that one of the critical considerations in structural design is the materials being used, and adequate knowledge of the

same is very important. He noted that the best designs by the most qualified designers do not guarantee a safe structure. The materials mostly used (CONCRETE) - cement, fine aggregate (sand), coarse aggregate (gravel or granite chips), water, and rebar—must be of the right specifications. He posited that sharp sand obtainable from shallow upland river beds has low salt contents; hence, this is permissible and may not require testing. However, sharp sand (fine aggregate) from lagoons and oceans should always be tested for salt content. He concluded by giving preference to the use of well-washed gravel as coarse aggregate. This position is affirmed by Ikponmwosa *et. al.*, [8][35].

Madam Vice Chancellor, this is one of the critical areas this lecture will address today. The Bible says that 'my people are destroyed (perish) because of lack of knowledge because they have rejected knowledge ...' - **HOSEA 4:6**. **We are where we are today on this matter because we have refused to embrace the knowledge of construction materials, especially the material called CONCRETE.** [1]

Akoh [9] reported on incidents of building collapses when concrete turned out to be a foe to Nigerians between 1974 and 2005. He posited that, from the data he could gather, there were 114 reported cases. Out of these, 78 (68.42%) were in Lagos. The total number of lives lost from the incidents was reported to be 694, out of which Lagos recorded 315 (45.4%). Billions of Naira in assets were also reported lost.

The causes of the collapses when concrete turned out to be our foe were traced to **a) the use of substandard building materials, b**) non-compliance with existing development regulations, **c**) the illegal conversion of structures, **d**) the poor or non-availability of design instruments, etc.

Further analysis of the events (Building Collapse) in Lagos revealed the following:

Table 1. Frequency of Collapse with Time

Year	Frequency	Percentage (%)
Between 1984 - 1988	13	16.67
1989-1993	10	12.82
1994-1998	23	29.49
1999-2003	24	30.77
2004-2005	8	10.39

A chronicle of some reports of some collapsed buildings in Nigeria as of 2010 is presented below. This list is not exhaustive but also a pointer to the causes of building collapses being experienced nationwide today.

1. A 2-storey Building Collapsed in Auchi, Edo State. The cause of the collapse was primarily the use of poor-quality concrete of 10 N/mm^2 in place of $25N/mm^2$. Also, due to the additional load of one extra floor that was purportedly added.

2. Multi Storey Building Collapse in Jabi, Abuja, FCT. The root cause of the collapse was that the blocks with infill concrete were used as foundations with columns resting directly on them. Also, inadequate member sizing of columns was found to be prevalent in the design.

3. Around 2010, a building collapsed in the Oshodi area of Lagos State. Unfortunately, no proper investigation could be carried out because of some interest groups.

4. About the same time, a building collapsed in Port Harcourt, Rivers State. It was reported that the promoter did not believe in soil tests and also engaged non-registered or certified structural engineers to design and supervise the work. The use of poor-quality materials was also observed as one of the main reasons for the collapse.

In 2014, the Building Collapse Prevention Guild (BCPG) presented a list of collapsed buildings in Nigeria. The list below is not exhaustive.

Table 2. Building Collapse Occurrences by BCPG in 2014

S/No.	DATE	LOCATION	TYPE OF STRUCTURE
1	Mon. April 26, 2010	Cairo Market, Oshodi, Lagos	
2	Thurs. Dec. 9, 2010	Shoprite Building, Alausa, Ikeja, Lagos	Collapse of suspended first floor slab under construction due to failed centering
3	Thurs. Dec. 15, 2011	Within the precinct of the seat of Government, Alausa, Ikeja, Lagos	
4	Wed. Nov. 21, 2012	Housing Estate, Oke-Afa, Isolo, Lagos	
5	Tues. May 7, 2013	Four Square Church, Bashiru Street, Ojodu, Lagos State	4-Storey Building, 3 floors in use and 4th floor under construction
6	Wed. May 8, 2013	6, Adenaike Alagbe street, Ejina, Ikorodu, Lagos state	3-Storey commercial building. Framed. Ground floor in use, two upper floors under construction
7	Wed. May 8, 2013	4, Community Street, Bariga, Lagos State	2-Storey residential building
8	Sun. May 12, 2013	Liverpool Estate, Zone 2, Ijegun-Egba, behind satellite town, Lagos state	4-StoreyResidential Building under construction
9	Mon. May 13, 2013	Ibereko, Badagry, Lagos State	1-StoreyBuilding under construction

10	Tues. May 14, 2013	Lagos State Govt. Housing Estate, Oke-Afa, Isolo, Lagos	2-Storey Residential Building
11	Wed. May 16, 2013	Agbama Street, Umuahia, Abia State	4-StoreyResidential Building under construction
12	Sat. May 18, 2013	Talba Farm Road, Minna, Niger State	2-Storey Hotel Building under Construction
13	Thurs. July 11, 2013	Along Hadeija Road, Kaduna State	3-Storey Building
14	Thurs. July 11, 2013	Estate 11, Behind car park 'F', Redemption camp, Ogun State	A Storey Building under Construction
15	Thurs. July 11, 2013	Oloto Street, Ebute Meta, Lagos	3-Storey Residential Building
16	Sun, July 21, 2013	29, Onasanya Street, Ishaga, Surulere, Lagos	2-Storey Residential Building
17	Wed. Aug. 28, 2013	Building Behind Dunes Plaza, Maitaima, Abuja	Uncompleted Building
18	Mon. Nov. 4, 2013	8, Muri Okunola Street, VI, Lagos	2-Storey Building
19	Mon. Nov. 4, 2013	8, Muri Okunola Street, VI, Lagos	5-Storey Building
20	Mon. March 1, 2014	Enugu road, Nsukka, Enugu State	2-Storey Hotel Building under Construction

Of the 20 cases documented above, 14 occurred in Lagos. This represents 70% of the lot. This makes Lagos the epicentre of collapse building syndrome in Nigeria.

Gana [10], presented a more detailed report on building collapses in Nigeria and highlighted the roles expected to be played by Development Control Agencies in eradicating incidents of Building Collapses in

Nigeria.

Odeyemi *et. al*. [11] investigated the number of collapsed buildings in Nigeria when concrete structures turned out to be our foe between 2009 and 2019, based on the factors that were identified to have been responsible for the events. Published journal articles, conference proceedings, academic reports, and newspaper reports were reviewed to obtain the data used for the analysis.

During the period reviewed, the highest rate of collapse when concrete turned to be our enemy occurred in 2014 while 2016 recorded the highest number of lives lost. Southwest Nigeria recorded 34 collapses (60.71%) and 132 lives lost (64.08%) of the total for the period.

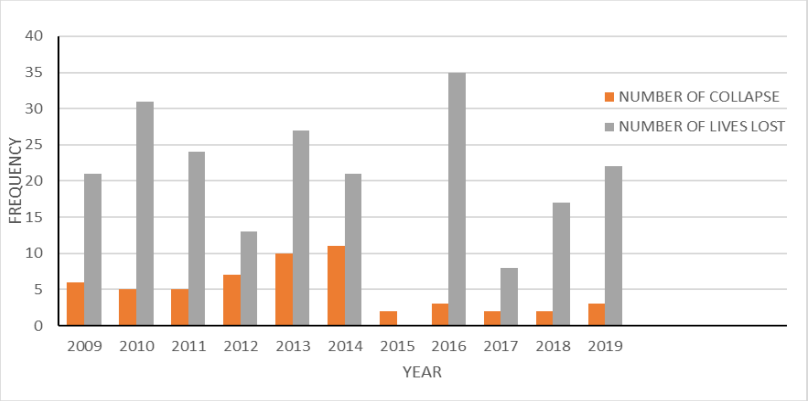


Figure 1. Collapse Record Based on Year

The leading causes of building collapse in Nigeria were identified **as substandard and poor-quality materials,** structural defects, hasty construction processes, and the lack of or non-availability of geotechnical reports. Of course, there are other causes, as noted in Figure 2.

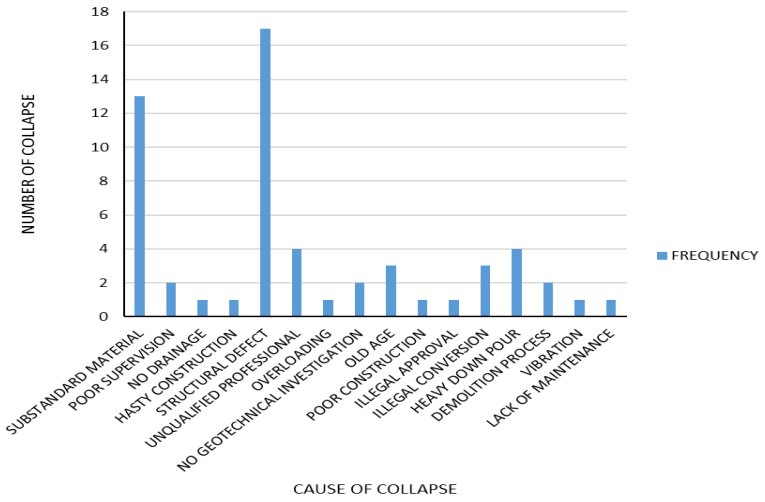


Figure 2. Cause of collapse.

Madam Vice Chancellor, permit me to bring to the fore of this lecture two classical examples of our carelessness that turned concrete to be our foe; the collapse of the 22-storey 360 Degrees Towers that was then being developed by Fourscore Homes Limited on Gerard Road at Ikoyi which claimed 46 lives, and the Synagogue church building collapse in Ikotun, Lagos in 2014 that claimed 116 lives.

With a deep sense of loss and sorrow, I remember today and always, the late Adesanya Adebayo Emilola and late Alabi Babatunde Isaiah.

Figure 3: Adesanya Adebayo Emilola (RIP)

Figure 4: Alabi Babatunde Isaiah (RIP)

They both graduated from our University and our Department. They were my project students. They died in the Fourscore Ikoyi disaster on November 1st, 2021. The building came down for many reasons. And there are many unanswered questions about that project. May their souls rest in peace, Amen.

A planning expert, Okunola [12] reported that Nigeria, over the past 20 years, has witnessed a significant increase in building collapse that has resulted in the loss of lives and properties, livelihoods, and the displacement of families. He emphasized that the collapse of the fourscore 22-floor building on Gerald Road in Ikoyi, Lagos, is just one example of the severity of structural building collapse in Nigeria.

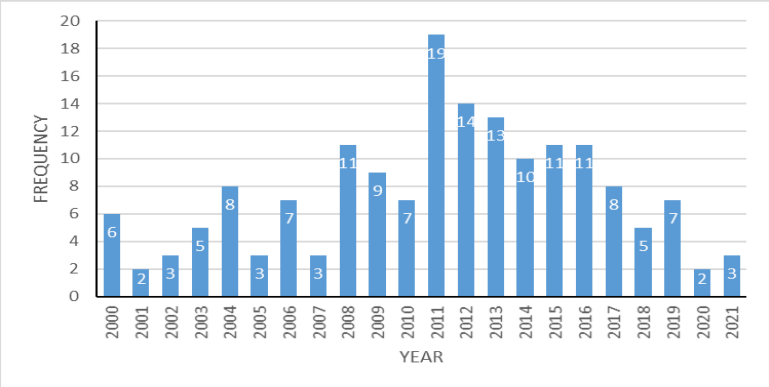


Figure 5. Building collapse in Lagos, 2000-2021.
(Source: Lagos State Fire Service)

Evidence from various government agencies and a review of literature revealed that between 1974 and 2019, over 221 buildings collapsed across Nigeria, and more than 50% of this occurred in Lagos. Facts indicate that Lagos experienced 167 reported cases between 2000 and 2021. 78.4% were residential buildings, 12.8% were commercial buildings, and 8.8% were institutional buildings. It was estimated that over 6,000 households were displaced, and properties worth trillions of Naira were lost. Virtually all these buildings had structural concrete components.

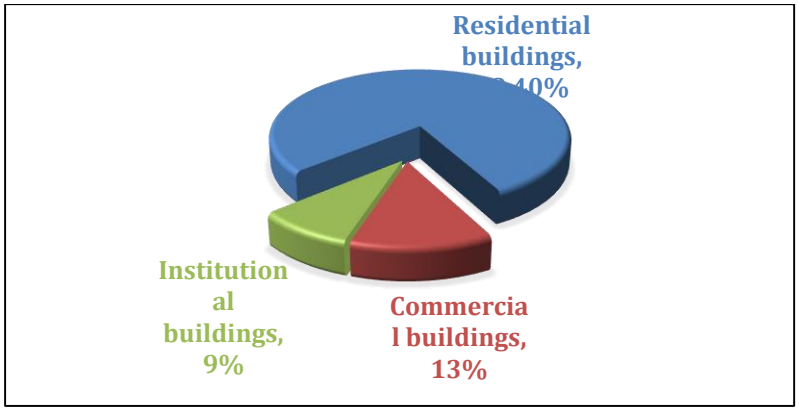


Figure 6: Classification of Building Collapse in Lagos Based on Usage.

Today, Cities like Lagos, Abuja and Port-Harcourt have become forerunners in reported cases of Building collapse when CONCRETE, reinforced or unreinforced, has turned to be man's enemy. The reported reasons for some of the occurrences include but not limited to the following: Defective Design, Defective Construction, **Use of Substandard/poor quality Materials,** Absence of Building or Planning Permit, Corruption, Non-adherence to approved Building plans, **Absence of proper site and soil (geotechnical) investigation**, Engagement of inexperienced personnel to take charge of design and construction works, Engagement of ill-equipped and incompetent contractors, lack of proper supervision, inspection and monitoring of construction works, illegal conversion, alterations and additions to existing structures and lastly, undue interference of clients on Building works.

Madam Vice Chancellor, Members of Management of our great University, distinguished ladies and gentlemen, in all these categories of building collapses that we have talked about in which concrete, being the main building material, has turned out to be our foe instead of being our friend, it is observed that during year 2009, 2010, 2011, 2013, 2014, 2016 and 2019, the number of building collapses that we have on record exceeds 20 for each of the years mentioned (Fig. 1). Not only that,

South-Western Nigeria, where we have Lagos, tends to claim about 34.5% of all the building collapses recorded in that period. Furthermore, the most common are usually 2-story, 3-story, and 4-story buildings. Collapse records indicate that the greater percentage of collapses recorded is attributed to structural defects. **This is followed by the "use of substandard and poor-quality materials" (Fig. 2).** In building collapses with high fatalities, the sub-standard or poor-quality material is usually CONCRETE. Although there are conflicting figures in Nigeria on the number of occurrences of Building Collapses in the country, the fact remains that we have a high rate of occurrence in which many lives and properties are lost.

In view, the knowledge of the material called **CONCRETE** becomes very important in our quest to find measures to mitigate building collapse in Nigeria. God, in Genesis 1: 26-28 declared that he has given us (Man) dominion over everything on earth (living and nonliving). But we cannot have dominion without knowledge! The Bible in Proverb 24:5 says "A Wise Man Is Strong; A Man of Knowledge Increaseth (in) Strength". Addressing the World Bank Conference in 1997, the UN Secretary General (1997-2006) KOFI ANNAN said "Knowledge is POWER, Information is Liberating". Education is the Premise of Progress in Every Society, In Every Family". Benjamin Carson, an American Neurosurgeon posited thus "I am convinced that Knowledge is Power - To overcome the Past, to change our own situation, to fight new obstacles, to make better decisions".

Apart from the lack of knowledge of the material called concrete, tied to the issue of structural defects, is of course, the geotechnical investigation of site reports; that is soil test reports because, as noted by Oyenuga (7) if the structural design is good, if structural considerations/decisions are good enough to sustain the building or infrastructure, then, the geotechnical report for determination and construction of the foundation becomes very vital because any error in the report could result in the future collapse of the infrastructure - the building. Ironically, Nigerians are willing and always ready to spend hundreds of millions for building construction and aesthetics of buildings

but are very unwilling and reluctant to spend a couple of millions to execute quality geotechnical tests. This undermines the fact that any major error in geotechnical reporting could result in the total collapse of the structure during construction or later. We have seen this happen on many sites in Lagos.

Madam Vice Chancellor, in a lighter mood, permit me to note here that every Nigerian presents himself or herself as a civil/structural engineer on matters relating to materials and structures; we all present ourselves as builders when we lack technical know-how and expertise in these areas of human endeavours. I agree that everyone here is a developer because, at one time or another, we aspire to build our own homes or houses through a direct labour approach to be 'supervised' by us. This does not mean that that is the right way to go or to get things done!

To mitigate against the challenges that may arise from the aforesaid, it is considered important and expedient for us ALL to understand the material called CONCRETE as this is the main material, we all engage in putting up structures all around us. Madam Vice Chancellor, at this juncture, it is indeed a pleasure to talk to you and the audience about the concrete that we deploy and use on construction sites daily.

6.0 WHAT IS CONCRETE?

CONCRETE is an artificial conglomerate, artificial material or artificial stone made essentially of Portland Cement (Binder), Aggregates (Coarse & Fine), water and admixture. It is an artificial stone-like mass, the composite material that is created by mixing binding material (cement or lime) with aggregates (sand, gravel, stone, brick chips, etc.), water, admixtures, etc. in specific proportions in order to get the desired strength. **We can have concrete without fine or coarse aggregates and also, without admixture; but we cannot have concrete without binder and water. The strength and quality of concrete are dependent on the mixing proportions as well as the qualities of the parent materials.**

Concrete = Binding Material + Fine & Coarse Aggregate + Water + Admixture (optional)

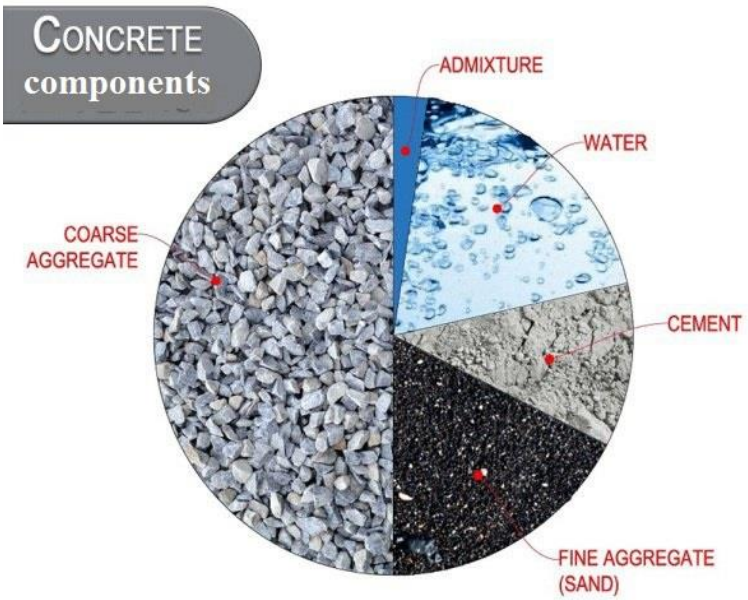


Figure 7: Composition of concrete. [22]

Once all the ingredients -cement, aggregates, and water are mixed in the required proportions, the cement and water begin a reaction (hydration process) with one another, transforming the plastic mass into a hardened mass.

Figure 8: Plastic Concrete [20]

Figure 9: Concrete Test Specimen [21]

Concrete is powerful, easy to create, and can be formed into varied shapes and sizes. Besides that, it is reasonably low cost, and instantly mixed. It is designed to allow reliable and high-quality fast-track construction. Structures designed with concrete are many. Concrete structures can be designed and constructed to be durable. They can be designed to face up to earthquakes, hurricanes, typhoons, and tornadoes.

Water is required to instigate chemical reactions with the cement (hydration) and to supply workability properties to the concrete. The ratio of the quantity of water that combines with the quantity of cement is named the water/cement ratio. The lower the w/c ratio, the stronger the concrete. (Higher strength, less permeability)

6.1 Types of Concrete

Concrete is employed for various projects starting from little home construction to large field buildings and structures. It is used for sidewalks, basements, floors, walls, columns (pillars); and other several alternative uses. Many types of concrete are utilised in the development works.

Based on the variations in concrete materials and purposes, concrete can be classified into three basic categories namely, Lime Concrete, cement concrete or Reinforced Cement Concretes.

Based on the production method of the concrete, we could have Dry Ready Mix, Ready Mix, Bulk Dry Materials and Transit Mix Concretes. There are other various types of concrete for different applications that are created by changing the mix proportions of the main ingredients. These are:

- Regular (Normal) Concrete
- No Coarse Aggregate Concrete
- No Fine Aggregate
- High-strength Concrete
- Stamped Concrete
- High-Performance Concrete
- Self-consolidating Concretes
- Vacuum Concrete
- Shotcrete
- Roller-Compacted Concrete
- Glass Concrete
- Asphalt Concrete
- Rapid Strength Concrete
- Polymer Concrete
- Limecrete
- Light-Transmitting Concrete
- Gas Concrete
- Foamed Aerated Concrete
- Aerated Concrete

The most common type used is **regular normal concrete** which is referred to as traditional normal weight concrete or traditional strength

concrete. This is the all-purpose concrete that is used generally for construction.

Madam Vice Chancellor, each component that makes up concrete has its importance in the outcome of the quality of concrete. It is not enough to say that you mix the three major components and add water. We must understand the part that each parent material will play in getting the right concrete quality that will give the desired target strength. **In Nigeria today, all sorts of materials are mixed to give concrete**. Now, the binder is usually Portland cement. It comes under different brand names. There is not much problem with the binder. Although there are little differences in their qualities when used, and depending on the season, you get different results relative to time. When it is hot, there are brands of cement that if used for rendering and plate-like structural elements (slabs), give cracks all over which is not desirable.

There are periods in the year that you will be praying for your concrete to harden in good time or early. But that is not the major problem with concrete. What constitutes a major problem of concrete comes with the water we use in preparing the material as well as the quality of both coarse and fine aggregates. Thereafter, we consider the mix ratio to get the target strength for the purpose we are considering. In other words, the quality of the parent materials and water for mixing, largely determine the quality of concrete we get; both in the short and long term.

6.2 Water for Concrete Production

When water is mixed with cement, we get a paste. When the paste surrounds all the individual aggregates to give a plastic mixture that results in CONCRETE in the initial plastic state, which later hardens. The level of plasticity to be allowed for concrete becomes very important in the scheme of events. Please, note that what makes the concrete plastic is the quantity of available moisture in the mix. That moisture is water, and that water must be potable. It must be water that you can easily drink. Of course, there are chemicals in water, they must be within acceptable limits else, they become injurious to the concrete.

Ikponmwosa *et. al.* [13], investigated the effect of water sources on some engineering properties of concrete with the Lagos metropolis as a case study. The investigation critically appraised sources of water used in concrete production as one of the likely causes of building collapse in Lagos City. The water samples used for the research work were obtained from the following sources and labelled as follows: Unilag tap water (Control), **sample A.** Borehole water from Surulere, **sample B**. Unilag lagoon water, **sample C**. Well water from Ajegunle, **sample D**. Borehole water from Iwaya, **sample E**. Well water from Agege, **sample F**. Borehole water from Abraham Adesanya, **sample G**. Concrete with a mix proportion of 1:2:4 at w/c ratio of 0.55 was adopted for the study. For each mix of water, 15 cubes (150mm x 150mm x 150mm) and 10 cylinders (300mm x 150mm diameter) were cast and tested.

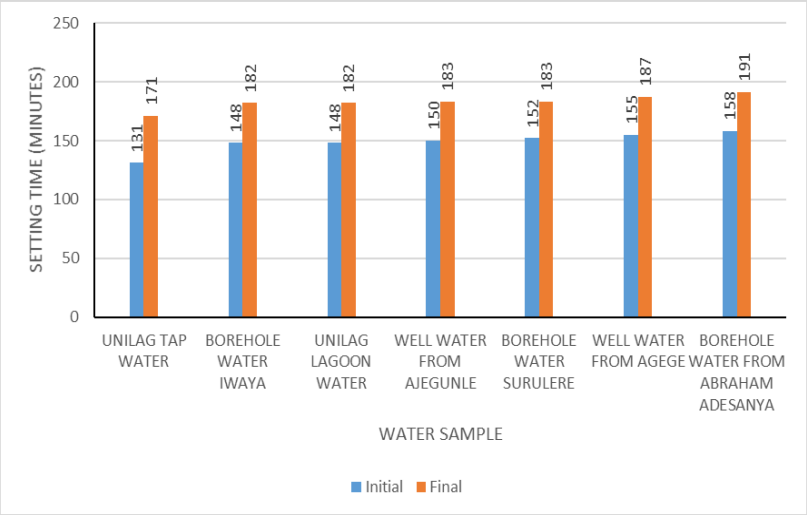


Figure 10. Setting time with different water samples (Ikponmwosa *et. al.,* 13)

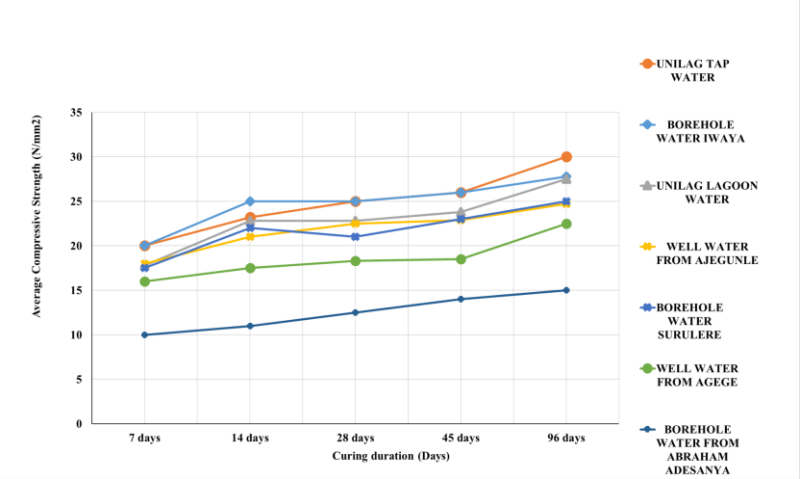


Figure 11: Variation of average compressive strength with different water samples at different curing ages (Ikponmwosa *et. al.,* 13)

All cubes and cylinders were tested in the laboratory at five curing days- 7, 14, 28, 45 and 96 days. The performance of six sources of water obtained from Lagos municipality on some engineering properties i.e., setting times of cement paste, compressive strength and split tensile strength of concrete were checked in the laboratory and compared with controlled specimens that were made with tap water as mixing and curing water.

The study revealed that the physical and chemical properties of water vary depending upon place, time, environment, exposure, and storage duration. The physical and chemical compositions of water react differently with different constituents of concrete. These reactions mostly affect the setting time of cement paste, compressive strength, and split tensile strength of concrete, some favourably while others unfavourably.

It was observed that the initial and final setting time of cement paste were found to be within the prescribed limits of (BSI-1978 and BS 4550) despite the type of water source. However, the setting time of the Ordinary Portland cement varied with the type of water mix. Unilag tap

water (potable water) has the least initial and final setting times of 131 and 171 minutes, respectively, while borehole water from Abraham Adesanya (non-potable water) recorded the highest initial and final setting times of 158 and 191 minutes, respectively.

It was observed that the compressive strength increased with an increase in curing age when mixed with all test waters. Based on compressive strength analysis, water from the Unilag tap (controlled) recorded the highest value while borehole water from Abraham Adesanya recorded the lowest after 96 days of curing. Furthermore, the results showed that concrete made with non-potable water from the borehole at Iwaya, Unilag lagoon, well water from Ajegunle, borehole water from Surulere, well water from Agege and borehole water from Abraham Adesanya have 7- and 28 – day compressive strength equal to 99.6% & 99%, 92% & 91%; 90% & 88%, 88% & 85%, 79% & 73% and 51% & 50% of the strength of controlled specimens made with Unilag tap water respectively. This implies that only water from Iwaya borehole and Unilag lagoon met the prescribed limit for 7- and 28-day compressive strength (90% of the controlled specimens). This is an indication that the use of non-potable water yields lower compressive strength in comparison to concrete made with potable water.

Madam Vice Chancellor, many sources of water that are untreated in the coastal areas are not good enough for concrete production; yet we regularly use the water without treatment. When concrete is prepared with non-potable untreated water, during the hydration process, the gaining of strength is hindered. Therefore, if we use contaminated water, our concrete will not gain adequate strength as expected.

Secondly, if we use too much water in our concrete, it will also not gain adequate strength as excess water in the mix creates other challenges for concrete. Several problems can occur in concrete due to improper mixing, curing, and placing. One such problem is “bleeding”. **BLEEDING** in concrete is a phenomenon in which free water in the mix rises to the surface and forms a paste of cement on the surface known as “laitance”. Bleeding occurs in concrete when coarse aggregates tend

to settle down and free water rises to the surface. This upward movement of water while traversing from bottom to top, makes continuous channels. If the water-cement ratio used is 0.6 or more, the bleeding channel will remain continuous. These continuous bleeding channels are often responsible for permeability in the concrete structure. **In the process of upward movement, the water accumulates below the aggregates, creates water voids, and reduces the bond between the aggregates and paste.** Similarly, the water that accumulates below the reinforcing bars reduces the bond between the reinforcement and concrete. The process of bleeding is a normal phenomenon if it occurs at a normal rate but can create a weakening of bonds if occurs at a high rate. Bleeding is a type of segregation, in which water comes out of concrete. Segregation is the cause of bleeding in the concrete mix. Segregation is the phenomenon in which heavy aggregate particles settle down, due to the settling of heavy particles, water rises to the surface and forms a layer. This upward movement of water also carries fine particles of cement with it. The top surface of slabs and pavements will not have good wearing quality. Bleeding will be more frequent on the surface of concrete when water-to-cement ratio is higher. Furthermore, the type of cement used and the quantity of fine aggregate also play a key role in the rate of bleeding. Due to bleeding, concrete also loses its homogeneity. Due to bleeding, the pumping ability of concrete is reduced. It also increases the water-cement ratio at the top. The accumulation of water at the top, results in delayed surface finishing.

The best solution to bleeding is the use of a low water/binder ratio of not more than 0.45, use of chemical admixtures to reduce demand for water for a required workability as well as proper mix design and compaction of concrete.

Figure 12: Bleeding of Concrete [14]

Madam Vice Chancellor, another important phenomenon that occurs with concrete having excess water is shrinkage. Concrete shrinkage is the decrease in length or volume of concrete caused by changes in moisture content or chemical reactions. All types of concrete undergo shrinkage, and there are five categories of shrinkage seen in concrete: Drying Shrinkage, Carbonation Shrinkage, Chemical Shrinkage, Plastic

Shrinkage, and Autogenous Shrinkage. Drying shrinkage is the significant shrinkage mechanism in most concrete. Moisture lost during drying shrinkage is evaporated into the environment as the concrete dries out, and if not properly managed, it can lead to wide joint openings, cracking from internal stresses, and slab curling. Drying shrinkage is largely dependent on the water/cement ratio. However, it is most effectively managed by designing the volumetric ratio of paste-to-aggregate instead of the water-to-cement ratio. This approach is because of shrinkage occurring in the paste rather than in the aggregate. If shrinkage is a concern, especially during the dry season, consider the use of a low-shrinkage concrete or shrinkage compensating admixture. It is most effective to specify a maximum 28-day length change according to ASTM C157, “Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.” [19] At 28 days of age, the length change of a typical concrete due to shrinkage is about 0.06 per cent or greater. According to ACI 360 [18], “Design of Slab on Grade,” the length change of low shrinkage mixtures is 0.052 per cent or less. Specifications routinely require 28-day shrinkage to be below 0.04 per cent to reduce the risk of shrinkage-related defects.

While the knowledge of different types of shrinkage is not harmful in any way, the most important to us at this inaugural lecture is the drying shrinkage.

Plastic shrinkage develops on the surface of the fresh concrete. It is a consequence of water evaporation from the surface of fresh concrete or absorption in the concrete form or bedding. It is a contraction in volume due to water movement from the concrete while still in the plastic state, or before it sets. This movement of water can be during the hydration process or from the environmental conditions leading to the evaporation of water that resides on the surface of the wet concrete. So, the more the concrete bleeds, the greater the plastic shrinkage should be. It is proportional to cement content and, therefore, inversely proportional to the w/c ratio.

Carbonation shrinkage occurs in hardened concrete. CO_2 (carbon dioxide) from the environment on cement stone causes chemical reactions. This leads to the formation of calcium carbonate and water and, consequently, a reduction in volume. It is observed in areas that have intermediate humidity conditions.

Chemical shrinkage occurs due to a decrease of volume cement paste occurring due to the chemical binding of water in the process of cement hydration. Thermal shrinkage is caused by the contraction of the movement of concrete. Seasonal variations in temperature could lead to the cracking of concrete that can cause because of the thermal contraction in the concrete. These types of shrinkages can be prevented or controlled using shrinkage-compensating admixture and reducing agents.

Autogenous shrinkage occurs after the initial setting of concrete due to hydration since this process requires water and therefore reduces the internal free water. It is caused because of a self-desiccation process in the pores of cement stone, that is, the use of water during the cement hydration processes.

When bleeding and shrinkage occur, it is an indication of excess moisture in the hydration process. Therefore, for everyone here present, this lecture as delivered above is to make us understand the importance of water in making concrete.

6.3 Compounds of Cement

Madam Vice Chancellor, for us to understand some of the properties of concrete, there is a need to know the chemical compounds in the binder (Portland Cement paste) and the important role being played by the compounds in concrete.

The main compounds in cement are **tricalcium silicate, dicalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite**. These compounds determine most of the cement properties but also react with water to produce new materials (through cement hydration)

and consequently are responsible for concrete strength. **Tricalcium silicate hydrates and hardens rapidly, hence generating heat greatly, whereas hydration of the other three compounds is slow and consequently heat of hydration would be much lower.** Generally, tricalcium silicate and dicalcium silicate provide most of the concrete strength but the contribution of tricalcium aluminate and tetracalcium alumino ferrite to the concrete strength is considerably low both at early strength and at ultimate strength. It is worth mentioning that tricalcium silicate is the only compound that provides high early strength to concrete.

The chemical formula for Tricalcium silicate (C_3S) and Dicalcium silicate (C_2S) are $3CaO.SiO_2$ and $2CaO.SiO_2$, respectively. These two silicates, namely C_3S and C_2S, control most of the strength-giving properties.

Table 3. Compounds of Cement. Source: https://theconstructor.org/concrete/compounds-cement-strength/5170/

Component elements	O_2		Si	Ca	Al	Fe
	↓					
Component oxides	CaO		SiO_2	Al_2O_3	Fe_2O_3	
	↓					
Cement compounds	C_3S		C_2S	C_3A	C_4AF	
	↓					
Portland cements		Various types				
	↓					
Hydration products		C-S-H gel		$Ca(OH)_2$		

Upon hydration, both C_3S and C_2S give the same product called calcium silicate hydrate ($C_3S_2H_3$) and calcium hydroxide. Tricalcium silicate (C_3S), giving a faster rate of reaction accompanied by greater heat evolution develops early strength. On the other hand, dicalcium silicate (C_2S) hydrates and hardens slowly and provides much of the ultimate strength. It is likely that both C_3S and C_2S phases contribute equally to the ultimate strength of cement/concrete as can be seen in Fig. 13.

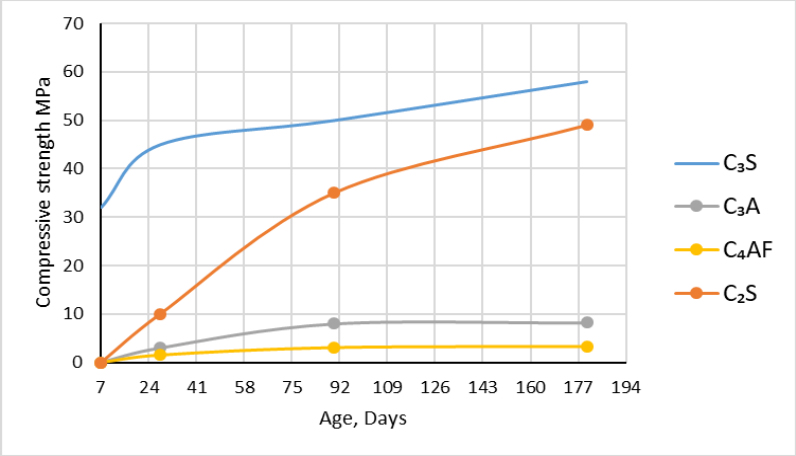


Figure 13: Contribution of Cement Compounds to the Strength of Cement [15]

C_3S and C_2S need approximately 24 and 21 per cent water by weight, respectively for chemical reactions but C_3S liberates nearly 3 times as much calcium hydroxide in chemical reaction as C_2S. However, C_2S provides more resistance to chemical attack. That is why a higher percentage of C_3S results in rapid hardening with an early gain in strength at a higher heat of hydration.

On the other hand, a higher percentage of C_2S results in slow hardening, less heat of hydration and greater resistance to chemical attack. The C_2S is responsible for concrete strength beyond 7 days of age.

The chemical formula of tricalcium aluminate (C_3A) and tetracalcium alumino ferrite (C_4AF) are $3CaO.Al_2O_3$ and $4CaO.Al_2O_3Fe_2O_3$, respectively. The compound tricalcium aluminate (C_3A) is characteristically fast reacting with water and may lead to an immediate stiffening of paste and this process is termed flash set.

The role of gypsum added in the manufacture of cement is to prevent such a fast reaction. C_3A reacts with 40 per cent of water by mass, and this is more than that required for silicates. However, since the amount

of C_3A in cement is comparatively small, the net water required for the hydration of cement is not substantially affected. It provides weak resistance against sulphate attack and its contribution to the development of strength of cement is perhaps less significant. Tetracalcium alumino ferrite hydrates rapidly but contributes little to concrete strength.

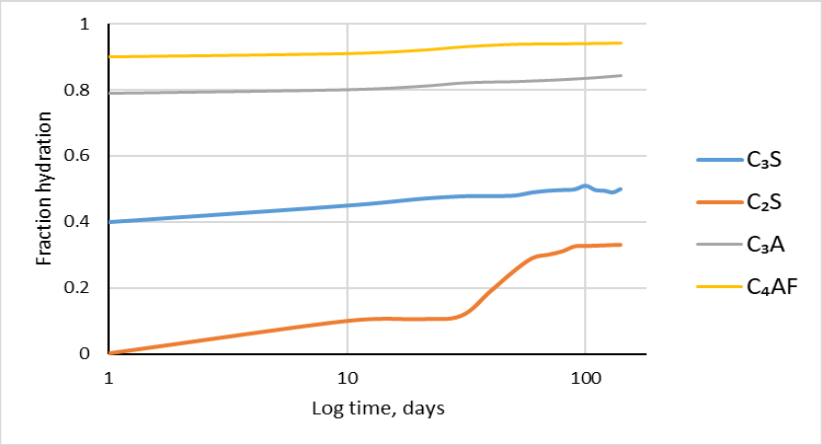


Fig. 14: Rate of Hydration of Pure Cement Compound
Source: https://theconstructor.org/concrete/compounds-cement-strength/5170/

Table 4 Percentage by Mass of Each Compound in Cement

Compound	Percentage by mass in cement
C_3S	30 to 50
C_2S	20 to 45
C_3A	8 to 12
C_4AF	6 to 10

Table 5 Contribution of Different Compounds in Cement to Concrete's Early and Ultimate Strength

Cementing Value	C_3S	C_2S	C_3A	C_4AF
Early	Good	Low	Low	Low
Ultimate	Good	Good	Low	Low

In practical terms for our day-to-day concreting jobs/activities, depending on the season and weather conditions, the minimum w/c ratio of about 0.3 by weight is necessary to ensure that water comes in contact with all cement particles, assuming concrete hydration is the only challenge to be resolved. However, at this level of water/cement ratio, the concrete is less workable. Hence, we need to assist the workability by introducing air-entraining admixture or by increasing the w/c ratio; being mindful of the slump value of the mix. For most concreting jobs, typical w/c ratio values of 0.4 to 0.6 are adopted. When the water-cement ratio is not in excess, you have increased strength and low permeability; that means low pore content in your concrete. You have increased weather resistance, better bond strength between concrete and reinforcement, reduced shrinkage and cracking and less volume change from wetting and drying.

6.4 Effect of Coarse Aggregate Sizes on Concrete Strength

In our quest to develop High-Performance Concrete Using Local Materials through Optimisation of Mix Design, the Inaugural Lecturer with his team of researchers investigated the effect of particle size distribution of coarse aggregates and w/c ratio on the strength parameters of concrete. (Ikponmwosa *et. al*., [16].).

Twelve different concrete mixes were prepared and coded as S1 to S12. All mixes had a baseline mix ratio of 1:1:2 and the same cement content, while aggregate sizes were varied and combined in different proportions. For each of the mix, water-cement ratios of 0.3, 0.35 and 0.4 were used separately. The samples were further grouped into four (A to D), depending on the content of the aggregates. For instance, concrete Sample S1 represents concrete containing 10 mm size aggregate with a w/c of 0.3, while Sample Group A indicates concrete samples that contain 10 mm size aggregate irrespective of the value of w/c ratio. Table 5 shows the details of the sample classification and their designation.

In each mix, Conplast SP430 was added at a rate of 0.5 litres/50 kg of cement. The choice of dosage was based on the manufacturer's recommendation. Each concrete mix was cast in the steel mould of size 150 x 150 x 150 mm for the compressive strength test, while a cylinder mould of diameter 150 mm and height 300mm was used for the tensile strength test. The fine aggregate used could be classified as well graded as its coefficient of uniformity (Cu) was 2.43, while curvature (Cc) was 0.84 and they were within the recommended boundaries [22]. The fine aggregate used could be classified as well graded as its coefficient of uniformity (Cu) was 2.43, while curvature (Cc) was 0.84 and they were within the recommended boundaries [22]. In each case, the fresh concrete was left in the mould for 24 hours and demoulded. The concrete samples were weighed and cured in water (by immersion) for 7, 14, 21, 28, 45 and 90 days.

Table 5. Design Mix for High Performance Concrete Source: (Ikponmwosa et. al., [16])

Concrete Mix Code Name	Aggregate Size (mm) (% Proportion)	w/c Ratio	Sample Group
S1	10 (100%)	0.30	A
S2		0.35	
S3		0.40	
S4	10 (25%)	0.30	B
S5	12 (50%)	0.35	
S6	15(25%)	0.40	
S7	10 (25%)	0.30	C
S8	12 (25%)	0.35	
S9	15 (25%)	0.40	
	19 (25%)		
S10	10 (25%)	0.30	D
S11	12 (25%)	0.35	
S12	15 (50%)	0.40	

There were differences in the moisture content and dry density of the aggregates. This may be due to the difference in their grain sizes, which make their surface areas to also differ. Figure 15 shows the effect of the w/c ratio on the workability of the concrete mixes.

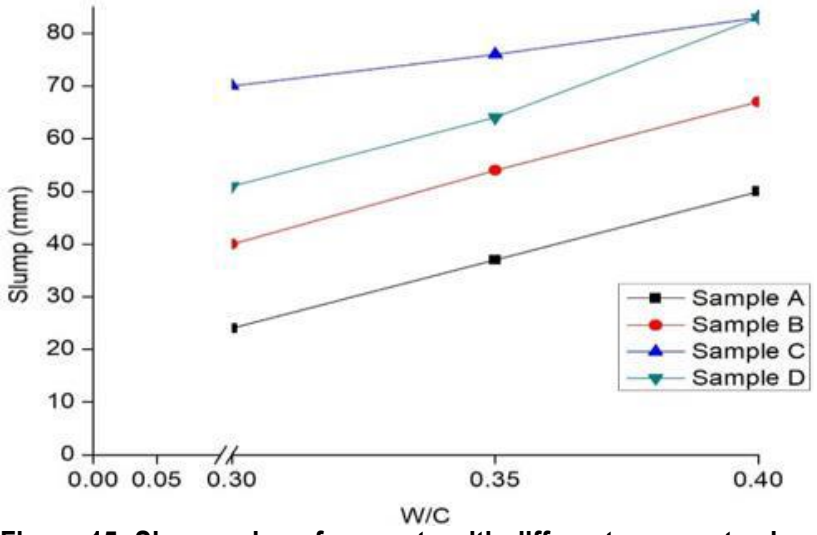


Figure 15: Slump value of concrete with different aggregate sizes at various water-cement ratio (Ikponmwosa *et. al.* [16])

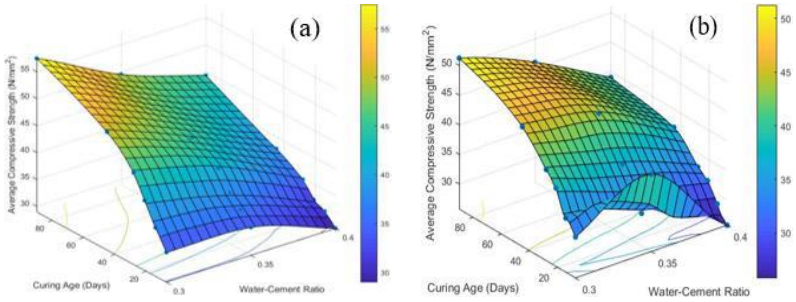
It shows that the slump value increased with an increase in water content for all the mixes. This observation is similar to what Vardhan et al., (2018) reported in their work. The pattern was that about 50% slump was gained, when the w/c ratio increased from 0.3 to 0.35 for concrete sample A, while it was increased by 35% and 25% for Samples B and D. For Sample C, there was a slight increase (about 8%) in the slump as the w/c increased to 0.35. A similar trend was observed when the w/c increased from 0.35 to 0.4 for all the samples.

Considering the effect of aggregate size on the slump, there was a significant influence of the aggregate size and combination of aggregates on the workability. Concrete specimen that contained smallest aggregate sizes of 10 mm only (Sample A) had the lowest slump value at all the w/c ratios, while Sample C (a combination of

aggregates sizes of 10, 12, 15 and 19mm) had the highest slump values at 0.3 and 0.35 w/c ratios and had equal slump value of 83 mm with Sample D at w/c of 0.4. What could be attributed to these trends is the variation in the particle sizes of the samples.

Effect of water-cement ratio on the strength properties

Figures 16 & 17 show the effect of w/c on the compressive strength of the concrete mixes at different ages. It was observed that the compressive strength of concrete was reduced with an increase in the water-cement ratio for all the mixes and at all ages. For concrete Sample A, compressive strength with w/c of 0.3 had a strength of about 17% and 25% higher than the strength of concrete with w/c of 0.35 and 0.4, respectively at 28 days. Similarly, at the same age of 28 days and for concrete Samples B, the strength increased by 10 and 26%, when w/c increased from 0.3 to 0.35 and 0.4 respectively. As for Samples C, the corresponding increase in strength was 5% when w/c increased to 0.35 and 10% at w/c of 0.4. But for Sample D, the increase in strength was about 10% at w/c with 0.35 and 32% at w/c of 0.4. It is observed that the percentage increase varied with each sample of concrete, indicating that aggregate content also has an attendant effect on the compressive strength. The same trend is observed in the flexural strength as well as tensile strength. At 28 days for concrete Sample A, when w/c increased from 0.3 to 0.35, the flexural strength decreased from 9.78 N/mm2 to 8.89 N/mm2 representing a 10% reduction.



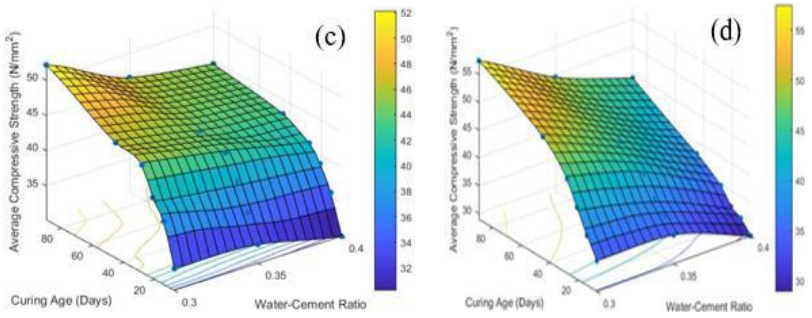


Figure 16: Compressive strength at different w/c ratios for (a) Sample A (b) Sample B (c) Sample C and (d) Sample D (Ikponmwosa et. al., [16])

A further increase in w/c to 0.4 also brought about a 24% reduction in flexural strength. These results further showed that water content in concrete influences the strength development of concrete when the pore size within the concrete matrix is increased as reported by Kim *et. al*. [17]. However, there is a limit to which w/c ratio can be lowered because the decrease in w/c could lead to concrete being less workable (Figure 15) and could cause honeycomb in the hardened concrete, posing durability challenges. Thus, there is a need to strike a balance between strength and workability. Definitely, in the absence of a superplasticizer, concrete made with w/c 0.3 to 0.4 will not be workable. However, in the presence of a superplasticizer, workable concrete can be achieved, while increased strength is obtained. From these results, a w/c ratio of 0.3 would be appropriate for all the concrete samples under investigation.

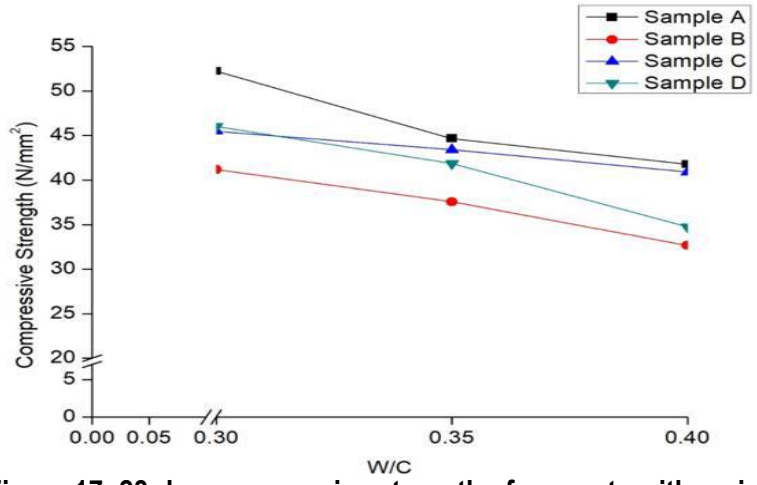


Figure 17: 28-day compressive strength of concrete with varied aggregate sizes (Ikponmwosa et. al., [16])

As observed earlier, the strength reduced with an increase in the w/c ratio for all the concrete samples, irrespective of the aggregate size. Figure 17 (28-day strength) however, shows that aggregate sizes also influenced the trend of compressive strength, similar to what was obtained with different ages. It was that, compared to concrete with varying aggregate sizes, higher strengths were recorded for concrete with having lower aggregate size of 10 mm (Sample A) For instance, at 0.3 w/c (equally for other w/c ratios), Sample A had strength which was about 126% higher than that of Sample B and 114% and 113% higher than the strength of concrete Samples C and D, respectively. However, there is a tendency to use more cement paste due to the relatively higher surface area occasioned by the relatively small size of the aggregate.

In summary, the results of this investigation revealed that slump value increased with an increase in w/c ratio, while the concrete with 100% 10 mm particle size coarse aggregate had a minimum slump of 24, 37, and 50 mm at w/c of 0.3, 0.35 and 0.4 respectively, but higher slump values of 70, 76 and 83 mm were obtained with concrete containing larger particle sizes combination i.e. 25% of each of 10, 12, 15 and 19

mm sizes. However, strengths were reduced with an increase in w/c and aggregate particle sizes.

6.5 Curing of Concrete

Another very important aspect that we must not overlook is the issue of the curing of concrete. Virtually for all construction works that every one of us is involved in, we don't think about curing concrete. In fact, the only curing method we tend to practice is the AIR Curing method. This is not sufficient an approach in concreting. We must put in place and practice sustainable curing procedures that will enable the concrete to retain its moisture during the hydration and strength-gaining period. The season and timing of concreting works; the temperature, humidity of the environment as well as the quality of the concrete being handled will go a long way in determining the method and extent of curing due to evaporation. Generally, the purpose of curing concrete is to mitigate against undesirable moisture loss due to evaporation in the concrete during the hydration process and not allow for the occurrence of cracks, which is not desirable; especially in plate-like structural elements like slabs. Therefore, it is important to consider and think seriously about the curing process during concreting works as the procedure, when properly done, helps concrete to gain strength properly at the early stage of its life; especially when exposed to outdoor conditions.

In concrete technology, the design strength is taken as 28-day strength of cube and cylinder test specimens. Over the years, experimental investigations have shown that the 7-day strength of concrete hovers between 67% to about 70% of the 28-day strength which is about 95% of the total strength expected of the concrete in its lifespan before it starts to lose strength due to usage and environmental factors. During the first week, 7 to 10 days of curing, it is important that the concrete should not be permitted to freeze or dry out as this will affect the strength-gaining process. In real terms, the concrete strength at all ages is dependent on the quality and proportion of the ingredients as well as the curing environment.

6.6 Concrete Placement - Pumping

Another important factor that affects the quality of our concrete is the method of placement of concrete in formworks/position. Recently, due to the introduction of technological innovations, we now pump concrete into its final 'resting' place. We pump to place concrete at heights. If you are handling piling, we pump concrete to depths. On restricted sites, we pump concrete. When concrete is prepared with 0.3, 0.4 and 0.5 w/c ratio, extra work is required to be done to place concrete in position. Unfortunately, most concrete pumping machines available for leasing are old and weak to pump well prepared concrete mix as they are required to do extra work to be able to pump well mixed concrete. This has led many companies to use small sized (⅜ ins. or less than 10mm) coarse aggregates as well as a 0.7+ w/c ratio. The use of a 0.7+ w/c ratio instead of air entraining admixture usually works against strength development of such concrete. The air-entraining admixture will improve the workability of the concrete but not at the expense of strength gains. Likewise, the use of excessively small sized coarse aggregates increases the surface area that is to be 'lubricated' by the cement slurry/mortar. In view, there is a need to compensate for that by adding more binder material to the mix. This is a very common challenge with CFA piling machines. Furthermore, in piling, to avoid segregation in concrete, the material is fed into the bored shafts by the tremie method – a bottom-up procedure.

Madam Vice Chancellor, basically, for all general-purpose construction activities that we may be involved in, it is advised and highly desirable that we use an all-in-aggregate of 8mm-19mm grade. Concrete produced with such aggregate, having the right w/c ratio and well-designed mix proportion, if well compacted, will always give the desired target strength. If the aggregate is monograde and big, there will be a high possibility of having voids in the structure after compactions as the big particles of coarse aggregates cannot close up all the voids. We may also have segregation if we use a high w/c ratio to prepare the mix. All-in aggregates tend to close up the gaps that may be left between the bigger particles and help to densify the concrete on compaction as the aggregates are more closely bonded. In the process of carrying out the

appropriate concrete mix, slump tests become important. The average value of slump should be within 75mm. When we have a collapsed slump for a mix that is not aided with air entraining agent, it means we have excess water. And when we have excess water, it means the concrete product is not likely to develop the desired target strength.

Slump test is a good indicator of the water content in concrete mix, and this helps to evaluate workability in concrete. Please, note that most good concrete mixes have slump values between 50mm and about 100mm. In the dry and hot weather, we may have a 125mm slump to enable the concrete to be placed and compacted before it starts losing water. Once a good slump value is recorded, this is followed by a good compaction or consolidation exercise in order to have a well densified, well compacted concrete.

As studies have shown, after structural design errors/defects, the deployment and use of sub-standard/poor-quality materials on sites for the construction of infrastructure are said to be the next most critical reason for the collapse of infrastructure in Nigeria. Therefore, it is important that we all learn to understand the material called **"CONCRETE"** and relate to it appropriately. The lack of knowledge and gross abuse of the material in construction is responsible for the unacceptable high collapse rate of concrete structures in the country. In the construction industry, concrete is the most abused construction material. We need to learn to treat it with the respect that it deserves. Coupled with this are the challenges associated with knowledge of geotechnical investigation and foundation engineering.

7.0 GEOTECHNICAL INVESTIGATION AND FOUNDATION ENGINEERING

It is sad to note that generally, Nigerians don't believe in soil tests. We are willing to spend a lot on the superstructure but next to nothing on Geotechnical Investigation and foundation construction. It is only a purely geotechnical engineer or a geotechnical engineering-biased structural engineer that can comfortably and appropriately determine the bearing (load carrying) capacities of founding natural bases

(foundation soils) of structures. In order to diligently determine the bearing capacities of soils, we require artisan-drillers to help extract soil samples at different predetermined depth intervals to appreciable depths in the ground where we encounter appropriate foundation founding layers. Recent events have shown that Artisan-Drillers should be closely monitored as many have been found wanting and dishonest in the discharge of their professional responsibilities.

Also, taking into consideration the leading role that Lagos State plays in respect of this matter and considering the general terrain of the state, it is hereby strongly advised/advocated that the section of LABCA regulations 2019 [36] [37], which tends to suggest that Sub-Soil Investigation Report is only required "In the case of structures above four (4) floors and all developments in areas with low bearing capacity soils" be modified. **ALL BUILDINGS AND CIVIL INFRASTRUCTURE,** irrespective of their suspected locations, require geotechnical sub-soil investigation reports. There should be a sub-soil geotechnical investigation report for design and a confirmatory sub-soil investigation report prior to the commencement of construction. The two should be independently carried out by different teams of experts. Furthermore, ideally, the number of boreholes on building sites for geotechnical investigation should not be less than two (2) as soil stratification can vary considerably within short length intervals. Adequately comprehensive sites' geotechnical sub-soil investigation and reporting is very important because, when natural foundation (soil) breathes, the superstructure becomes stressed and/or distressed. When the foundation breathes excessively, the superstructure may experience total collapse or ultimate failure. That is the situation we have today when concrete has turned to be our foe, instead of being our friend.

For infrastructural development, the tasks of checking disasters, the tasks of ensuring that concrete remains our friend rather than our enemy start from the beginning, which is geotechnics (sub-soil) investigation. All infrastructure that requires soil tests must have appropriate soil test reports. It is also desirable that all soil test reports should carry full information on the identity of all personnel involved in

the work, including the artisans and the drillers. It is not just about Engineers alone. The artisans and drillers should be registered by the government in order to check their activities in practice.

Madam Vice Chancellor, whatever situation we seem to have found ourselves today in respect of the subject matter, that has always been our choice because we don't like doing things the right way and oftentimes, we like to cut corners in all construction site operations. So, the spate of infrastructural collapses in Nigeria is indeed the choice we have made.

8.0 MATERIALS TESTING AND CONTROL

Although no legislation enforces people to carry out preliminary and regular tests on parent materials for concrete production, however, it is expedient that such materials for concrete production be tested regularly. Likewise, there are no laws that empower people and test centres to report to any government agency if tested concrete specimens fail or fall below standard. In view, it is hereby opined that the situation be reviewed by the government; both at state and federal levels.

To this end, it is hereby suggested that an agency, more legally empowered than the Materials testing agency, be set up in each state of the Federation and the Federal Capital territory. The Agencies will register ALL testing laboratories in their respective domains. All testing laboratories by law should be mandated on a weekly basis to file-in reports/results of tests conducted during the past week at a pocket-friendly fee for effective quality control and monitoring. If there is no law that mandates the test centres to report, to file such reports or to file results of tests at designated agencies, we will continue to record instances when concrete will turn out to be our foe rather than our friend. Also, the results should be made available online for the public to access for their participation in the control process. If we had an enhanced process like this in place, this could have helped check the Fourscore disaster that claimed over 45 lives in 2021, which included two of our former students in Civil and Environmental Engineering

Department. **May their souls and those of others departed in similar disasters rest in peace, Amen.**

9.0 COMMUNITY SERVICE AND CONTRIBUTION TO UNIVERSITY INFRASTRUCTURAL DEVELOPMENT

Madam Vice Chancellor, permit me to express my profound gratitude to the Management of our University at different times during the past twenty-four (24) years of my service to the university community for finding me worthy to be saddled with different tasks and responsibilities. During this period, I served on the following committees:

- Member, Admissions Committee For Civil Engineering Dept. Unilag - 2000/2001
- Examination Officer, Civil Engineering Dept., Unilag - 2001/2002
- Examination Officer, Faculty of Engineering, Unilag - 2002/2003
- Member, Faculty of Engineering Committee on Performance of Undergraduate Students (1997-2002) Unilag - 2004
- Chairman, Faculty of Eng. Exams Results Committee, Unilag - 2004/2006
- Member, Post-Graduate Committee, Civil Eng. Dept. Unilag - 2002/2023
- Course Adviser to Civil Engineering Students Unilag - 2000/2011
- Staff Adviser, Civil Engineering Students Society - 2003/2011
- Member, Senate, University of Lagos - 2006 -2010
- Member, LOC, Faculty of Engineering Distinguished Lecture Series - 2011
- Member, LOC, Faculty of Engineering (IET 2011) Conference - 2011
- Member, Unilag Students Disciplinary Board - 2011/2013
- Member, Senate sub-committee on investigation of 2011 academic misconduct of a staff in Faculty of Arts
- Member, School of Postgraduate Studies Board, University of Lagos 2011-2013
- Member, Admissions Committee, SPGS Board, University of Lagos 2011-2013
- Member, Task Force for Teaching Facilities Upgrade (TETFUND/ NEEDS ASSESSMENT PROJECTS) - 2012/2022
- Member, Unilag Central Research Laboratories Management Committee -2013-2022

- Member, Committee on Needs Assessment for Equipment and Consumables 2014, 2019
- Board Member, Unilag Property Management & Development Coy. Ltd. 2014 -2023
- Member, Tenders Evaluation Committee, University of Lagos 2015-2016
- Member, Univ. of Lagos Property Management & Development Board - 2018 -2020
- Chairman, Univ. of Lagos Property Management & Development Board - 2021 - 2025
- Member, Uni. of Lagos Committee to Interact with Family Homes on Projects - 2018 - 2020
- Member, University of Lagos Committee on Restructuring & Capacity Building in Works and Physical Planning Unit of the University - Sept. 2023
- Permanent Member of the Senate since 2018

Madam Vice Chancellor, during this period, I also served as a visiting professor/external examiner to some tertiary Institutions/universities in Nigeria. They are:

- Niger Delta University, Amassoma, Bayelsa State, Nig. - 2014-2015 (Visiting Professor)
- External Examiner to Civil Engineering Dept., UNN, Nsukka. 2013/14, 2014/15 sessions
- External Examiner to Civil Engineering Dept., YabaTech., Lagos.2013/14, 2014/15 sessions
- External Examiner to Civil Engineering Dept., UI, Ibadan. 2015/16, 2016/17 2017/18 sessions.

Furthermore, I was a Member of the SON Stakeholders' Forum on the Review of NIS 444-1:2014 on Cement in 2017 and 2018. I worked as Secretary, LOC, 1st, 2nd and 5th African Regional Conference on Engineering Education and Sub-Regional Workshop on Engineering Curriculum; Unilag, Lagos, Nigeria.

Between September 2010 and December 2023, I participated actively in the structural design of at least twenty-seven building projects at the University of Lagos. Some of the projects have been completed, delivered and commissioned while others are yet to take off. The

projects are listed below:

Table 6. Design Projects Executed by Inaugural Lecturer

SEPTEMBER 2010	Structural Design of Proposed J. P. CLARK CENTRE, Faculty of Arts, University of Lagos
NOV. – DEC. 2011	Structural Design of Proposed University of Lagos Digital Centre Development. Proposed Location is at Faculty of Science.
SEPTEMBER 2012	Structural Design of Proposed Aderinokun Lecture Theatre for Faculty of Business Administration, University of Lagos.
JANUARY 2014	Structural Assessment & Redesign of Unilag Gwarinpa Estate, Abuja. (UNILAG CONSULT).
SEPTEMBER 2014	Structural Design of Proposed El-Kanemi Students Hostels, University of Lagos.
OCTOBER, 2014	Structural Design of Proposed 500-Seater Lecture Theatre for Faculty of Social Sciences, University of Lagos.
OCTOBER 2014	Structural Assessment For The Restructuring (Upgrade) of Sodeinde Students' Hall of Residence, University of Lagos.
MARCH, 2015	Structural Design of Proposed New Students Affairs Building, University of Lagos.
APRIL, 2015	Structural Design of Proposed New Clinical Skills Laboratory Building, College of Medicine, University of Lagos.
NOVEMBER, 2016	Structural Design of Proposed New Pharmacy Building and Vertical Extension to X-ray Building at Health Centre, University of Lagos, Akoka.
2017	Structural Design of Overhead steel (Breitweight) Water Tank Facility for Sodeinde Hall of Resident
2017	Structural Design of Overhead steel (Breitweight) Water Tank Facility for El-Kanemi Hall of Resident
2018	Structural Design of Proposed Unilag - Iwaya Link Bridge
2019/2020	Structural Design of Proposed 1000 Beds Multi-Storey Students (Male) Hostel Building, Unilag

2019/2020	Structural Design of Proposed 1000 Beds Multi-Storey Students (Female) Hostel Building, Unilag
2019/2020	Structural Design of Proposed Commercial Building for Multi-Storey Students Hostels, Unilag
2019/2020	Structural Design of Proposed 3BR blocks (2-Units) Multi-Storey Unilag On-Campus Staff Apartments, Unilag
2019/2020	Structural Design of Proposed 2BR blocks (2-Units) Multi-Storey Unilag On-Campus Staff Apartments, Unilag
2019/2020	Structural Design of Proposed 1BR blocks (2-Units) Multi-Storey Unilag On-Campus Staff Apartments, Unilag
2020	Structural Design of Proposed 250 Units 2BR/3BD Unilag Staff Housing Scheme at Mowe, (Family Homes/ Unilag Project
2020	Structural Design of Proposed Faculty of Science Laboratory Extension Building, Unilag
2021	Structural Design of New Faculty of Education New Building Project
2021	Structural Design of New Student Hostels Project facilitated by Hon. Gbajabiamila and Funded by Fed. Min. Of Educ. = over 2.0 Billion Naira
2022	Structural Design of New DLI Building
2022	Structural design of New School of Foundation Building
2023	Structural Design of New BUA Unilag Botanical Garden Research Complex
2023	Structural Design of New NIMASA IMS Complex, Unilag

The pictures of some of the completed and commissioned projects which form part of my contributions to infrastructural development in the university are attached below:

Fig. 18. Fac. of Eng. Vertical Extension

Fig. 19 Fac. of Social Sc. Lecture Theatre

Fig. 20 Unilag Campus - Iwaya Link Bridge

Fig. 21 New El-kanemi Hostel Complex

Fig. 22: Rt. Hon. Femi Gbajabiamila

Fig. 23: New Fac. of Educ. of Complex Hall of Residence

Fig. 24 New Pharmacy Block for Med. Centre

Fig. 25 JP Clark Centre

I sincerely appreciate successive administrations of the University since 2009 for allowing me to display my knowledge in structural design on projects being executed in the university.

Madam Vice Chancellor, permit me to note that the tradition, whereby experts from within the university were allowed to participate in projects, in recent times, has been attacked from both within and beyond for unwarranted, unprogressive, and selfish reasons. I have always deployed my knowledge as a mentor, an engineer and a lecturer on projects and I allow student-trainee participation. Please, what is wrong in training students with real life projects?

I appreciate the efforts of the following people who worked with me as student trainees on the above listed projects. Kamaldeen Adefemi, Kehinde Onasanya, Ehikhuenmen Onosedeba Samuel, Seriki Musiliudeen Gbolahan, Busari Abdullah Olamide, Salvador Abdulrasheed, Samuel John-Nwafa, Fadare Ademilade Oluwatobi, Debola Adedoyin, and many others too numerous to mention here. I appreciate you all. I thank God for counting me worthy to be one of their lecturers and one of their mentors during their training as students in this university. To GOD ALONE be all the glory, Amen.

10.0 CONTRIBUTION TO SCHOLARSHIP

Madam Vice Chancellor, I consider myself a practical academic. Not only have I participated in training thousands of civil engineering graduates in the Department (undergraduate and postgraduate levels) but many who passed through me as project students are now reaping the benefits of research works jointly conducted and supervised by me. My areas of research interest are: -

- Investigation of the engineering properties of locally sourced industrial and agricultural waste materials as aggregates and pozzolans in concrete production.
- Research on alternative reinforcing materials (natural fibre) in concrete structures
- Research on sustainable energy from communal waste and
- Research in areas relating to engineering education.

I have seventy-four (74) publications only to my credit in both international and local journals as well as in conference proceedings; local and international. I have extensively researched societal challenges from the angle of civil engineering materials. My research in the last two decades focused largely on engineering properties of locally sourced and readily available industrial and agricultural waste materials such as aggregates and pozzolans in concrete production. I have extensively worked and published with my mentors, Professor Falade and Late Professor Salau as well as my mentees in these areas. Furthermore, we have researched alternative reinforcing materials for reinforced concrete production; especially for low-cost housing delivery as this could help check the Rural-Urban migration syndrome in Nigeria. Of the 74 nos. publications, 90.54% are on Concrete and Reinforced Concrete related matters.

On Aggregates and Pozzolans, **Ikponmwosa** *et. al.,* [23], investigated the effects of partial replacement of crushed granite as coarse aggregate with washed gravel on the strength and workability of concrete prepared with 1:2:4 concrete mix (Cement: Fine Aggregate: Coarse Aggregate) having 0.65 w/c ratio. Six batches of concrete were produced in which the granite was progressively replaced with washed gravel at intervals of 20 per cent, from 0% to 100% replacement level. (0% replacement was the control). Twelve (12) nos. 150x150x150 mm concrete cubes were cast from each batch and cured in a water tank at ambient temperature. The cubes were crushed for strength in sets of three at curing ages of 7, 14, 21, and 28 days, respectively. A slump test was carried out on each batch. It was observed that the workability of the concrete decreased with an increase in gravel content.

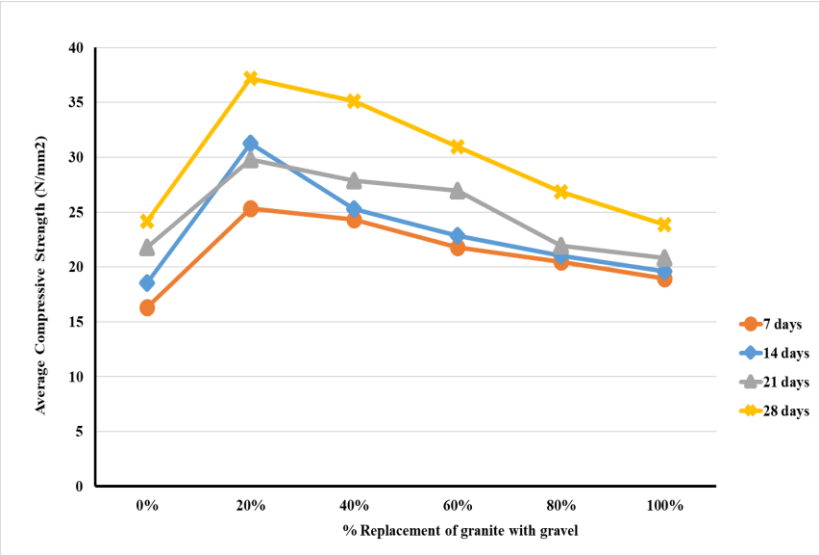


Figure 26. Variation of compressive strength with percentage replacement (at different ages).
Source: Ikponmwosa et. al., (23)

Also, it was observed that for all curing ages, as the percentage replacement level increased, the compressive strength of the concrete increased to a maximum of 20 per cent replacement level. Thereafter, it decreased as the replacement level increased to 100%. The maximum 28-day compressive strength at a 20% replacement level was 37.20 N/mm2; indicating a 54% increase when compared to the 28-day strength of the control mix (24.2 N/mm2). The results also showed that the 28-day strengths of 100% granite concrete and 100% gravel concrete were comparable.

Ikponmwosa and Ehikhuenmen [24] carried out a study on the effect of partial replacement of coarse aggregate with ceramic waste on the strength properties of concrete. Compressive strength tests were conducted using 150mm cube specimens. The results of tests show that the workability, density and compressive strength of the concrete specimens decreased with increased replacement level of the ceramic

waste. The strength at 90 days of curing suggests that ceramic waste could be used for structural and non-structural concrete production, but the level of replacement is limited to 75%.

Also, Ikponmwosa et. al., [25], investigated the suitability of polyvinyl waste powder as a partial replacement of cement in concrete production. Up to 50% by weight at intervals of 10% was replaced. The results show that the polyvinyl waste powder (PWP) has a pozzolanic effect by the strength activity index and higher compressive strength than the control specimen for replacement up to 20% level. The study concluded that PWP could be used as a partial replacement of cement in concrete production.

In the same vein, Fapohunda et. al., [26], proposed an innovative way of converting palm kernel shell waste to wealth by having it used as aggregates in concrete. In the study, we looked at the structural behaviour of reinforced concrete beams with crushed palm kernel shells as aggregates. Properties investigated were workability and strength characteristics. Replacement levels were varied from 0% to 100% at intervals of 25%. The findings revealed that PKS can be adopted and used for concrete production for low-cost housing projects. [34]

Ikponmwosa and Olonode [27], investigated the effect of cassava peel ash (CPA) on the shrinkage properties of concrete. Cement was replaced with CPA at replacements levels of 0, 5, 10, 15, 20 and 25% by weight, the results show an optimum w/b ratio of 0.7 was required to produce workable cement-CPA concrete. Furthermore, the compressive strength of concrete containing up to 15% CPA had a strength activity index in excess of 75%. Shrinkage strain of CPA blended concrete was found to be less than normal concrete by 24%. The study concluded that CPA has the capacity to reduce shrinkage in concrete.

On Alternative Reinforcing Materials, Falade and Ikponmwosa [28], investigated the behaviour of bamboo-reinforced concrete columns under applied axial loads. Column specimens of 150x150x1000mm

dimensions were cast with 1:2:4 concrete mix with 0.65 w/c. The bamboo content varied from 0% to 2.5% at intervals of 0.5%. 10x10mm bamboo splints were used. The investigation was to determine the suitability of bamboo as an alternative reinforcement in concrete columns. Results of the investigation show that for all test ages, the theoretical failure loads of bamboo-reinforced columns increased when compared to unreinforced column specimens. However, the experimental failure loads decreased with an increase in bamboo reinforcement. The deflection of the reinforced concrete columns increased with the percentage of bamboo content. This is an indication that bamboo splints will be found to be weak as reinforcement in concrete columns.

Ikponmwosa and Falade [29] investigated the use of bamboo as secondary reinforcement in reinforced concrete beams. The results indicate that the load carrying capacity of the beams that contain bamboo as secondary reinforcement increased when compared with the performance of beams with tensile reinforcements only. The use of bamboo as secondary reinforcement also helps to improve the post cracking abilities of the beams. This generally is an indication that bamboo can be an alternative to steel as secondary reinforcements in beams.

On Foamed Aerated Concrete, Ikponmwosa et. al., [30] [38] [39] [40] [43], researched extensively aerated concrete production in Nigeria. The inaugural lecturer, Professor Ikponmwosa and his mentor, Professor Falade are the pioneer researchers/investigators on aerated concrete in Nigeria. Apart from producing Dr. Fapohunda Christopher and Dr. Bright Ukponu as Ph.D. degree holders in this area of research, we have also produced many M.Sc. degree holders. On aerated concrete, we have jointly produced numerous publications. It has been a worthwhile experience and honour to have worked with this scholar and a mentor par excellence, Professor Funso Alphonsus Falade. Incidentally, He will be retiring in a couple of days as he clocks 70 years.

Falade et. al., [31] [41], carried out a structural assessment of foamed concrete containing steel slag as a partial replacement for sand. In this referenced study, the potential of foamed concrete having river-dredged sand replaced with pulverized steel slag as a structural material was investigated. The results of the investigation showed that 30% replacement of sand with steel slag gave a maximum of 20.3% increase in compressive strength on the 28th day for air-cured cube specimens. For aerated concrete, air-cured specimens generally showed higher strength than water-cured.

Lastly Falade et. al., [32], carried out a laboratory assessment of some structural properties of foamed aerated concrete. Among the properties examined are compressive strength and water absorption capacity. The results show that as the ratio of foam concentrate increased, the compressive strength of test specimens cured in air and water decreased. However, air-cured test specimens had higher compressive strength than water-cured specimens; an indication of weakness of aerated concrete in moisture-ladened environment.

Madam Vice Chancellor, it has been a very challenging but fulfilling experience in the world of concrete research. During this period, working with the late Professor M. A. Salau and Professor F.A. Falade, the Inaugural Lecturer delivered four (4) Doctoral candidates. They are: Dr. Christopher Fapohunda, Dr. Olonode Kolawole Adisa, Dr. Bright Ukponu and Dr. (Mrs.) Adeyemo Adetukasi.

On Engineering Education, **Ikponmwosa** [33], presented a research paper on funding of tertiary education in Nigeria using the University of Lagos as a case study. In the paper presented at the 5th AEEA conference in Lagos, the lecturer compared the funding structures in Nigeria, Ghana, the UK and some East African countries and posited that the Nigerian Government has since lost the capacity to effectively fund free and qualitative engineering education at the tertiary level in Nigeria. Furthermore, the lecturer noted that the yearly volumetric increase in Naira budgetary allocation to the sector does not necessarily translate to effective qualitative increase in funding as a result of non-

guarantee of full cash backup of the budgetary allocation as well as the perennial devaluation of the Naira.

To resolve the challenges of public universities, the lecturer suggested ways of improving the funding of higher education in Nigeria. This includes but not limited to the following:

- Government should improve the level of funding for education to a minimum of 15% of the federal budget and 20% of state budgets. Funding should be distributed among recipient institutions based on enrolment criteria and area of specialisation.
- Re-introduction of students' grants, scholarships, bursary and loan schemes up to an equivalent of $1,000.0 USD per annum
- Introduction of appropriate level of service charges in universities while government holds on to tuition fees (free tuition).
- Introduction to public institutions modernisation bond proposals to be managed appropriately by CBN-led government agency.

The above are just some of the recommendations made by the lecturer in 2013. Then, our economy was more buoyant, and Nigerians were not as hungry and angry as we are today. Then, Nigerians were not as emotionally traumatized as we are today. However, we must come to terms with realities now; we must both fight and make sacrifices for the sector's survival. May God help us in Jesus Mighty Name, Amen.

11.0 CONCLUSIONS

Madam Vice Chancellor, I started my inaugural lecture on how a local, Ebute Metta, Lagos boy with a very humble background rose to the enviable class of Professors. It was not by my powers or might or that of my parents; it was only by the grace and mercy of the Almighty God. To Him alone I give all thanks and adorations, Amen.

I have presented in this inaugural lecture my contributions; to both scholarship and infrastructural development in general in the university. The conclusion of my inaugural lecture is succinctly expressed in the Bible in 2Chronicles 1:11-12, "**11** God said to Solomon, "Since this is your heart's desire and you have not asked for wealth, possessions or

honor, nor for the death of your enemies, and since you have not asked for a long life but **for wisdom and knowledge** to govern my people over whom I have made you king, **12 therefore wisdom and knowledge will be given you**. And I will also give you wealth, possessions, and honour, such as no king who was before you ever had and none after you will have." [1] If we seek the face of the Lord and turn away from greed and ask **for wisdom and knowledge** to understand and dominate the material called CONCRETE in whichever form it presents itself to us, then, we will overcome the challenges posed by infrastructural collapses in Nigeria.

However, Proverbs 1:19 says that "So are the ways of everyone that is greedy for gain, which taketh away the life of the owners thereof". Also, Proverb 15:27 says "He that is greedy for unjust gain troubleth his own house, but he that hateth bribes shall live". [1]

The above Bible verses say it ALL. Without knowledge of the material called CONCRETE, we cannot dominate the challenges caused by collapses of infrastructure in our country. In the same vein, greed as expressed by project promoters, professionals, artisans and regulators in the industry will also continue to create challenges in the built environment.

It is good to always recall that since we brought nothing into this world, we shall take nothing out (1 Timothy 6:7). For us to mitigate against building collapse related stresses in Nigeria, our national character (self-discipline, core values, and integrity) must be re-appraised and re-engineered in line with global best practices around the world.

12.0 RECOMMENDATIONS

1. For centuries now, the production of OPC, the global major binder is constantly being improved upon, the Standard Organisation of Nigeria (SON) should continually ensure that ALL cement brands being used in Nigeria for construction purposes meet minimum global standards.

2. Materials Testing Centres should be established in all States of the Federation and the FCT for materials testing. Institutions of higher learning that are running related programmes should be encouraged to participate in materials testing quality control and assurance services.

3. Water and all other parent materials for concrete production should be subjected to tests regularly.

4. A control agency should be set up to whom all test centres MUST send in reports weekly of their activities. No test centre should be saddled with regulatory responsibilities as this will be counter productive

5. Geotechnical soil test reports should be made mandatory for ALL infrastructural development, irrespective of their nature and proposed site locations.

6. All Artisan-Drillers should be registered in Nigeria and their professional activities checked.

7. On Engineering Education, this lecturer's 2013 recommendations on funding engineering education at the tertiary level in Nigeria should be revisited for consideration and probable implementation.

13.0 ACKNOWLEDGEMENTS

Madam Vice Chancellor, my utmost gratitude is to the Almighty God (Jehovah El Shaddai), God my creator (Jehovah Elohim), The God that is always there for me (Jehovah Shammah), (Covenant Keeper (Yahweh!) the King of Kings, for making today a reality in my life, for His kindness, mercy and unparallel, steadfast love. I cannot thank Him enough today for all HE has done for me. TO HIM ALONE BE ALL THE GLORY, Amen.

I am grateful and greatly indebted to the University of Lagos for employing me in the first instance and for giving me the opportunity to serve the academic community. I am grateful to the Vice Chancellor

Prof. Folashade Ogunsola for giving me the opportunity to deliver this inaugural lecture.

A big thank you to all members of the Senate of this University for your support. Also, my sincere appreciation to all non-academic staff of this University. To all Guests and well-wishers, thank you for your support. And to members of the Senate and Ceremonies unit of the University, thank you for putting all the relevant papers together and for your support in making this day a reality. I thank members of staff of Unilag Press, the Manager, Mrs. Golda Nkenchor and the Editor, Mrs. Loice Ukaonu-Maduagwu for facilitating the prompt production of this inaugural lecture materials at the press.

I am thankful to God the more for allowing me to come into this world through my late parents **Pa Nelson Cyril Oviawonyi Ikponmwosa and Madam Victoria Irowa Ikponmwosa**. They made sure I got educated. I thank God for my siblings and acknowledge their contributions individually and collectively to my success story in life. Since we all turned orphans, my eldest brother, Dr. Alexander Nelson Ikponmwosa has been keeping the family together and doing his best at that. To my immediate elder brother, Flight Capt. Benson Ikponmwosa (Rtd.), I say thank you for tolerating me always. To my sisters, Mrs. Adesuwa Junaid, Engr. Isoken Ikponmwosa and Miss Elizabeth Iroghama Ikponmwosa, I say thank you all for being wonderful siblings to me. I appreciate my sisters-in-law, Mrs. Folake Nelson Ikponmwosa and Evelyn Benson Ikponmwosa, I thank you both immensely. To all the children of my siblings, I recognize you all and I say thank you.

I express my gratitude to my aunty, Madam Christiana Akinola. And to all her children, cousins and nieces, in no particular order, Mrs. Gbemisola Adefope, Gbolahan Akinola, Tunde Akinola and Banji Akinola, for being there always to keep the extended family system going. I am not taking for granted the Edunjobis; Mr. Kayode and Mrs Bukola Edunjobi and other members of the family; the brothers and sisters for being part of and keeping the extended family chain going.

I express my gratitude to all members of the Sokpunwu dynasty for keeping the larger family together, Uncle Osadolor Omorodion, Sylvester Aghafua, Osaro Aghafua, Madam Josephine Idada, and many others under the Sokpunwu Dynasty Umbrella, I say thank you all.

I am grateful to the Federal Government of Nigeria for the scholarship awarded in 1981 which enabled me travel to the defunct Soviet Union for further studies. That was a game-changer in my life.

I am very grateful and appreciative of the training, mentoring and moulding received at Immaculate Conception College (ICC), Benin City. I thank God for being in the ICC set of '71 –'75. You are simply wonderful people, and it is indeed a pleasure being one of you.

I appreciate all my colleagues in the Department of Civil and Environmental Engineering; both present and past. I also appreciate Professor A. S. Adedimila, my first HOD at the University of Lagos. To all my students and colleagues in the faculty of Engineering, past and present, I appreciate you all for the role you have all played in my life. I thank you all for believing in my capabilities, I recognize and appreciate all members of University of Lagos Senior Staff Club for the platform provided to fellowship with you all at the club.

I thank Mr. Lekan Adebiyi for his support always. He allowed the lecturer to use his sites for research in geotechnics and structures-related challenges and he has been very supportive in all ramifications. I thank my sister Dr. Ifueko Bello Fadaka for touching my life in many ways. I cannot forget all the good things she has done for me. Thank you.

I thank my mentors, Late Prof Musbau Salau and Prof. Funso Falade for their mentorship for preparing me well to work in this environment. I thank them for their guidance and constructive criticism during my learning period here. I appreciate Prof. R. A. Bello, Prof. Toyin Ogundipe and Prof. Duro Oni for their unalloyed support and contributions to my development as a staff of this University.

I thank my Professional colleagues too many to mention. I appreciate my acting Head of Department, Dr. Akiije Isaac for all his assistance. I am grateful to the planning committee members of this inaugural lecture. Notwithstanding the short time we had for planning, you all got the job done in record time. In no particular order, thank you Dr. Olonade, K.A., Dr. Osoba L., Dr. Adedokun, S. I., Dr. Oyelade, A. O., Dr. (Mrs.) Abdulsalam K. A., Dr. Orolu K., Dr. Adeleye O. A., Dr. (Mrs.) Folorunso C., Dr. (Mrs.) Balogun-Adeleye R. M., Dr. (Mrs.) Abiodun, Y., O., Dr. (Miss) Echeta, O. C., Dr. Afolabi, O. A., Mr. Orebiyi K. O., Mrs. Taiwo E. O., Mrs. Ashon O., Mrs. Edunjobi O., Mr. Adegeye, P. A., Mr. Jimoh, M. A., Mr. Moshood, A. S., Mr. Nosaghare F. E. and Mr. Ojo. A. To all men and women of the security unit headed by the C.S.O, Mr. Alao S. A., I say a big thank you. I am grateful to Mrs. Bukola Ashon, Prof. Falade's secretary for all her support.

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Madam Vice Chancellor, Members of University Management, distinguish ladies and gentlemen, with due respect to men and women of the wig profession, permit me to say that I “rest my case” for today. Thank you for listening to this lecture. God bless you ALL.
This is my Inaugural Lecture.

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