THE EFFECT OF LIME AND BITUMEN ON CONCRETE

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ABSTRACT

The purpose of this paper is to investigate the effect of some substances that are in contact with concrete can have on the concrete, either positively or negatively, especially on concrete's compressive strength. The substances used are Lime and Bitumen. Concrete cubs were casts with dimension 150mm by 150mm moulds. Certain percentages of 5% and 10% of each of the substances were mixed with concrete. Curing and crushing was done at intervals of 7 days. Control uncontaminated cubes was also cast. The following fact emerged. On comparing with uncontaminated cube (controlled concrete cubes) presence of lime and bitumen of any proportion in sand resulted in lesser compressive strengths. This revealed clearly that lime and bitumen are compressive strength inhibitor in concrete production. The 28 day compressive strength of concrete made of contaminated sand of 5% and 10% of bitumen were on the range of 43.4% and 28.9%. The higher the percentage of oil on sand, the lower the compressive strength obtained. Also, it follows that bitumen in small proportion must be properly evaluated before using such material for concrete production because 5% of bitumen brought about 53.8% reduction in the 28day compressive strength occurred. Since, all the percentage of contaminant use i.e. (lime and bitumen) the resulted compressive strength fell too low to control cubes cast (uncontaminated). We therefore recommend that. Both lime and bitumen at percentage used for this research should not be used for concrete production. Further research can be carried out on lesser percentage of contaminant, so as to get a result for light weight concrete .

Key words: *Lime, Bitumen, Compressive strength, Concrete*

1.0 INTRODUCTION

The purpose of this paper is to investigate the replacement of cement with lime and bitumen which can be used in the production of normal weight concrete with the express objective of reducing the production of greenhouse gas emission by manufacturers of pozzolans. In environmental terms, lime does not generate as much CO2 in its production as does the production of Portland cement. Lea, (2010)

Bitumen is actually the liquid binder that holds asphalt together. The term bitumen is often mistakenly used to describe asphalt. A bitumen-sealed road has a layer of bitumen sprayed; and then covered with an aggregate. This is then repeated to give a two-coat seal.

Lime has been used as the basis for the pozzalonic material in concrete for thousands of years. Portland cement's development in the late eighteenth century and its adoption as the primary pozzalonic material in concrete resulted in the displacement of lime as the primary cementitiousmaterial. Lime has a number of properties that are of interest in the development of long term durability of materials, particularly the slow carbonation rate and resulting self-healing properties

This project deals with the physical strength properties of concrete when the Portland cement is replaced with hydrated lime and bitumen of varying proportions. Future research will look at the economic impact of the replacement in terms of full life cycle of the concrete and other physical characteristics. Soroka, I. and Stern, N., (2012),

The addition of lime reduces the initial and final setting time, as well as porosity, whereas free lime and combined water increase with increasing limestone content. The quality of the limestone filler affects the performance of the cement in concrete as well as the water demand of the cement. Limestone filler affects the crystallization nucleus for the precipitation of CH. These effects produce an acceleration of the hydration of cement grains.

Limestones are sedimentary rocks primarily of calcium carbonate. Limestones are generally obtained from the calcareous remains of marine or fresh water organisms embedded in calcareous mud. They change from the soft chalks to hard crystalline rocks.

According to Lea, (2013) the use of limestone as a concrete aggregate has sometimes been suspected on account of the unsuitability of the poorer grade rocks; and also because of a widespread fallacy that limestone concrete is less resistant to the action of fire than concrete made from other aggregates. He suggested that the use of limestones might not be beneficial in concrete products, which are to be cured in high-pressure steam. Neville, (2012),

The combination of Portland cement and lime is used for stabilization and solidification of the ground through establishing of lime cement columns or stabilization of the entire upper mass volume. The method provides an increase in strength when it comes to vibrations, stability and settling. When building e.g. roads and railways, the method is more common and widespread. Uchikawa, Hanehara, and Hirao, (2012),

The concrete strength is often regarded as the most important property of concrete. The compressive strength of concrete is about ten times its tensile strength (British Cement Association, 2001). Concrete suffers from one major drawback compared with other materials like steel and timber; its strength cannot be measured prior to its being placed. Factors affecting concrete compressive strength are water cement ratio, mix ratio, degree of compaction, type of cement, the grades of aggregates, design constituents, mixing method, placement, curing method and presence of contaminants.

The aim of this study is to determine the effect of cement, lime and bitumen on concrete. To achieve this aim, the following are the objectives;

- To investigate the effect of lime cement lime and bitumen on concrete strength
- To determine the physical characteristics of lime and bitumen
- To make recommendations on cement lime and bitumen on concrete

Bituminous materials are extensively used for pavement construction, primarily because of their excellent binding characteristics: water proofing properties and relatively low cost But In bitumen concrete mix, the strength of bitumen concrete depends on all the constituent materials that are used in the mix design i.e. bitumen, coarse aggregate, fine aggregate and filler. Above all, the bitumen concrete is prepared by bitumen and mineral aggregates.

Lime concrete, produced by this mix, makes a good base for load bearing walls, columns, or laying under floors because it has a degree of flexibility that regular concrete does not. It also has a certain waterproof property to it that prevents subsoil dampness in floors and walls. Additionally, lime concrete can be made easily and cheaply while still providing a durable material that resists weathering and wear and tear.

Lime can also be used simply as an additive in other concrete mixes, as well as cement concretes. For concretes, this process can take time, as quicklime has to be mixed with water to create a putty which will then have to mature; so other concrete plasticizers will often be used instead to achieve the same effect.

This research focused on cement lime and bitumen in concrete, therefore, the objective of this project is to provide an improved insight into how the mechanical properties of emulsion mixtures may be improved and to determine the influence of cement on emulsified asphalt mixtures. Laboratory tests on strength, temperature susceptibility, water damage, creep and permanent deformation were implemented to evaluate the mechanical properties of emulsified asphalt mixtures. The test results will show that mechanical properties of emulsified asphalt mixtures have significantly improved with Portland cement addition.

2.0 LITERATURE REVIEW

2.1 Lime

Lime is an hybrid citrus fruit, which is typically round, lime green, 3–6 centimetres (1.2–2.4 in) in diameter, and contains acidic juice vesicles. There are several species of citrus trees whose fruits are called limes, including the Key lime (*Citrus aurantifolia*), Persian lime, kaffir lime, and desert lime. Limes are a good source of vitamin C although having about half the vitamin C of an equal amount of lemons; and are often used to accent the flavours of foods and beverages. They are grown year-round. Plants with fruit called "limes" have diverse genetic origins; limes do not form a monophyletic group. Wikipedia, (2017)

Many authors infer benefits of cement concretes with lime additions for specific concrete or masonry properties such durability. However, only few have specifically undertaken research into the role lime itself plays. Much of the works published focus on the different performance when compared to OPC (Ordinary Portland Cement), Masonry Cement and Blended Cements, with and without air entrainment. The papers therefore generally fail to identify the causation of the benefit, namely, what role the lime has played in this modification of performance, or if the actual properties (particle size distribution, chemical composition, etc) of the lime influence the end results. Bowler, (2010)

2.1.1 Lime as a Building materials

Lime used in building materials is broadly classified as "pure", "hydraulic", and "poor" lime; can be *natural* or *artificial*; and may be further identified by its magnesium content such as dolomitic or magnesium lime. Uses include lime concrete, lime plaster, lime render, lime-ash floors, tabby concrete, whitewash, silicate mineral paint, and limestone blocks which may be of many types. The qualities of the many types of processed lime affect how they are used. The Romans used two types of lime concrete to make Roman concrete, which allowed them to revolutionize architecture, sometimes called the Concrete Revolution. Bowler, et al (2010)

Lime has many complex qualities as a building product including workability which includes cohesion, adhesion, air content, water content, crystal shape, board-life, spreadability; and flowability; bond strength; comprehensive strength; setting time; sand-carrying capacity; hydrolocity; free lime content; vapor permeability; flexibility; and resistance to sulfates. These qualities are affected by many factors during each step of manufacturing and installation, including the original ingredients of the source of lime; added ingredients before and during firing including inclusion of compounds from the fuel exhaust; firing temperature and duration; method of slaking including a hot mix (quicklime added to sand and water to make concrete), dry slaking and wet slaking; ratio of the mixture with aggregates and water; the sizes and types of aggregate; contaminants in the mixing water; workmanship; and rate of drying during curing. Zeng, Li, (2012)

Pure lime is also known as fat, rich, common, air, slaked, slack, pickling, hydrated, and high calcium lime. It consists primarily of calcium hydroxide which is derived by slaking quicklime (calcium oxide), and may contain up to 5% of other ingredients. Pure lime sets very slowly through contact with carbon dioxide in the air and moisture; it is not a hydraulic lime so it will not set under water.

Pure lime is pure white and can be used for whitewash, plaster, and concrete. Pure lime is soluble in water containing carbonic acid, a natural, weak acid which is a solution of carbon dioxide in water and acid rain so it will slowly wash away, but this characteristic also produces autogenous or self-healing process where the dissolved lime can flow into cracks in the material and be redeposited, automatically repairing the crack.

Semi-hydraulic lime, also called partially hydraulic and grey lime, sets initially with water and then continues to set with air. This lime is similar to hydraulic lime but has less soluble silica (usually minimum 6%) and aluminates, and will set under water but will never harden.

Hydraulic lime is also called *water lime*. Hydraulic lime contains lime with silica or alumina and sets with exposure to water and can set under water. *Natural hydraulic lime* (NHL) is made from a limestone which naturally contains some clay. *Artificial hydraulic lime* is made by adding forms of silica or alumina such as clay to the limestone during firing, or by adding a pozzolana to pure lime. Hydraulic lime is classified by their strength: *feebly*, *moderately* and *eminently* hydraulic lime. Feebly hydraulic lime contains 5-10% clay, slakes in minutes, and sets in about three weeks. It is used for less expensive work and in mild climates. Moderately hydraulic lime contains 11-20% clay, slakes in one to two hours, and sets in approximately one week.

It is used for better quality work and exterior walls in freezing climates. Eminently hydraulic lime contains 21-30% clay, slakes very slowly, and sets in approximately a day. It is used in harsh environments such as damp locations and near saltwater. Hydraulic lime is off-white in color. "The degree of hydraulicity of concretes will affect many characteristics. By selecting an appropriate ratio of clay to limestone concretes that carbonate or set hydraulically to a varying extents can be designed for particular application requirements such as setting time, strength, colour, durability, frost resistance, work ability, speed of set in the presence of water, vapour permeability etc.

Poor lime is also known as lean or meager lime. Poor lime sets and cures very slowly and has weak bonding. Poor lime is grey in color. Magnesium lime contains more than 5% magnesium oxide (BS 6100) or 5-35% magnesium carbonate (ASTM C 59-91). Dolomitic lime has a high magnesium content of 35-46% magnesium carbonate (ASTM C 59-91)Dolomitic lime is named for the Dolomite Mountains in the Italian and Austrian Alps.

In the United States the most commonly used masonry lime is Type S hydrated lime which is intended to be added to Portland cement to improve plasticity, water retention and other qualities. The S in type S stands for special which distinguishes it from Type N hydrated lime where the N stands for normal. The special attributes of Type S are its. ability to develop high, early plasticity and higher water retentivity and by a limitation on its unhydrated oxide content. The term Type S originated in 1946 in ASTM C 207 Hydrated Lime for Masonry Purposes. Type S lime is almost always dolomitic lime, hydrated under heat and pressure in an autoclave, and used in concrete, render, stucco, and plaster. Type S lime is not considered reliable as a pure binder in concrete due to high burning temperatures during production.

Kankar limes, a lime made from kankar which is a form of calcium carbonate. Selenitic lime, also known as Scotts' cement after Henry Young Darracott Scott is a cement of grey chalk or similar lime, such as in the Lias Group, with about 5% added gypsum plaster (calcinedgypsum).[10]Selenite is a type of gypsum, but selenitic cement may be made using any form of sulfate or sulfuric acid.[15]Sulphate arrests slaking, causes the cement to set quickly and stronger.

2.1.2 Properties of Lime

The addition of lime (hydrated lime/building lime, Ca(OH)2) into cement in concrete production has been common place for over 50 years, and in parts of Europe for over 100 years. The main purpose has been to provide better "workability" of the concrete in the fresh state, thus providing an easier material for the brick or stone layer to work with. Much of this "workability" is attributed to two modifications to the concrete when lime is added; water retention and air entrainment. Wright, Wilkins, (2014)

Although the water retention properties of lime additions have the potential to modify the hardened concrete properties, namely the connectivity of the pore structure, they predominately impact upon the fresh state properties, whereas air entrainment modifications are in general carried over into the hardened concrete, and have been shown to have an impact upon durability, specifically with frost resistance. Building Research Establishment, UK, (2007)

2.2 Bitumen

Also known as bitumen is a sticky, black, and highly viscous liquid or semi-solid form of petroleum. It may be found in natural deposits or may be a refined product; and is classed as a pitch. Before the 20th century, the term asphaltum was also used. Ahod (2012). The word is derived from the Ancient Greekἄσφαλτος *ásphaltos*.

The primary use (70%) of asphalt is in road construction; where it is used as the glue or binder mixed with aggregate particles to create asphalt concrete. Its other main uses are for bituminous waterproofing products, including production of roofing felt and for sealing flat roofs.

The terms "asphalt" and "bitumen" are often used interchangeably to mean both natural and manufactured forms of the substance. In American English, "asphalt" (or "asphalt cement") is commonly used for a refined residue from the distillation process of selected crude oils. Outside the United States, the product is often called "bitumen", and geologists worldwide often prefer the term for the naturally occurring variety. Common colloquial usage often refers to various forms of asphalt as "tar", as in the name of the La Brea Tar Pits.

Naturally occurring asphalt is sometimes specified by the term "crude bitumen". Its viscosity is similar to that of cold molasses; while the material obtained from the fractional distillation of crude oil boiling at 525 °C (977 °F) is sometimes referred to as "refined bitumen". The Canadian province of Alberta has most of the world's reserves of natural asphalt, covering 142,000 square kilometres (55,000 sq mi), an area larger than England.

2.2.1 Characteristic of Bitumen

Bitumen is defined as "A viscous liquid, or a solid, consisting essentially of hydrocarbons and their derivatives; which is soluble in trichloro-ethyelene and is substantially nonvolatile; and it softens gradually when heated". It is black or brown in colour and possesses waterproofing and adhesive properties. It is obtained by refinery processes from petroleum; and is also found as a natural deposit or as a component of naturally occurring asphalt, in which it is associated with mineral matter.

Bitumen has the following five characteristic properties.

i. Bitumen Adheres
ii. Bitumen is Elastic
iii. Bitumen is Plastic
iv. Bitumen is Viscoelastic
v. Bitumen Ages
vi. Bitumen Hardens

i. Bitumen Adheres

Bitumen has excellent adhesive qualities provided the conditions are favorable. However, in presence of water, the adhesion does create some problems. Most of the aggregates used in road construction possess a weak negative charge on the surface. The bitumen aggregate bond is because of a weak dispersion force. Water is highly polar; and hence it gets strongly attached to the aggregate displacing the bituminous coating.

ii. Bitumen is Elastic

When one takes a thread of bitumen from a sample and stretches or elongates it, it has the ability to return to a length close to its original length eventually. For some bitumens, this process may take longer time than others. This property is referred to as the elastic character of bitumen.

iii. Bitumen is Plastic

When temperatures are raised, as well as when a load is applied to bitumen, the bitumen will flow, but will not return to its original position when the load is removed. This condition is referred to as plastic behavior. Applying a load means that you put a weight on the bitumen in order to subject it to stress. This could be in a lab or in the bitumens final position in the road and it is done to assess the bitumens reaction to the load.

iv. Bitumen is Viscoelastic

Bitumen has a Viscoelastic character. Its behavior may be either viscous or elastic depending on the temperature or the load it is carrying. At higher temperatures, there is more flow or plastic behavior, while at lower temperatures and short duration loading, the bitumen tends to be stiff and elastic. At intermediate temperatures, it tends to be a combination of the two.

v. Bitumen Ages

Aging refers to changes in the properties of bitumen over time, which is caused by external condition. These changes are visible as cracks or crumbling areas. When bitumen is exposed to atmospheric conditions, the bitumen molecules react with oxygen, which results in a change of the structure and composition of the bitumen. This process of combining with oxygen, called oxidation, causes the bitumen to become brittle and hard and to change colour from dark brown or black to grey. This change is usually referred to as oxidative hardening or age hardening. This form of ageing occurs more frequently in warmer climatic or during warm seasons, causing older pavements to crack more easily. The condition can also occur where the surface films of bitumen are thin; or if there has been inadequate compaction during construction.

vi. Bitumen Hardens

Exposure to ultraviolet (UV) rays and the evaporation of volatile compounds can cause bitumen to harden. A volatile material is a material that can change in to a gas very quickly. There are two kinds of hardening:

- **Physical hardening**
- **Exudative hardening**

Physical hardening occurs when waxy crystals form in the bitumen structures, or when asphaltenes agglomerates clump together. This condition can be reversed if the temperature is raised.

2.3 Concrete

Concrete is extremely a versatile material for construction which is used for varieties of work. It could be either reinforced or unreinforced (mass). Concrete is a composite material that is obtained by mixing together the coarse aggregate, fine aggregate, cement and water in a suitable manner to achieve the required strength of the concrete with or without ad-mixture. Ayinde O. (2010)

In addition to natural gravel and crushed rocks, a number of manufactured aggregate are available for use in concrete. Air-coded blast furnace slag, which could otherwise be waste production and it's covered by BS1047 used in areas within haulage range of suitable steel work.

Light weight aggregates have been used in concrete for many years. The Romans made use of pumice in some of the construction works. Pumice is still being used today and small quantities are imported and used in Britain; but most light weight aggregate concrete is made using manufactured aggregates. All lightweight materials are relatively weak because of the porosity which gives them reduced weights. This imposed a limitation on strength, though this is not often a serious problem; because the strength that may be obtained is comfortably in excess of most structural required elements; or to give improved thermal insulation. Further information regarding their use may be found in the cement and concrete association publications

In addition to lightweight materials, other manufactured aggregates have been used in concrete. These are mainly used for special purpose. For instance, steel punching or lead shot have been used to produce heavy concrete for radiation shielding. Lightweight aggregates include pumice, scoria, volcanic cinders, tuff and diatomic. (The compressive strength is not as much). Extension research has been undertaken in the use of industrial wastes consisting of fly ash from power plants as a raw material for manufacturing building materials.

The large volume of waste has become one of the most widely accepted problem of environment pollution; as its disposal is expensive and non-productive. Experiment shows that this waste material can be used for the production of high quality building elements.

Light weight aggregates also include:

1. Elephant grass, saw dust, palm kernel shell and ceramic tiles, so we used ceramic tiles as replacement of coarse aggregate in order to determine the strength and workability of the concrete when using light weight; then, this can also be added to economic resources of the nation just as wastes-to-wealth.

Concrete is the most commonly used structural materials. It is a composite material which consists of a medium in which particles of a relatively filter materials (sand and gravel aggregate) are embedded. It begins as a plastic mixture and gradually hardens into a stone like mass.

The properties of hardened concrete are of greatest concern because they determined the ultimate usefulness of the product. Investigation into the use of saw dust as a fine aggregate in concrete shows that the introduction of sawdust on concrete mixes reduces strength and that the densities of the specimens are comparable to those of normal concrete mixes. Concrete having cement, aggregate and water only as constituents is called plain concrete. Plain concrete is very good in compression but very poor in tension. However, if steel is introduced to the constituents above, the type of concrete formed is reinforced concrete. This is very good in tension. Concrete differs from many other materials in that; it is normally produced on site. Hence, Civil Engineering is concerned with both its production and use.

2.3.1 Composition of Concrete

Concrete consists basically of cement, water, and aggregates (fine and coarse).

Cement

Cement can be described as a material with adhesive and cohesive properties, which makes it capable of bonding material fragment into a compact whole for constructional purpose. The meaning of the term "cement" is restricted to the bonding material used with stone, sand, bricks and building blocks. The principal constituencies of cement are compound of lime.

Building and Civil Engineering are concerned with calcareous cement. The cement of interest in making of concrete has the property of setting and hardening under water by virtue of silicate and aluminates of lime; and can be classified broadly as natural cement.

Water

In determining the workability of a concrete, the main factor is the water content of the mix expressed in kilograms of water per cubic meter of concrete. It is convenient to assume that for a given type and grading of aggregate, the water content is independent of the aggregate cement ratio when used for making concrete water of suitable quality that is fit for drinking should be used.

Aggregate

Aggregate is much cheaper than cement and maximum economy is obtained by using as much aggregate as possible in concrete. In fact, aggregate is not truly inert but it is physical, thermal and sometimes also chemical properties influence the performance of concrete. It confers a considerable technical advantage on concrete, which has a higher volume, stability and better durability than the cement paste alone.

The following are the types of aggregates in the construction industry

- Normal Aggregate
- Heavyweight Aggregates
- Lightweight Aggregate

3.0 RESEARCH METHODOLOGY

For this study, the equipment used was collected from Civil Engineering Department, Osun State College of Technology, Esa-Oke.

Enough quantity of fine aggregates and coarse aggregates were stockpiled. Bitumen and cement lime were procured. Each was stored in well labeled containers. The Bitumen was made of 100% bitumen (as revealed in manufacturer's specification).

Potable water for concreting was obtained at the Faculty of Engineering Treatment Plant. Enough bags of ordinary Portland cement were purchased. The sharp sand was air-dried and divided into three parts. One part was for casting control concrete cubes; the second was used for cement lime contaminated cubes production and the last part was reserved for bituminous concrete cubes production. The Batching of concrete constituents in all cases was by weight. The mix ratio adopted was 1:2:4 with water cement ratio of 0.6% by weight. On a flat concrete slab, the right quantity of weighed uncontaminated sharp sand was spread and mixed with cement of known weight. Granite of determined weight was added to the sand cement mixture. Already determined weight of potable water was added. The mixture was mixed together to produce a homogeneous fresh concrete. (Control concrete cubes)

Steel moulds of size 150mm by 150mm by 150mm with inside coated with oil were placed on flat concrete floor. Fresh concrete was poured into the waiting moulds in three equal installments or layers. Using a tamping rod, each layer was tamped 35 times to remove entrapped air. After compaction, the top surface of concrete was trowel smooth and leveled with the top of the mould.

After hardening sufficiently, each cube was labeled for identification purpose. Altogether, 15 control cubes were prepared and kept in cool environment. After 24 hours, the cubes were removed from moulds and completely immersed in a trough full of potable water.

The second portion of sharp sand set aside for cement lime contaminated concrete cubes production was divided into three parts. One part received 5% of cement lime, the second received 10% and the third 15% (all by weight). The measurements were carried out by weighing using 0.1g sensitive balance. The cement lime and sand were mixed thoroughly and air-dried between 3 to 5 days for maturation. Measured quantity of cement lime contaminated sand was used to produce concrete cube of 45 in number. The above procedure was repeated for the production of bitumen contaminated cubes, (45 cubes). Prior to mixing, the bitumen was heated to about 100^0C to aid its mixing with sharp sand. Altogether, 105 concrete cubes were produced and cured in trough filled completely with potable water. The concrete cubes crushing strength were determined experimentally on the 3, 7, 14, 21, 28 days of concrete cubes production. On each day, 21 cubes were crushed, made up of three (3) uncontaminated cubes and eighteen (18) contaminated ones.

Each cube was placed with the cast faces in contact with the platens of the Universal Testing Machine. The cubes were loaded to failure in accordance with BS. 1881: Part 116 (1983).

4.0 RESULTS AND DISCUSSIONS

4.1 Results

The summary of the result of cubes compressive strengths is shown in Table 1, Table 2, and the comparisons are made in Table 3. Also, pictorial representations of the results are displayed in Figures 1 and 2. A sound concrete is expected to have its compressive strength increased with ages.

This was demonstrated by the concrete cubes cast with uncontaminated sharp sand (i.e controlled cubes) as shown in Figures 1 and 2.

In 3 days, the uncontaminated cubes attained 32.9% of their 28 days' compressive strength.

Also in 7 days, 14 days and 21 days, the compressive strength rose to 56.2%, 93.9% and 97.2% of its 28 days' strength respectively.

All these observed variations in compressive strength were similar to those suggested by British Cement Association (2001), which revealed that for a typical Portland cement, the approximate relative proportions of the 28days strength achieved at 7days and 14days suggest that it should be 67% and 83% respectively. Generally, for uncontaminated sharp sand, hydration will continue for a long period of time.

Initially, the rate of hydration will be very fast leading to rapid gaining in concrete compressive strength. But with time, lesser cement particles would remain for hydration, hence the reduction in the rate of strength of concrete cube cast with time contaminated sand was quite different from those of concrete cubes as shown in Figure 1.

In all the three sets of cubes investigated for lime contamination, there were initial rapid increases in compressive strengths development up to 28days of concrete casting. In addition, the higher the percentage of lime present in the fine aggregate, the lower the resulting concrete strength irrespective of concrete age as shown in Figure 1.

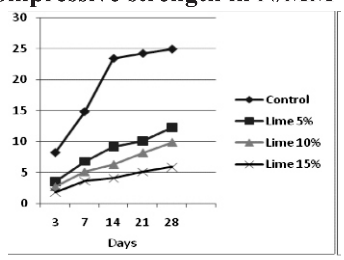
As presented in Table 4.1 at 28days, the cubes compressive strengths were 12.3, 9.9 and 5.9 N/mm^2 for 5%, 10% and 15% lime contamination respectively. This trend was noticed throughout in Table 1.In comparison with the controlled cubes compressive at 28days, these values are equivalent to 49.4%, 39.8% and 23.7% respectively.

TABLE 4.1: Mean compressive strength of cube cast with lime as contaminant and uncontaminated cube (control).

		Lime Contaminated Sand		
Testing Days	Control Cubes	5%	10%	15%
3	8.2	3.5	2.7	1.8
7	14.8	6.8	5.1	3.6
14	23.4	9.2	6.3	4.1
21	24.2	10.1	8.2	5.01
28	24.9	12.3	9.9	5.9

All values are in N/mm^2

Compressive strength in N/MM^2



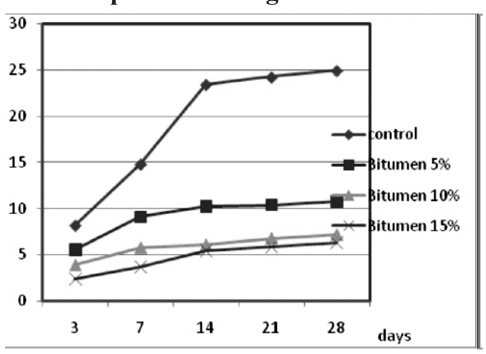
Concrete Cubes Age in days
Figure 1: Variation of compressive strengths of Lime contaminated concrete with ages

TABLE 4.2: Mean compressive strength of cube cast with bitumen contaminated sand and uncontaminated sand (control)

		Bitumen Contaminated Sand		
Testing Days	Control Cubes	5%	10%	15%
3	8.2	5.5	3.9	2.4
7	14.8	9.1	5.8	3.7
14	23.4	10.2	6.3	5.4
21	24.2	10.4	6.8	5.9
28	24.9	10.8	7.2	6.3

All values are in N/mm^2

Compressive strength in N/MM^2



Concrete Cubes Age in days

Figure 2: Variation of compressive strengths of Bitumen contaminated concrete with ages

TABLE 4.3: Comparison between mean compressive strengths of cubes cast with bitumen contaminated sand, lime contaminated sand and uncontaminated cubes

		Lime Contaminated Sand			Bitumen Contaminated Sand		
Testing days	Control Cubes	5%	10%	15%	5%	10%	15%
3	8.2	3.5	2.7	1.8	5.5	3.9	2.4
7	14.8	6.8	5.1	3.6	9.1	5.8	3.7
14	23.4	9.2	6.3	4.1	10.2	6.3	5.4
21	24.2	10.1	8.2	5.1	10.4	6.8	5.9
28	24.9	12.3	9.9	5.9	10.8	7.2	6.3

All values are in N/mm^2

4.2 Discussion

Similarly, Referring To Table 2 And Figure 2, the higher the percentage of bitumen in sand, the lower was the observed compressive strength with ages . The 28day compressive strength of cube made with 15%, 10% and 15% bitumen contaminated sand were 43.4%, 28.9% and 25.3% respectively of those of controlled cubes. The concrete compressive strength development depends to a large extent on cement hydration and aggregate – cement paste bond.

In the presence of water, the particles hydrated form a firm called hydrate cement paste. The cement paste formed physical bond with both fine and coarse aggregates which resulted to concrete strength. Initially, not all cement particles hydrated, the quantities involved in hydrated, the quantitives involved in hydration process in the first few days were much.

As such the, rate of hydration was very high, but gradually reduced as less unhydrated cement particles were present in the controlled cubes. The surface areas of sand particles were heated with bitumen, physical bond formation between cement paste and aggregate (fine) was adversely affected.

The higher the quantity of bitumen present, the higher the barrier to the formation of physical bond responsible for concrete strength would be. The presence of bitumen and C_aO of lime firm around the fine aggregate was responsible for the lower rate of strength development in concrete cubes cast with either time or bitumen contaminated sharp sand.

The quantity of cement particles available for hydration process was much in the first few days of concrete casting as expected for a normal concrete, even though the excepted bond generated with aggregate was hindered by the presence of time and Bitumen respectively, notwithstanding increase in strength development rate still occurred. During hydration, heat was a bye-product which reduced the covering produced by time around sand particles.

In contrast, the heat of hydration effect on bitumen covering around the sand particle was insignificant. The above reasons accounted for higher in values of compressive strength of concrete cubes made with bitumen contaminated sand over those of lime in all cases considered. In addition, the acidity of lime coarse has adverse effect on concrete compressive strength.

4.3 CONCLUSION AND RECOMMENDATIONS

The impact of bitumen and time contaminated sand on concrete compressive strength was investigated. The following fact emerged.

(1) On comparing with uncontaminated cube (controlled concrete cubes) presence of lime and bitumen of any proportion in sand resulted in of lesser compressive strengths. This

revealed clearly that lime and bitumen are compressive strength inhibitors in concrete production.

(2) The 28day-compressive strength of concrete made of contaminated sand of 5% and 10% of bitumen were on the range of 43.4% and 28.9% respectively. The higher the percentage of oil on sand, the lower the compressive strength obtained.

(3) Also, it follows that bitumen in small proportion must be properly evaluated before using such material for concrete production because 5% of bitumen brought about 53.8% reduction in the 28day compressive strength occurred.

Since, all the percentage of contaminant usei.e (lime and bitumen) the resulted compressive strength fell too low to control cubes cast (uncontaminated), we therefore recommend that;

- Both lime and bitumen at percentages used for this research should not be used for concrete production.
- Further research can be carried out on lesser percentage of contaminant, so as to get a result for light weight concrete.

5.0 REFERENCES

Adeagbo, (2010); "Properties and Uses of Lime in Concrete Production," University Press, University of Lagos, Lagos, Nigeria, pp. 88.

Ahod (2012); "Lime additions Portland cement: uptake, chemistry and effects," Proc. 9th International Congress The Chemistry of Cement., National Council for Cement and Building Materials, New Delhi, India, pp. 181-186.

Colantuono (2011) Cement based concretes the addition of lime promotes; Journal of materials in civil engineering, ASCE, Reston; 14 (5), 392 – 398

Bowler, (2010); Progress of the particle size distribution during the intergrading of a clinker-limestone mixture, Zement-Kalk-Gips, International Ed. B., Vol. 45, No. 12, pp. 648-651. Building Research Establishment, UK.

Givens(2013) Lime additions to cement concretes; Proceedings Institution of Civil Engineers Geotechnical Engineering, Thomas Telfords, London, 189 – 193 Establishment's (BRE) "Building Concrete" digest

Goodwin & West, (2014) Influence of Lime in concrete, Innovative Pavement Research Foundation Research Report.

Rafter, (2012), "The effect of fillers on strength of cement mortars," Cement and Concrete Research, Vol. 7, No. 4. pp. 449-456.

SicklesTaves (2012); Percolation and pore structure in mortars and concrete," Cement and Concrete Research, Vol. 24, No.1, pp. 25 .

Zeng, Li, (2012); Strength development and autogenously shrinkage of high-flow concrete with limestone powder," Journal of the Society of Materials Science, Vol. 50, No. 5, Nihan Zairyo Gakkai, Japan, pp. 543-549.

Zeng, (2011); Use of ground limestone in concrete: a new look," Building Research. Journal, Institute of Construction and Architecture, Vol. 43, No. 4., pp. 245-261.

Wright (2012), Impact of lime addition on bond in Concrete, Concrete Research, Vol. 24, No.1, pp. 2 5 37.