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Production of lightweight Concrete using Plastic Wastes as Coarse Aggregates

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ABSTRACT

Concrete is regarded as the most widely used constriction material available nowadays because it can be prepared from locally available material , and also because of its flexibility in handing and placing, despite all its advantages, when it come to attaining the desired strength, it is the most unpredictable material encountered ever. Extensive research work and experiences gained over the years have shown that quality and durability of concrete depend mostly on the properties of its constituents, and at the same time, mix design, method of preparation, placement, curing condition, etc. This study examines the production of lightweight concrete by using plastic water as coarse aggregates, and also analyzed the effect of replacing material aggregate with plastic aggregate on the workability and compressive strength of structural lightweight concrete with ordinary Portland cement (OPC). The study also examines a new potential technique to produce structural .lightweight concrete, and to encourage the constitution industry to make it as a new approach for future use in budding and construction sectors.

Keyword: production lightweight concrete, plastic wastes as coerce aggregates

INTRODUCTION

Lightweight concrete (LWC) has been successfully used the ancient roman times and it has gained its popularity due to its lower (NWE), LWC can significantly reduce the dead load of structural element, which makes it especially attractive in multi-story buildings. Yet, most studies on LWC concern "semi-lightweight" contract, i.e concrete made with lightweight coarse aggregate and natural sand. Although commercially available lightweight fine aggregate has been used in investigations in place of natural sand to manufacture the "total lightweight" concrete (Chandra S. and Berntsson L. 2002, Bera M. and Ferrara G 1990), more environmental and economic benefit can be achieved if waste materials can be used to replace the fine lightweight aggregate. The use of lightweight concrete in reinforced concrete structure has several advantages when compared with ordinary concrete or normal concrete such as crossing of larger spans, high earthquake resistance, heat conductivity property, and fire strength etc. (Husem, 1995; Neville, 1975; Durmus, 1998; Karaca, 1996). Because of the advantages cited above lightweight concrete is being used in many industrial countries. Although lightweight concrete has so many advantages and superiorities over ordinary concrete, thus, the usage of this type of concrete is not as common as ordinary concrete. The reasons for low usage of lightweight concrete are the high price of aggregates in countries whose lightweight aggregate resources are poor, lack of experience, and knowledge of workers about lightweight concrete (Karaca, 1996).

Lightweight concrete may also contain normal or lightweight, fine and/or coarse aggregates. The rigid foam air cell system differs from conventional aggregate concrete in the method of production and in the more extensive range of end uses. Lightweight concrete may be either cast-in-place or pre-cast. Lightweight concrete mix designs in general are designed to create a product with a low density and resultant relatively lower compressive strength (when compared to plain concrete) (J.L. Clarke, 1993). When higher compressive strengths are required, the addition of fine and/or course aggregate will result in a stronger lightweight concrete with resultant higher densities. We should note that most lightweight concrete applications call for a lightweight material. When considering the addition of coarse aggregate, one must consider how appropriate this heavy aggregate will be to a project, which typically calls for lightweight material.

Structural lightweight concrete has an in-place density (unity weight) on the order 1440kg/m^3 to 1840kg/m^3 compared to normal-weight concrete with a density in the range of 2240-2400kg/m^3. For structural applications the concrete strength should be greater than 17.0MPa. The concrete mixture is made with a lightweight coarse aggregate or in some cases the engineers can use a portion or the entire may be a lightweight product. Lightweight aggregate to be used is Plastic wastes.

Lightweight Concrete

Lightweight concrete can be produced using a variety of lightweight aggregates. Lightweight aggregates originate from either:

- Natural materials like volcanic pumice
- The thermal treatment of natural raw materials like clay, slate or shale
- Manufacturer from industrial by-product such as fly ash
- Processing of industrial by-product like FBA or slag

The required properties of the lightweight concrete will have a bearing on the best type of lightweight aggregate to use. If little structural requirement, but high thermal insulation properties are needed, then a light, weak aggregate can be used. This will result in relatively low strength concrete.

Lightweight aggregate concretes can however be used for structural applications, with strengths equivalent to normal weight concrete. The benefits of using lightweight concrete include:

- Reduction in dead loads making savings in foundations and reinforcement.
- Improved thermal properties.
- Improve fire resistance.
- Savings in transporting and handling pre-cast units on site.
- Reduction of formwork and propping

No-Fines Concrete

No-fines concrete is obtained by eliminating the fine material sand, from the normal concrete mix. The single sized coarse aggregate are surrounded and held together by a thin layer of cement paste giving strength of concrete. The advantages of this type of concrete are:

- Lower density
- Lower cost due to lower cement content
- Lower thermal conductivity
- Relatively low drying shrinkage
- No segregation and capillary movement of water
- Better insulating characteristic than conventional concrete because of the presence of large voids.

Waterproof of Concrete

Water resistant concrete are impermeable to water and other fluids either above or below ground. They are high density concretes that incorporate fine particle cement replacements.

Autoclaved Aerated Concrete

Autoclaved aerated concrete was first commercial produced in 1923 in Sweden. Since then, AAC construction system such as masonry units, reinforced floor/roof and well panels and lintels have been used on all continents and every climatic condition.AAC can also be sawn by hand, sculpted and penetrated by nails, Screws and fixings.

Fire Resistance Concrete

Concrete provides the best fire resistance of any building material. It does not burn, it cannot be set on fire like other materials in a building and it does not emit any toxic fumes, smoke or drip molten particles when exposed to fire. Concrete and its mineral constituents enjoy the highest fire resistance classification.

This excellent fire performances is due in the main to concretes constituent materials (I.e. cement and aggregates) which, when chemically combined, form a material that is essentially inert and has poor thermal conductivity. It is this slow rate of heat transfer that enables concrete to act as an effective fire shield not only between adjacent spaces but also to protect itself from fire damage.

The only potential risk to life safety from concrete in fire occurs in the form of spilling, which principally affects high performance and ultra high performance concrete. Even here, effective measure can be taken to reduce the probability of spilling.

Beneficial use of Lightweight Concrete

There are many beneficial use of light weight concrete such as to reduce the dead load of a concrete block, which then allows the structural designer to produce such a lightweight concrete (with high strength and density), to reduce the size of block and other load bearing element in case to let them to stand up to carry the structure loads imposed upon them from various partitions of structural load. However, structural lightweight concrete provides a more efficient strength-to-weight ratio in structural elements. In most cases, the marginally higher cost of lightweight concrete is offset by size reduction of structural elements, less reinforcing steel and reduced volume of concrete, resulting in lower overall cost, for instance, in this study the plan is to produce structural light weight concrete mix design with ordinary Portland cement (OPC), a replacement of conventional coarse aggregate by lightweight aggregate (plastic wastes aggregate) and to cheek the failure of the samples under flexural. In continuation, some of the reasons of using plastic wastes aggregate to produce lightweight concrete is also to access the economic benefit as against normal weight concrete. Due this function if successful, it will lead to customer convincing attitude as the will result in a decrease in dead loads thereby marking saving in foundations and reinforcement hence to a reduction of funding costs, also a powerful way to put new building to useful and profitable employment as early as possible.

Materials and Methods

A proper understanding of the methods adopted during this study on the production of lightweight concrete using plastic wastes as coarse aggregates is fully discoursed. This study focused on analyzing the effect of replacing natural aggregate with plastic aggregate on the workability and compressive strength of structural lightweight concrete with ordinary Portland cement (OPC).

In this research, 3-4 batches of different sample were provided consisting of:

- A control batch which is normal weight concrete
- A batch of lightweight concrete with partial replacement of coarse aggregate (gravel) with plastic wastes aggregate (44.7% plastic wastes).
- A batch of lightweight concrete with full replacement of coarse aggregate (gravel) with plastic wastes aggregates.

Laboratory tests was performed to study the effect of replacing natural aggregate with plastic aggregate on weight of concrete, to analyses the effect on replacing natural aggregate with plastic aggregate on the workability and compressive strength of structural lightweight concrete and also to report on the durability of lightweight concrete. In the run of the laboratory tests performed, the lightweight was compared with the normal weight concrete

MATERIALS

The following materials are going to be used in the preparation of the research specimens:

Cement

The Dangote brand of Portland cement of grade 42.5R with the major chemical composition of the cement as weight accordance to ASTM C150-07 specifications are 63.48% calcium oxide (CaO). 16.56% silica (SiO_2). 4.78% aluminum oxide (Al_20_3) and 2.86% iron oxide (Fe_20_3) (K.I omoniyi *et al*., 2015) was utilized. This cement classified as Portland cement type 1 will act as binder agent at the specimen preparation stage. The cement was gotten from the Omu-Aran market

Fine Aggregate

Fine aggregate (sand) was acquired from within Landmark University and will be used as filler in the preparation of the concrete samples. Only aggregate passing the 600um sieve was used as per the requirement of MS: 30 part 2, 1995. Aggregate size analysis was performed to grade the particles and the aggregate was properly air dried before use to prevent excess water during mixing.

Coarse Aggregate

The coarse aggregate occupies about 70% of the total volume. Aggregate used was collected within Landmark University and was air dried to meet the standard surface dry condition such that the water-cement ratio was not affected. Aggregate used is of size 10mm-20mm in accordance with the requirements of MS: 30 parts 2, 1995 this provided the mass of particles for resisting the action of applied loads, abrasion, percolation moisture and the action of weather and reduced the volume changes resulting from moisture changes in the cement-water paste.

Water

Water was used to aid the workability of the concrete during mix to ensure consistency. Water also, is the reacts chemically with cement to start-up the concrete hardening process. The water used in was portable to ensure quality.

Plastic Wastes

Plastic was collected from the disposal area in Landmark University (PPD disposal area) and Ajase-Ipo and were sorted out to get the superior one. The plastic aggregate gotten from both location summed up to a total of 50kg. Crushing or shredding into smaller fraction and washing to remove the foreign particles were done. The plastic was shredded to a size of 10mm minimum and 20mm maximum.

Fig 3:1: Plastic Aggregates

METHODS

Preparation of Samples

The samples of these studies are to be prepared in accordance with the method published by the United Kingdom department of environment (1988). (Magendran, 2007).

Mix Design

Mix Ratio	1:1:2
Phase 1:	
Characteristics strength: defective 5%)	25 N/mm^2 at 28 days (proportioning
Standard Deviation (S):	$4N/mm^2$
Margin:	k x s,(k=1.65)→ 1.65 x 4 =6.6
Target mean strength:	$f_t = f_{ck} + k.S$
	25+6.6=31.6 N/mm^2
Water-cement ratio:	0.5
Phase 2:	
Slump:	30-60mm
Maximum Aggregate Size:	10mm
Free water content:	$208kg/m^3$
Phase 3:	
Cement content:	203/0.5=$416kg/m^3$
Phase 4:	
Relative density of Aggregate:	2.68(NA)
	0.94(PA)
Concrete Density:	Normal weight =$2,400kg/m^3$

	Light weight:1, 840kg/m^3(full replacement) 2,120kg/m^3 (partial replacement)
Total Aggregate content	2400-416-208=1776kg/m^3(NWC) 2120-416-208=1496kg/m^3 (LWC)$_{PR}$ 1840-416-208=1216kg/m^3 (LWC)$_{FR}$

Phase 5:

Grading of the Aggregate:	Percentage Passing 600um Sieve: 33.33%
Proportion of Fine Aggregate	(30%-55%). Talking 33.33%
Fine Aggregate Content	1776 x 33.33%=591.9kg/m^3 (NWC) 1496 x 33.33%=498.62 kg/m^3 (LWC)$_{PR}$ 1216 x 33.33%=405.29 kg/m^3 (LWC)$_{FR}$
Coarse Aggregate content	1776-592=1184.1kg/m^3 (NWC) 1496-498.62=997.38 kg/m^3 (LWC)$_{PR}$ 1216-405.29=810.71 kg/m^3 (LWC)$_{FR}$
Total volume of concrete per batch:	9(vol. of concrete moulds)+slump cone vol. =9 x (0.150)^3+ 0.0058 =0.03617 m^3
Volume per batch + factor of safety	=0.03675m^3 =36.175 liters

Note: for the reason of only 9 cubes per batch being needed, the slump cone volume will serve as factor of safety in this research.

Total 3: Normal Concrete

PARAMETERS	CEMENT	WATER	FINE AGGREGATE	COARSE AGGREGATE
DENSITY(kg/m^3)	416	208	591.9	1184.1
VOLUME(M^3)	0.036175	0.036175	0.036175	0.036175
WEIGHT(kg)	15.0488	7.5244	21.4119	42.8348

Lightweight Concrete with 44.7% Plastic Wastes

PARAMENTRS	CEMENT	WATER	FINE	CORASE	PLASTIC
DENSITY(kg/3)	416	208	498.62	551.2155	446.1645
VOLUME(m3)	0.036175	0.036175	0.036175	0.036175	0.036175
WEIGHT	15.0488	7.5244	18.0376	19.9402	16.14

Lightweight Concrete with Full Replacement

PARAMENETRS	CEMENT	WATER	FINE AGGREGATE	PLASTIC AGGREGATE
DENSITY (kg/m3)	416	208	405.29	810.71
VOLUME(m3)	0.036175	0.036175	0.036175	0.036175
WEIGHT(kg)	15.0488	7.5244	14.6614	29.3274

Mixing Method

The traditional concrete mix method was adopted in this study: the traditional method of mixing by manual labor was used. Three concrete batches were produced with the following feature:

- A control batch which is concrete with 100% normal aggregate
- A batch containing 44.74% plastic wastes aggregate and 55.26% normal aggregate
- A batch containing 100% of plastic wastes aggregate

Fig. 3.2: Mixing Process

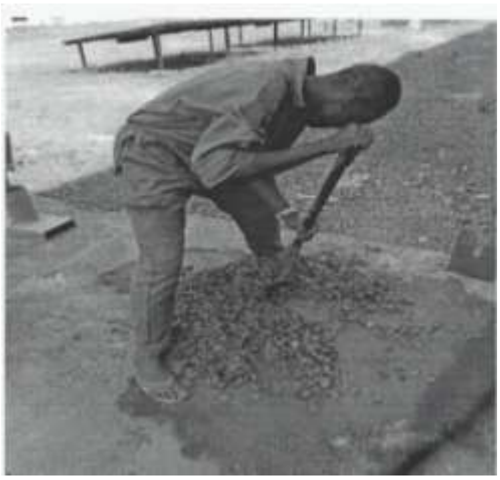

Fig. 3.3: Concrete Mixing

All materials was weighed separately in accordance with the mix design then mixed manually in a thorough manner so as to ensure homogeneity of the concrete mix.

Concrete Mixing

All material was weighed separately in accordance with the mix design than mixed manually in a through manner so as to ensure homogeneity of the concrete mix.

Curing Method

The continuous hydration of cement is essential in concrete strength. Hence, all test specimens, after 24hours of setting will be carefully removed from their moulds and placed in a curing tank filled with water at a controlled temperature sat 20-25C. The specimens will only be removed from the curing tank when due for testing in accordance with BS 188: 111, 1983. The necessity of curing arises from the fact that hydration of cement can take place only in water filled capillaries. This is why a loss of water by evaporation from the capillaries must be prevented. Furthermore, water lost internally by self-desiccation has to be replaced by water from outside; i.e. ingress of water into the concrete must be made possible.

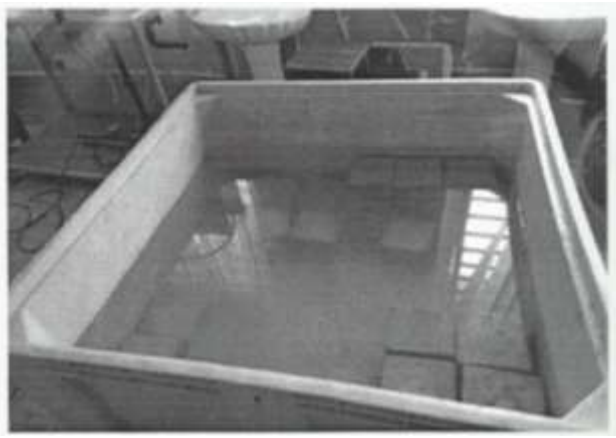

Fig 3.4: Concrete Curing

LABORATORY TEST

CONCRETE SLUMP TEST

Aim: To determine the workability of concrete.

Apparatus or Equipment Used:

- Tamping rod
- Slump cone
- Tape rule
- Hand trowel
- Straight edge

Diagram

Fig 3.5: Slump Cone and Tamping Rod

Theory

Unsupported fresh concrete, flows to the sides and a sinking in height takes place; the vertical settlement is known as slump.

In this test fresh concrete is filled into mould of specified shape and dimension & the settlement or slump is measured when supporting mould is removed slump increase as water cement is increased.

Slump is a measure indicating the consistency or workability of cement concrete. If gives an idea of water concrete needed for concrete to be used for different works. A concrete is said to be workable if it can be easily mixed and placed, compacted & finished. A workable concrete should not show any segregation or bleeding.

Procedures

1. Calculate the weight of various concrete components according to the mix design and volume of concrete required.
2. Measure or weight out the various concrete components and mix on a flat surface.
3. Measure the weight of the mould.
4. Clean the slump test mould and other apparatus to be used.
5. Place the slump mould on a flat non-absorbent moist and rigid surface and hold firmly to the ground by foot or hand support.
6. Fill one third of the mould with the prepared fresh concrete and rod it 25times uniformly over the cross section.

7. Likewise fill the mould to two third height and rod it 25timesx.
8. Fill the mould to the top completely and rod it 25times and level with a trowel.
9. If the concrete settles below the top of the mould, add more concrete and level off with trowel.
10. Remove the mould immediately in one attempt.
11. Measure and record the slump as the vertical height/ distance/ difference from the top of the mould to the average concrete level.
12. Clean up the mould, apparatus and work area used.

Result and Calculations

Slump= Height of the slump cone- Height of the unsupported concrete

COMPRESSIVE STRENGTH TEST FOR CONCRETE

Aim: To determine the compressive strength of concrete.

Apparatus

150mm cube moulds, ramming rod, mixer, weighing machine, capping apparatus, 200 tones compression machine and 5 tones trances verse testing verse testing machine, buckets and base plate.

Diagram

Fig 3.6: Compression Machine

Theory

One of the important properties of concrete is its strength in compression. The strength in compression has a definite relationship with all properties of concrete i.e. these properties improved with the improvement in compressive strength. The height of the test specimen in relation to its lateral dimensions greatly influences the results. The more slender the best specimen. Lower will be crushing strength. The ratio of the minimum dimension of the specimen to maximum size of aggregate should be at least 4:1.

Materials

Fine Aggregate, Course Aggregate, Cement and Water

Procedures

1. For preparing the concrete of given proportions (1L: 2:4) by mass and w/c ratio of 6.
2. Mix thoroughly in a mechanical mixer until uniform colour of concrete is obtained.
3. Pour concrete in the moulds oil with medium viscosity oil. Fill concrete in cube moulds in two layers each of approximately 15mm and ramming each layer with 35 blows evenly distributed over the surface of layer.
4. Struck off concrete flush with the top of the moulds.
5. Immediately after being made, they should be covered with wet mass.

Curing

Specimens are removed from the moulds after24 hours and curing in water for 7, 14, 21 and 28 days respectively.

Testing

Compression test of cube specimen are made as soon as practicable after removal from curing pit, test-specimens during the period of their removal from the curing pit and till testing are kept by a wet blanket covering and tested in a moist condition. The size of specimen is determined to the nearest of 2mm by averaging the perpendicular dimension at least two places. The mass of each specimen is recorded.

a) Place the specimen centrally on the location marks of the compression testing machine and load is applied uniformly and without shock. The rate of loading is continuously adjusting through rate control value by hand to 14n/mm2/ minutes for cube. The load is increased until the specimen fails and record the maximum load carried by each specimen during the test also notes the type of failure and appearance of cracks.

Result and Calculate

P= F/A (N/mm^2)

COMPACTING FACTOR APPARATUS TEST

Aim: To determine the workability of concrete mix of given proportions by compaction factor test.

Apparatus

Compaction factor apparatus, trowels graduated cylinder of 1000ml capacity, balance to weigh up 30kg tamping rod and iron bucket.

Diagram

Fig 3.7: Compacting factor Apparatus

Theory

Compaction factor test is adopted to determine the workability of concrete, where nominal size of aggregate does not exceed 40mm. It is based on the workability which is that property of the concrete which determine the amount of work required to produce full compaction. Test consists essentially of applying a standard amount of work to standard quality of concrete and measuring the result compaction workability givens an idea to concrete mix to get uniform strength.

Procedure

1. Keep the compacting factor apparatus on a level ground and apply grease on the inner surface of the hopper and cylinder.

2. Fasten and flap doors.
3. Weigh the empty cylinder accurately and note down the mass WI kg.
4. Fix the cylinder on the base with fly nuts and bolts in such a way that the central point of happens and cylinder lie on one vertical line.
5. Mix is to be prepared with water cement ratio. 50. .60, .70 and 80
6. Fill the freshly concrete in upper hopper gently and carefully with hand scoop without compacting.
7. After 2min, release the rap door so that the concrete may fall in the lower hopper bringing the concrete into standard compaction.
8. Immediately after the concrete has come to rest open the trap door of lower hopper and allow the concrete to fall into the cylinder and bring the concrete into standard compaction.
9. Remove the excess concuss concrete above the top of the cylinder by a pair of trowels, one in each hand will blades horizontal slide them from the opposite edges of the mould in ward to the centre with a sawing motion.
10. Clean the cylinder from all side properly find the mass of partially compacted concrete thus filled in the cylinder W2kg.
11. Refill the cylinder with the same sample of concrete in approximately 50mm layer vibrating each layer weaving so as to expel all the air to obtain full compaction.
12. Struck off level the concrete and weigh the cylinder full with fully compaction concrete let the mass be W3 kg.

Lightweight

Lightweight concrete has extreme importance to the construction industry. Most of current concrete research focuses on high-performance concrete, by which is meant to be cost-effective material that satisfies demanding performance requirements, including durability. Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as lessened dead weight. it is light than the conventional concrete. The use of lightweight concrete has been widely spread across countries such as USA, United Kingdom and Sweden. The other main specialties of lightweight concrete are its low density and thermal conductivity. So its advantages are that there is a reduction of dead load, faster building rates in construction and lower transport and handling costs.

Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. Sufficient water can cause lack of cohesion between particles, thus loss in strength of concrete. Likewise too much water can cement to run off aggregate to from layer, subsequently weakens in

What is the Light Concrete?

Light weight concrete (foamed concrete) is a versatile material which consists primarily of a cement based mortar mixed with at least 20% of volume air. The material is now being used in an ever increasing number of applications, ranging from one step house casting to low density void fills. Light weight concrete has a surprisingly long history and was first patented in 1923, mainly for use as an insulation material. Although there is evidence that the Romans used air entertainers to decrease density, this was not really a true light weight concrete. Significant improvement over the past 20 years in production equipment and better quality surfactants (foaming agents) has enable the use of foamed concrete on larger scale.

Lightweight are free flowing, it is a material suitable for a wide range of purposes such as, but not limited to panels and free flowing, it is a material suitable for a wide range of purpose such as, but not limited to panels and block production, floor and roof screeds, wall casting, complete house casting, sound barrier walls, floating homes, void infill, slope protection, outdoor furniture and many more applications.

Not everyone knows that density and compressive strength can be controlled. In the light weight concrete this is done by introducing air through the proprietary foam process which enables one to control density and strength precisely.

Normal concrete has a density of 2,400 kg/m^3 while densities range from 1,800, 1,700, 1,600 down to 300kg/m^3. Compressive strength range from 40 MPa down to almost zero for the really low densities. Generally it has more than excellent thermal and sound insulating properties, a good fire rating, is non-combustible and features cost savings through construction speed and ease of handling.

The technology is the result of over 20 years of R%D, fine tuning the product and researching the possible applications. It is used in over 40 countries worldwide today and has not reached the end of its possible uses. Lightweight concrete is concrete weighing substantially less than that made using gravel or crushed stone aggregates. This loose definition is generally agreed to cover a broad spectrum of concrete ranging in weight from 12 to 120 pounds per cubic foot. Many type of concrete fall within this range: some are cellular concretes made with form or foaming agent: some are made with lightweight aggregate: and some cellular concretes also contain lightweight aggregates. Other lightweight concrete may contain some normal weight sand. The compressive strength of these concrete covers an even border spectrum, with structural lightweight at 600 psi and higher at one extreme, and cellular fill concrete at 5 psi at the other extreme lightweight aggregate concrete is usually chosen for structural purposes where its use will lead to a lower overall cost of structural than would be expected with normal weight concrete. The generally higher unit cost of lightweight structural concrete is offset by reduced dead loads and lower foundation costs. There may be a special advantage when existing structural are being altered or expanded. For example, four stories were added to an existing Cleveland department store without modifying the foundation. When the Tacoma Narrows Bridge was replaced, the original piers were able to carry the load of additional traffic lanes, thanks to the use of structural lightweight concrete in the bridge deck.

AGGREGATE

General

Aggregate generally occupy about 70 to 80% of the volume of concrete, it is not surprising that its quality is of considerable importance. Not only may the aggregate limit the strength of concrete, as weak aggregate cannot produce strong concrete, but the properties of aggregate greatly affect the durability and structural performance of concrete.

Aggregate are granular materials, derived for the most part from nature rock, crushed stone, or natural gravels broken brick and sands. Aggregate was original viewed as an inert material dispersed throughout the cement past largely for economic reasons. It is possible however, to take an opposite view and to look on aggregate as a building material connected into a cohesive whole by means of the cement paste, in a manner similar to masonry construction. In fact, aggregate is not truly inert and its physical, thermal and sometimes also chemical properties influence the performance of concrete.

The mineral aggregate, has three principal functions while used in concrete.
These are:

- To provide a relatively cheap filler for the cementing material.
- To provide the mass of particles for resisting the action of applied loads, abrasion, percolation of moisture and the action of weather.
- To reduce the volume change resulting from moisture change in the cement-water paste.

  Soft, porous aggregate can limit strength, wear resistance and also may break down during mixing and adversely affect workability by increasing the amount of fines. Aggregate should also be free of impurities like silt, clay and other fine materials will also increase the water requirement of the concrete. Organic matter may interfere with cement hydration.

Classification of Aggregate

Strength of concrete and mix design is essentially independent of the composition of aggregate. No particular rock or mineralogical type in itself, is required for aggregate in the absence of special requirements, most kinds of rocks and most of the artificial materials can produce acceptable aggregate that conform to BS and ASTM specification. Thus, classification by mineralogy or rock type has almost no practical engineering significance.
The simplest and most useful classifications of aggregates are:

- Classification on the basis of gravity and origin

a. Normal weight aggregate

i. Natural aggregate (e.g. sand, gravel, crushed rock such as granite, quartz, basalt, sandstone e.t.c).

ii. Arterial aggregate (e.g. broken brick, air cooled slag etc.)

b. Lightweight Aggregate
c. Heavyweight Aggregate
- Classification based on Aggregate size

a. Fine Aggregate
b. Coarse Aggregate

Often fine aggregate are called sand are not lager than 5 mm or 3/16 in. the coarse aggregates comprise the materials in size greater than this size.

However, in the USA the division is at ₦4 sieve, which is a actually 3/16 inch or 4. 16 mm in size, i.e. the same as mentioned above.

Properties of Aggregate

Aggregate posses certain properties, which directly the strength of concrete.

Some of these properties cannot be measured qualitatively and some indirect measure are sometime adapted. The main properties, which may influence the concrete properties, are

- Shape
- Texture
- Size gradation
- Moisture content
- Specific gravity
- Bulk unit weight
- Strength of aggregate

Types of Aggregates

According to ACI (the American concrete institute), structural lightweight have a 28-day compressive strength of 2500 psi4 or more and a weight not exceeding 115 pounds per cubic foot. Lightweight concrete may also contain normal or lightweight, fine and/or coarse aggregates. The rigid foam air cell system differs from conventional aggregate concretes for structural use derives their special properties from the use of low density aggregates whose particles have an internal cellular structure. These may be either processed or naturally occurring and unprocessed materials. The ACI guidelines for structural lightweight concrete are based on concretes made with processed aggregates meeting the requirement of ASTM standard C330

These in include:

- Rotary kiln expanded clays, shale, and slates
- Sintering grate expanded shale and clays
- Pelletized or extruded fly ash
- Expanded slags

However, lightweight structural concrete may also be made with other types of aggregates such as naturally occurring pumice and scoria and with suitable cinders.

Properties of the lightweight aggregates such as shape and surface texture, specific gravity, unit weight, particle size, strength, moisture content, and absorption all affect properties of fresh and hardened lightweight concrete, just as comparable properties of normal weight aggregates do, but the quality of the cement paste also has an important influence on properties of the concrete.

PLASTIC WASTES

Wastes are those substances that regarded of on further use. Plastic wastes are those substances or materials with the property of plasticity that is regarded of no further use Due to rapid increase of population in world; the amount of waste products such as waste plastic also increases rapidly. These waste plastic will remain in the environment problems of years. The combined of these waste plastic in concrete may reduce the environmental problems up to certain extent. It is possibility of disposal of these wastages in mass concrete such as in heavy mass concreting in PCC in pavement where the strength of concrete is not a major criteria under consideration (Youcef Ghernouti, Bahia Rabehi, 2011).

The waste plastic is one component of Municipal Soil Waste (MSW). The disposal of the wastes plastic which cause the big problems to the environmental because the research concern that the use of by-products from industry may augment the properties of concrete. In the modern decades, the use of by-products such as silica fume, glass culvert, fly ash, ground granulated blast furnace slag (GGBs) etc., efforts have been made to use in civil construction. The application of the industrial by –products in concrete is as partial replacement of cement or partial replacement of aggregate (Batayneh, 2007).The use of these waste plastic in concrete can control the environmental problem or constraints if safe disposal of these products. In the present study the recycled plastic used to prepare the coarse aggregate there by providing sustainable option to deal with plastic waste (Nabajyothi and Jeorge, 2012).

General

The word "plastic" means the substances which have plasticity and accordingly that it can be formed in soft and used in solid state can be called plastic. The plastic can be separated in to two types. The first of plastic is thermosetting plastic and second is thermosetting the thermo setting plastic cannot be melted by heating because the molecular chains are bonded firmly with meshed crosslink. These types of

plastic are called polyurethane, silicone, epoxy resin, unsaturated polyester, melamine and Phenolic. The second type is thermoplastic, which can be melted by heating and use for recycling in the plastic industry. These types of plastics are polypropylene, polyamide, polyoxymethylene, polyetetrafluorethylene and polyethyleneterephthalate.
However at present these plastic wastages are disposed by either burning or burying, but the process is very costly. If the thermosetting plastics are reused, the cost of the process as well the pollution that is caused by the burning of plastic can be reduced. However to achieve this purpose, the thermosetting plastics are used in construction materials particularly concrete wall in construction (Panyakapo, 2007).

Plastic Waste Disposal

The quantity of plastic waste is increase rapidly and it is estimated that the rate of expansion is double every 10 years. This is due to growth of population and industrial sector rapidly (Phaiboon and Mallika, 2007). The National Council on Public Works Improvement identified that the solid waste crisis as an area of infrastructure with great needs of improvements (Rebeiz *et al.*, 1993). Among the solid waste materials, plastic have a lot of attention it is

- Polyethylene terephthalate (PET)
- High density polyethylene (HDPE)
- Un-plasticized polyvinyl chloride (UPVC)
- Low density polyethylene (LDPE)
- Polypropylene (PP)
- Polystyrene (PS)

Sources of Generation of Plastic Waste

- Household: Carry Bags, Bottles, containers and trash bags.
- Hotel and Catering: Mineral water bottles, Glasses, Packaging items, Plastic plates hand gloves
- Health and Medicare: disposable syringes, surgical gloves, glucose bottles, blood, intravenous tubes, catheters (Kiran Kumar & Prakash)

Making of Plastic Aggregate

After a review of various research studies, high density polyethylene (HDPE) was selected as a substitute for natural aggregate. HDPE is the largest of the three

polyethylenes by volume of consumption. HDPE is prepared from ethylene by a catalytic process. It is also harder, more opaque and can withstand higher temperature. They are impact and wear resistant and can have very high elongation before breaking when compared to other materials. They are chemical resistant and cheap too. It has a very linear structure with only a few short side branches and hence leading to higher density range as well as more crystalline structure. These properties give HDPE its higher strength compared to the PEs, allowing a wider range of use. The properties of
HDPE are:

- Excellent resistant (no attack) to dilute and concentrated acids, alcohols and bases.
- Melting point: 130°C – 180°C
- Specific Gravity: 0.95
- Water absorption: 0.001% - 0.010%
- Chemical resistant
- Impact and wear resistant
- Can withstand high temperature

The plastic aggregates were prepared from recycled HDPE sheets. Generally the plastic recycling can be completed through 5 steps: sorting, shredding, washing and extruding. The various steps involved in recycling and making of plastic are described below.

Sorting the Plastic

Once the recyclable plastic materials were collected, the first stage of recycling began by sorting out the plastic material of different types. Plastic recycling is a complex process compared to other recycling process because of the different types of plastic that exists. Mixed plastic cannot be used as it is poor in quality. Therefore it's essential to sort out plastic materials. HDPE is thus sorted out (Fig 1).

Fig 2.1: Sorting of Plastic

Fig. 2.2: Shredding the Plastic

The plastic materials were then prepared for melting by cutting them into small pieces. The plastic items are fed into a machine which has set of blades that slice through the material and break the plastic into tiny bits (Fig 2).

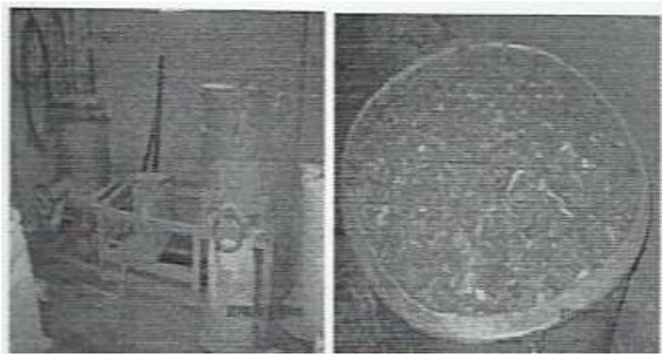

Fig 2.2: Shredding and shredded HDPE Materials

Washing Shredded Plastic

All residues of products contained in the plastic items and various other contaminants are removed. A particular wash solution consisting of an alkaline, cationic detergent and water are used to effectively get rid of all contaminants on the plastic (Fig 3).

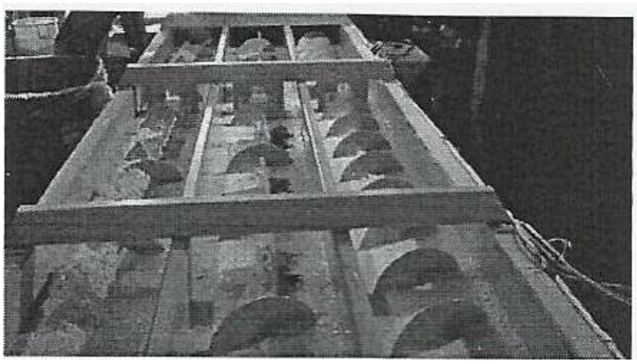

Fig 2.3: Washing of Shredded Plastic

Extruding

This is the final stage in the recycling process. The cleaned and chipped pieces of plastic are melted down and put through a machine called extruder. After the plastic is melted and compressed, it is channeled into the metering section. Here, the plastic undergoes pressurized pumping, while the root diameter of the screw and the flight size remain constant (Fig 4).

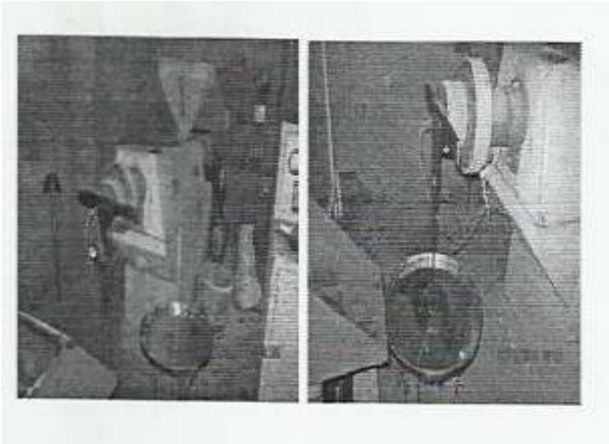

Fig 2.4: Extruder and Extrusion of Plastic (Anju Ramesan *et al.,*)

Plastic Aggregate

These melted plastics were allowed to fall on a rough surface through the die. Plastic sheets of 20mm thick were made out of these recycled materials. Undulations were made on the surface of the sheets. These sheets were then cut into aggregates of 20mm size (Fig 5).

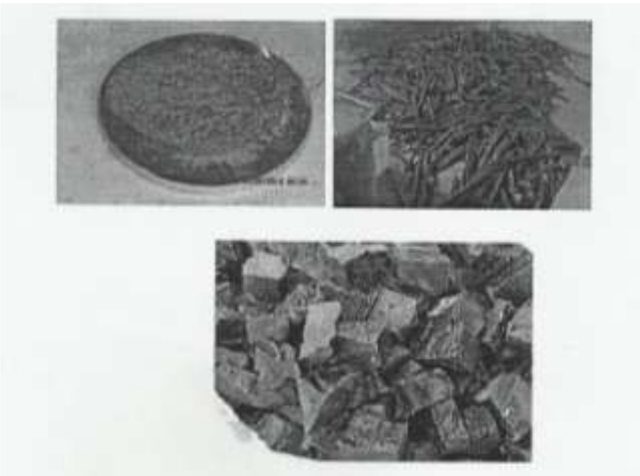

Fig 2.5: Making and Cutting of Plastic Sheets into Aggregate

RESULT AND CONCLUSION

Introduction

This section given a detailed analysis of the data obtained from each batch of concrete and also makes inferences from the observation of the experiment.

Density of Concrete

Density is defined as mass/volume.

For the Normal Concrete Batch

Normal Concrete Density

MASS (kg)	VOLUME (m^3)	DENSITY (kg/m^3)
7.9995	0.003375	2370.22
8.192	0.003375	2427.26
7.8165	0.003375	2316
7.995	0.003375	2368.89
8.1575	0.003375	2417.04
7.919	0.003375	2346.37
7.880	0.003375	2334.82
7.715	0.003375	2285.95
7.9175	0.003375	2345.92

Average Density is 2356.94 kg/m^3

For the Lightweight Concrete with 44.7% Plastic Wastes (Partial Replacement)

Partially Replaced Concrete Density

MASS (kg)	VOLUME (m^3)	DENSITY (kg/m^3)
7.0865	0.003375	2099.70
6.8695	0.003375	2035.41
6.269	0.003375	1857.48
5.7725	0.003375	1710.37
6.814	0.003375	2018.96
7.0145	0.003375	2078.37
5.919	0.003375	1753.78
5.9675	0.003375	1768.15
7.406	0.003375	2194.37

Average Density of concrete is 1946.29 kg/m^3

For the Lightweight Concrete with Full Replacement

Fully Replaced Plastic Concrete Density

MASS (kg)	VOLUME (m^3)	DENSITY (kg/m^3)
4.1065	0.003375	1216.74
3.630	0.003375	1075.56
4.309	0.003375	1276.74
3.4745	0.003375	1029.48
3.601	0.003375	1066.96
3.8745	0.003375	1148
3.285	0.003375	973.33
3.522	0.003375	1043.56
3.1655	0.OO3375	937.93

Average Density of concrete is 1085.37 kg/m^3

Thus it can be seen that the density of concrete decreases with increase in the weight content of lightweight aggregate. In other words a coarse aggregate of high density will produce a concrete of high density and a coarse aggregate of low density will produce a concrete of low density.

WORKABILITY TESTS

Slump Cone Test

The slump value for the 3 batches of concrete specimen is given in the table below.

Slump Value

Batch	Slump
Control	41mm
Partial replacement	73mm
Full replacement	0mm

The control batch had a slump value of 41mm. This is classified under Low Workability concrete and had a True Slump profile. The lightweight concrete with a partial replacement of normal aggregate using plastic aggregate which consists about 45% of the total coarse aggregate weight experienced a collapse slump of 73mm. This batch had the highest workability in the whole experiment.

The lightweight concrete with a full replacement of normal aggregate with plastic aggregate experienced a True Slump however the lowest workability occurred here as the value of the slump recorded is a 0mm slump. The factor responsible for this the shape of the plastic aggregate which was not totally in an aggregate shape and there by resulting in a Zero (0) slump. The profile for the slump of the 3 batches is shown below.

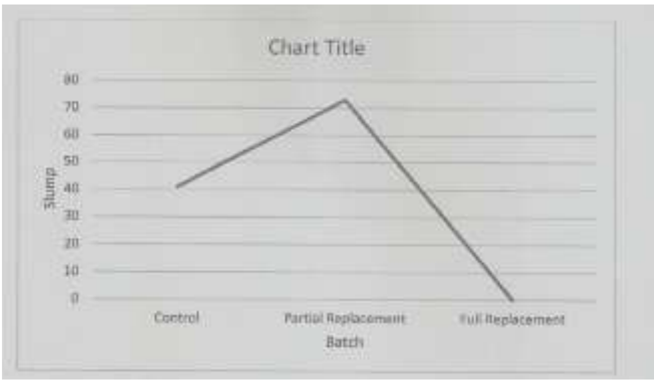

Fig.4.1: Slump Graph

From the profile above it shows that the value and workability of the concrete will increase with a proportionate increase in plastic wastes percentage under normal circumstances but due the shape of the plastic aggregate there was a drop to zero value of slump.

Compacting Factor Test

Compacting Factor

Batch	Weight Of mould	Weight Of Mould concrete	Weight of Mould+ Compacted Concrete	Compaction Factor
Control	7771g	19086g	19467.5g	0.98
Partial Replacement	7534.5g	14025g	14365.5g	0.95
Full Replacement	7763g	11572g	11572g	0.96

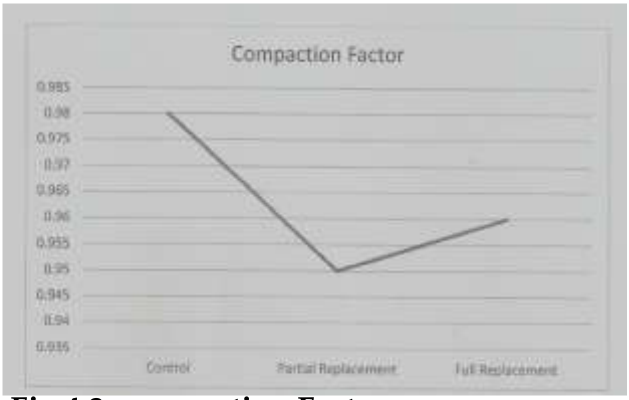

Fig.4.2: compacting Factor

Compressive Strength Test

The compressive strength test was done for each batch at uniform intervals consisting of cubical specimen of size 150mm. the specimens were left in the curing tank during these intervals and removed upon the time for testing. The percentage of plastic was 0%, 45% and 100%. The compressive strength test was carried out as per BS EN12390 PT 3. The test was carried at the end of 7days, 14days and 28 days for each batch and the average of three cubes for each batch was taken.

The compressive strength of concrete is determined at a water cement ratio of 0.50. The test done was at triplicate test so as to increase the accuracy of value by finding the average compressive strength. The compressive strength for control and plastic and plastic concrete for various percentage of plastic at 7 days, 14 days and 28days of curing are shown below.

7day Intervals

The table below show the date of the 7 days specimen for each batch

Table 4.6: 7 days Compressive Strength

BATCH	WEIGHT (G)	STRENGTH (KN)	COMPRESSIVE STRENGTH(n/mm²)
Control	7999.5	448.8	19.9
Control	8192	439.5	19.5
Control	7816.5	337.3	14.9
Partial Replacement	7086.5	154.7	6.8
Partial Replacement	6869.5	148.1	6.5
Partial Replacement	6269.0	96.6	4.2
Full Replacement	4106.5	25.9	1.1
Full Replacement	3630	12.7	0.5
Full Replacement	4309	27.5	1.2

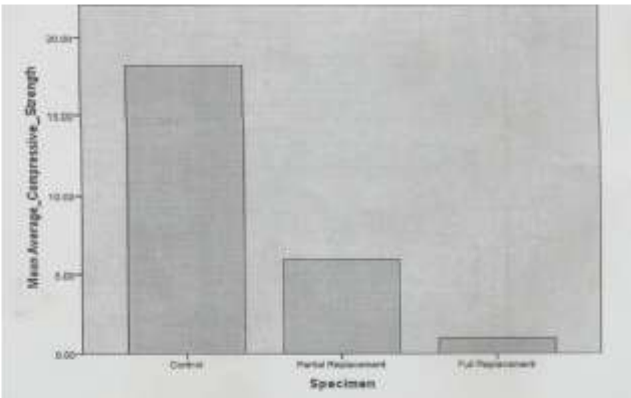

Fig 4.3: 7 days compressive Strength Bar Chart

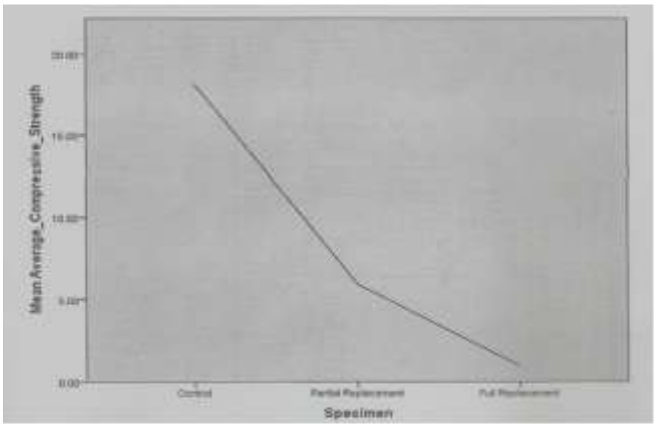

Fig 4.4: 7 days Compressive Strength Graph

14 Days Interval

14 days Compressive Strength

BATCH	WEIGHT (g)	STRENGTH(KN)	COMPRESSIVE STRENGTH (N/mm²)
Control	7995	585.7	26
Control	8157.5	465.7	20.7
Control	7919	409.7	18.2
Partial Replacement	5772.5	90	4
Partial Replacement	6814	136.6	6
Partial Replacement	7014.5	152.6	6.7
Full Replacement	3474.5	19	0.8
Full Replacement	3601	31	1.3
Full Replacement	3874.5	24	1

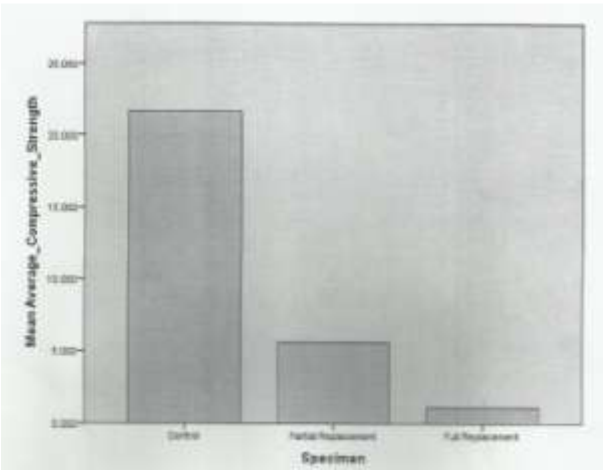

Fig 4.5: 14 days Compressive Strength Bar Chart

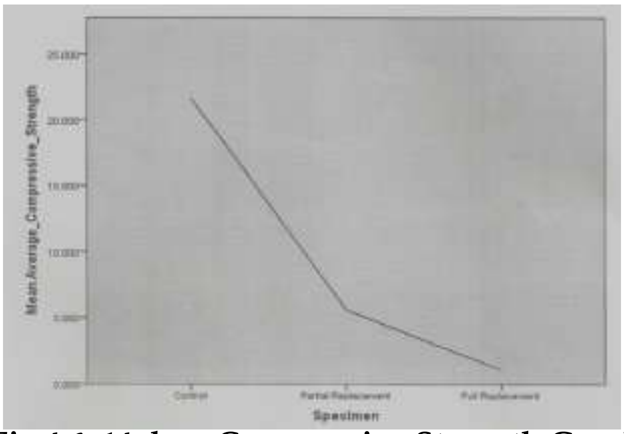

Fig 4.6: 14 days Compressive Strength Graph

28 Days Interval

28 days Compressive Strength

BATCH	WEIGHT (g)	STRENGTH (KN)	COMPRESSIVE STRENGTH (N/mm²)
Control	7880	438.8	19.5
Control	7715	447.1	19.8
Control	7917.5	355.3	15.7
Partial Replacement	5919	80	3.5
Partial Replacement	5967.5	86	3.8
Partial Replacement	7406	190.7	8.4
Full Replacement	3285	31.6	1.40
Full Replacement	3522	38.5	1.71
Full Replacement	3165.5	36.2	1.61

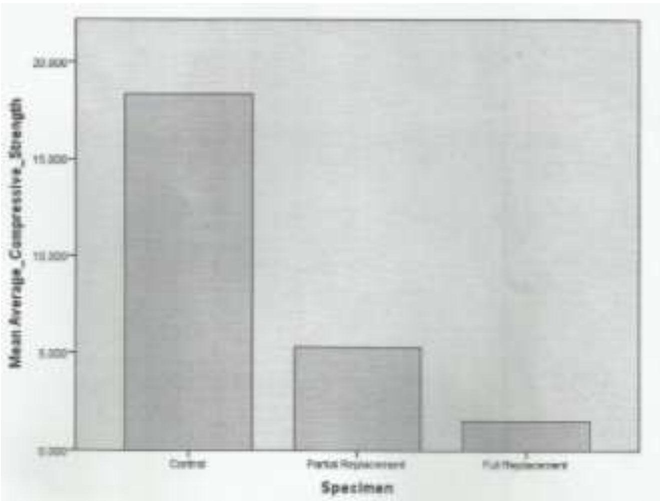

Fig 4.7: 28 days Compressive Strength Bar Chart

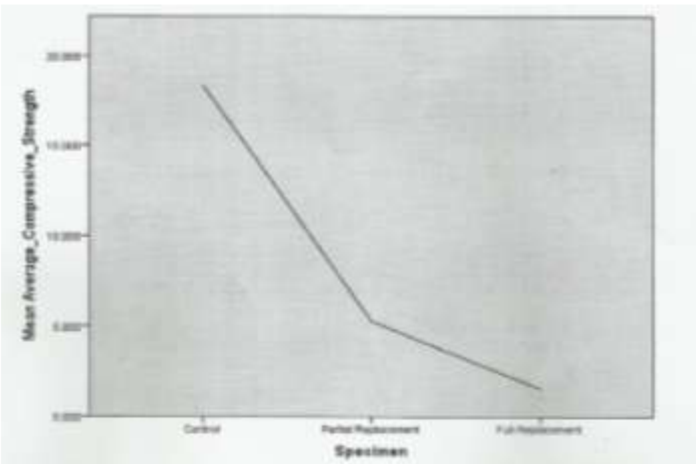

Fig 4.8: 28 days Compressive Strength Graph

From the test results above, by observation it can be inferred that the compressive strength as relates with this research decreases as the weight of lightweight aggregate increases. The reason for this is that one of the factors that is responsible for the strength of concrete is the strength of the coarse aggregate. Other factors may include the mix ration, self-desiccation (which can be reduced by curing) etc. but for the purpose of the concerned project we will be focusing on the Coarse aggregate strength as the factor responsible for the variation in the compressive strength of the Batches.

All Graphs in One

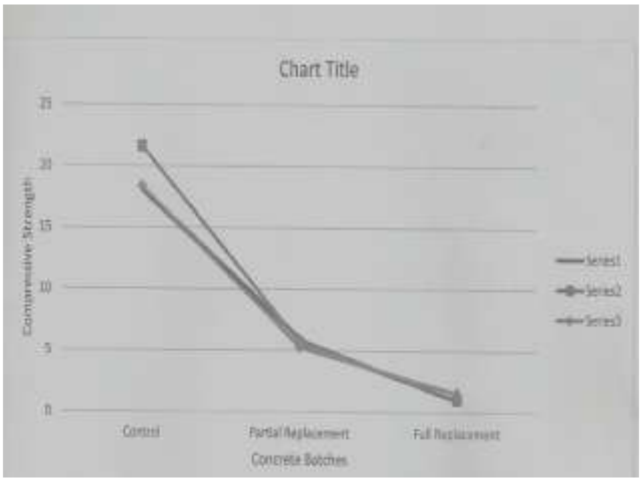

Fig 4.9: Comparison of Compressive Strength of Various Batches

Advantages of Lightweight Concrete

1. It is governed primarily by economic considerations
2. Reduces the dead load of a structure
3. Formwork will withstand low pressure
4. Improved hydration due to internal curing
5. Ease of Renovation and repair
6. Lightweight concrete are eco-friendly. They help in reducing 30% of the environment waste, 50% of greenhouse radiation and 60% integrated energy on the surface of the brick.
7. Lightweight concrete offer easy workability. It is easy and quick to install on site
8. The industrial waste if found suitable for

lightweight concrete can be utilized economically

9. The reduction in weight of concrete helps easy removal, transport and erection of precast product
10. The use of lightweight concrete results in reduction of cost to the extent of about 30%-40%.
11. The lightweight concrete has comparatively less tendency to spall. Hence its fire resistance is greater as compared to concrete.
12. The lightweight concrete has generally a lower thermal expansion than ordinary concrete. Because of this thermal efficiency, it reduces the heating and cooling load in buildings

CONCLUSION

In conclusion to this project embarked upon, lightweight concrete has its attendant advantages over normal concrete. It will be observed that the compressive strength decreases with increase in the weight of plastic aggregates, the self-weight of the lightweight concrete reduces and the workability of the lightweight concrete under normal condition also increases. This study intended to find the effective ways to reutilize the hard plastic waste particles as concrete aggregate.

Analysis of the strength characteristics of concrete containing recycled waste plastic have the following results.

- It is identified that plastic waste can be disposed by using them as construction material.
- Since the plastic waste is not suitable to replace fine aggregate it is used to replace the coarse aggregate.
- The compressive strength of concrete containing plastic aggregate is retained more or less in comparison with controlled concrete specimens by inference. However strength noticeably decreased when the plastic content was more than 30%.
- Has been concluded 15%-30% of plastic waste aggregate can be incorporated as coarse aggregate replacement in concrete without any long term detrimental effects and with acceptable strength development properties.
- Lightweight concrete is economical. It is more affordable to the low income earners

RECOMMENDATION

I therefore recommend that this phenomenon be adopted into and utilized more in Nigeria. I will recommend researches be carried out on Lightweight concrete as civil engineering is a general need and necessity and thus should be affordable to the populace irrespective of the status quo of individuals. I also recommend that lightweight concrete should be utilized more in Agriculture especially in Livestock farming such as construction f Poultry, Pens etc. after all required criteria have been performed and met. I also recommend that policies should be created that will encourage the utilization of waste as construction materials so as to have ease of acquisition of needed waste material

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